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BRIEFING BOOK

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How to Align Action Plans by CPSG with the National Biodiversity Strategies and Action Plans Developed By Governments

Convenor: Roopali Raghavan

Aim:

How to align action plans by CPSG (largely initiated by academicians or conservation groups) with the National Biodiversity Strategies and Action Plans developed by governments as part of the country's CBD commitment.

Background:

The Convention on Biological Diversity (CBD) is an international legally-binding treaty with three main goals: conservation of biodiversity; sustainable use of biodiversity; fair and equitable sharing of the benefits arising from the use of genetic resources. Recognising the threat of species extinction caused by human activities are at an alarming rate, CBD was opened for signature on 5 June 1992, at the United Nations Conference on Environment and Development (the Rio "Earth Summit"). CBD has 196 Parties and 168 Signatures. The Article 6 of the Convention states that each Contracting Party shall:

(a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity;

(b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

Article 6 creates an obligation for national biodiversity planning. A national strategy that reflects how the country intends to fulfil the objectives of the CBD, in light of specific national circumstances, and the related action plans will constitute the sequence of steps to be taken to meet these goals. These documents are referred to as National Biodiversity Strategy and Action Plans (NBSAPs).

To date, in accordance with Article 6 of the Convention, 190 of 196 (97%) Parties have developed at least one NBSAP. The attached document - nbsap-country-status.doc lists the names of these 190 countries. This link also provides access to the different NBSAPs and National Reports submitted to the CBD - https://www.cbd.int/nbsap/search/default.shtml .

The IUCN SSC Conservation Planning Specialist Group (CPSG) as part of our mission to save threatened species have been using scientifically sound, collaborative processes that bring together people with diverse perspectives and knowledge to provide species conservation planning expertise to governments, Specialist Groups, zoos and aquariums, and other wildlife organizations. CPSG uses the One Plan approach to species conservation in the development of management strategies and conservation actions by all responsible parties for all populations of a species, whether inside or outside their natural range. It is always attempted to have Government representatives involved as a crucial stakeholder in the action planning workshops. CPSG workshop reports are available here https://www.cpsg.org/document-repository .

These action plans are often not included or identified as government contributions to conservation in their NBSAP submissions. Given that the NBSAPs could be at a different scale (country wide across all biodiversity), from CPSG reports, could be a reason for such an omission.

The aim of this working group is to bring together other members of the CPSG community with an interest in this topic, to identify potential reasons for mis-alignment of both these conservation action documents. The intended outputs include to review opportunities for CPSG to minimise this as much as possible.

Process:

The workshop will be 3 hours long and will proceed as follows:

- Brief introduction to CBD, NBSAPs and knowledge currently available from various countries' submissions of NBSAPs. (Working group convener)
- Sharing of experiences by CPSG members on their use / reference to NBSAP content, in their CPSG workshop reports. (Brainstorming session with all working group participants)
- Sharing of experiences by CPSG members on relevant NBSAPs referring to their CPSG workshop reports where appropriate. (Brainstorming session with all working group participants)
- Identifying potential reasons/ challenges leading to mis-alignment of NBSAPs and CPSG reports, if any. (Brainstorming session with all working group participants)
- What can CPSG do to counter the reasons identified and arrive at practical management recommendations to avoid the same. (Brainstorming session with all working group participants)
- Summary of priority themes/solutions identified and discussion on these. (All working group participants)

Outcomes:

- Have CPSG members and government representatives be aware of any potential benefits of alignment of NBSAPs and CPSG reports.
- Suggestions for solutions identified, that can be shared with the respective CBD representatives of the governments of various countries, that could be used during revisions of various NBSAPs, where appropriate.

Materials:

Refer to NBSAPs of countries that various CPSG members have worked in, as available on the links provided above.

NBSAP Status by Country (PDF)

STATUS OF DEVELOPMENT OF NATIONAL BIODIVERSITY STRATEGIES AND ACTION PLANS OR EQUIVALENT INSTRUMENTS (NBSAPS) AT 7 JUNE 2019 (YEAR OF ADOPTION IN BRACKETS) [1]

A. Parties that submitted an NBSAP following the adoption of the Strategic Plan for Biodiversity 2011-2020, including the Aichi Biodiversity Targets

Since COP-10, **168** Parties have submitted NBSAPs: **144** Parties submitted revised versions (among these, 2 Parties completed their revisions prior to COP-10 however with consideration given to the draft Strategic Plan for Biodiversity 2011-2020 and are therefore included in this number); **15** Parties submitted their first NBSAPs; **2** Parties submitted both their first NBSAP and a revised version; **2** Parties submitted two revised versions; **1** Party submitted an Action Plan to 2020 for enhancing implementation of its Strategy adopted before COP-10; **1** Party submitted an Action Plan to 2028, as an addendum to the NBSAP prepared before 2010 which remains current and conforms with the Aichi Targets and will also be implemented to 2028; **2** Parties submitted addendums to their NBSAPs prepared before 2010 which contain national targets mapped to the Aichi Targets; and **1** Party submitted a first NBSAP developed in 2010 prior to COP-10. These NBSAPs reflect varying degrees of compliance with the current global biodiversity framework. Further details on these NBSAPs are available **here**.

1. Afghanistan (2014)
2. Albania (1999, 2016)
3. Algeria (2005, 2016)
4. Andorra (2016)
5. Antigua and Barbuda (2014)
6. Argentina (2003, 2017)
7. Armenia (1999, 2015)
8. Australia (1996, 2010)
9. Austria (1998, 2005, 2014)
10. Azerbaijan (2004, 2016)
11. Bahrain (2007, 2016)
12. Bangladesh (2006, 2016)
13. Belarus (1997, 2010, 2015)
14. Belgium (2007, 2013)
15. Belize (1998, 2016)
16. Benin (2002, 2016)
17. Bhutan (1997, 2002, 2009, 2014)
18. Bolivia (2001, 2018)
19. Bosnia and Herzegovina (2011, 2016)
20. Botswana (2005, 2007, 2016)
21. Brazil (2002, 2006, 2016)
22. Brunei Darussalam (2015)
23. Burkina Faso (1998, 2011)
24. Burundi (2000, 2013)
25. Cabo Verde (1999, 2014)
26. Cambodia (2002, 2016)
27. Cameroon (1999, 2012)
28. Canada (1996, 2016)
29. Chad (1999, 2014)
30. Chile (2003, 2018)
31. China (1994, 2010)
32. Colombia (2005, 2012, 2017)
33. Comoros (2000, 2016)
34. Congo (2001, 2015)

[1] **Year of NBSAP completion is indicated where the year of adoption is unknown**

35. Costa Rica (1999, 2016)
36. Côte d’Ivoire (2002*, 2016) *Strategy
37. Croatia (1999, 2008, 2017)
38. Cuba (1997, 2006, 2016)
39. Czech Republic (2005, 2016)
40. DPR Korea (1998, 2007)
41. DR of Congo (2000, 2002, 2016)
42. Denmark (1996*, 2004**, 2014) *Strategy, **Action Plan
43. Djibouti (2001, 2017)
44. Dominica (2002, 2013)
45. Dominican Republic (2011)
46. Ecuador (2001, 2016)
47. Egypt (1998, 2016)
48. El Salvador (1999, 2013)
49. Equatorial Guinea (2005, 2015)
50. Eritrea (2000, 2014)
51. Estonia (1999, 2012)
52. Ethiopia (2006, 2015)
53. European Union (1998, 2006, 2011)
54. Finland (1997, 2006, 2012)
55. France (2004, 2011) *Strategy adopted in 2004; Sectoral Action Plans adopted between 2006-2008 and revised in 2009; Strategy revised in 2011
56. Gambia (1999, 2015)
57. Georgia (2005, 2014)
58. Germany (2007*, 2015**) *Strategy, **Nature Conservation Action Programme 2020 for Strategy (2007)
59. Ghana (2002*, 2016) *Strategy only
60. Greece (2014)
61. Grenada (2000, 2016)
62. Guatemala (1999, 2014)
63. Guinea (2001, 2016)
64. Guinea-Bissau (2001, 2015)
65. Guyana (1999*, 2007*, 2015) * Action Plan only
66. Honduras (2001, 2017)
67. Hungary (2008, 2015)
68. India (1999, 2008, 2014*) *Addendum to NBAP 2008
69. Indonesia (1993, 2003, 2016)
70. Iran (2006, 2016)
71. Iraq (2015)
72. Ireland (2002, 2011, 2017)
73. Italy (2010)
74. Jamaica (2003, 2016)
75. Japan (1995, 2002, 2008, 2010, 2012)
76. Jordan (2001, 2015)
77. Kiribati (2006, 2016)
78. Kuwait (completed 1997 - not adopted; 2018)
79. Kyrgyzstan (1998, 2002, 2014)
80. Lao PDR (2004, 2016)
81. Latvia (2000, 2003*, 2014) *Action Plan revised
82. Lebanon (1998, 2005, 2016)
83. Liberia (2003, 2017)
84. Liechtenstein (2014)
85. Lithuania (1998, 2015)
86. Luxembourg (2007, 2017)
87. Madagascar (2002, 2007, 2016)
88. Malawi (2006, 2015)

89. Malaysia (1998, 2016)
90. Maldives (2002, 2015)
91. Mali (2001, 2014)
92. Malta (2012)
93. Mauritania (1999, 2014)
94. Mauritius (2006, 2017)
95. Mexico (2000, 2016)
96. Micronesia, Federated States of (2002, 2018)
97. Mongolia (1996, 2015)
98. Montenegro (2010, 2016)
99. Morocco (2002, 2004, 2016)
100. Mozambique (2001, 2003, 2015)
101. Myanmar (2012, 2015)
102. Namibia (2002, 2014)
103. Nauru (2010)
104. Nepal (2002, 2014)
105. Netherlands (1995, 2001, 2008, 2013)
106. New Zealand (2000, 2016)
107. Nicaragua (2001, 2016)
108. Niger (2000, 2009, 2014)
109. Nigeria (2006, 2015)
110. Niue (2001, 2015)
111. Norway (2001, 2004, 2006, 2015)
112. Pakistan (1999, 2018)
113. Palau (2005, 2018)
114. Panama (2000, 2018)
115. Paraguay (2003, 2016)
116. Peru (2001, 2014)
117. Philippines (1997, 2002, 2015)
118. Poland (2003, 2007, 2015)
119. Portugal (2001, 2018)
120. Qatar (2004, 2014)
121. Republic of Korea (1997, 2009, 2014)
122. Republic of Moldova (2000, 2015)
123. Romania (1996, 2001, 2014)
124. Russian Federation (2001, 2014)
125. Rwanda (2003, 2016)
126. Saint Kitts and Nevis (2004, 2014)
127. Saint Vincent and the Grenadines (2004, 2017)
128. Samoa (2001, 2015)
129. San Marino (2018)
130. Sao Tome and Principe (2005, 2016)
131. Senegal (1998, 2015)
132. Serbia (2011)
133. Seychelles (2008, 2015)
134. Sierra Leone (2003, 2017)
135. Singapore (1992, 2002, 2009, 2019)
136. Slovakia (1998, 2002*, 2014) *Action Plan updated only
137. Solomon Islands (2009, 2016)
138. Somalia (2015)
139. South Africa (2005, 2015)
140. Spain (1999*, 2005*, 2011**) *Strategy; **Action Plan
141. Sri Lanka (1998, 2016)
142. Sudan (2000, 2015)
143. Suriname (2006*, 2013**) *Strategy; **Action Plan
144. Swaziland (2001, 2016)

145. Sweden (1995, 2006, 2014)
146. Switzerland (2006, 2012)
147. Tajikistan (2003, 2016)
148. Thailand (1997, 2002, 2008, 2015)
149. TFYR Macedonia (2005, 2018)
150. Timor-Leste (2011, 2015)
151. Togo (2003, 2014)
152. Trinidad and Tobago (2001, 2018)
153. Tunisia (1998, 2009, 2017)
154. Turkey (2001, 2007, 2018)
155. Turkmenistan (2002, 2018)
156. Tuvalu (2013)
157. Uganda (2002, 2015)
158. Ukraine (1998*, 2000**, 2010***, 2011****) *Strategy only; **Strategy and Action Plan, ***Revised Strategy; ****Revised Action Plan
159. United Arab Emirates (2014)
160. United Kingdom (1994, 2006, 2011)
161. United Republic of Tanzania (2004, 2015)
162. Uruguay (1999, 2016)
163. Vanuatu (2000, 2018)
164. Venezuela (2001, 2010)
165. Vietnam (1994, 2007, 2015)
166. Yemen (2005, 2017)
167. Zambia (1999, 2015)
168. Zimbabwe (2002, 2014)

B. Parties that submitted a NBSAP *prior* to the adoption of the Strategic Plan for Biodiversity 2011-2020, including the Aichi Biodiversity Targets, and have advised SCBD that a revision is underway.
(19 Parties submitted a first NBSAP prior to 2010; 1 Party submitted more than one NBSAP prior to 2010).

1. Angola (2006)
2. Bahamas (1999)
3. Barbados (2002)
4. Bulgaria (2000, 2005)
5. Central African Republic (2003)
6. Cook Islands (2002)
7. Fiji (2003)
8. Gabon (1999)
9. Israel (January 2010)
10. Kazakhstan (1999)
11. Kenya (1999)
12. Lesotho (2000)
13. Marshall Islands (2000)
14. Oman (2001)
15. Papua New Guinea (2007)
16. Saint Lucia (2000)
17. Slovenia (2001) * Strategy only
18. Syrian Arab Republic (2002)
19. Tonga (2006)
20. Uzbekistan (1998)

C. Parties that submitted their *first* NBSAP *prior* to the adoption of the Strategic Plan for Biodiversity 2011-2020 and have advised SCBD that they do not intend to revise their NBSAP or have provided no information in this regard

1. Iceland (2008*, 2010**) *Strategy; **Action Plan (intend to develop Aichi-compliant targets only)

2. Saudi Arabia (2005) (do not intend to revise their NBSAP as existing framework responds to SP/ABTs)

D. Parties that have not yet submitted their first NBSAP however have advised SCBD that activities are underway

1. Cyprus
2. Haiti
3. Libyan Arab Jamahiriya
4. Monaco
5. South Sudan
6. State of Palestine

Overcoming Political and Governmental Obstacles to Increase the Impact of Zoo-based Programs in Latin America

Convenors: Karen Bauman and Martin Zordan (with Maggie Dwire and Carlos Lopez Gonzalez)

Aim:

The aim of this working group is to discuss the political and governmental obstacles that seem to limit ex situ conservation program growth in Latin America. We will cover the challenges and opportunities related to this topic. NOTE: we recognize that successful conservation programs may involve the integration of ex situ and in situ needs/resources sensu the One Plan Approach, so while we will use ex situ program structure as a framework, we do expect to discuss some in situ issues as well.

Background:

The world is in the midst of the 6th mass extinction, with concomitant losses of biodiversity (Ceballos et al. 2015). Latin America is home to some of the most biodiverse countries in the world, including Brazil, Bolivia and Mexico. According to the mid-term report on progress towards the Aichi biodiversity targets (CBD) for Latin America and the Caribbean (UNEP, 2016) declines in species abundance continue, while rates of habitat loss have slowed, but remain high. The region is undergoing rapid economic growth resulting in urbanization, infrastructure development, and agricultural expansion that can all have negative impacts on wildlife.

Therefore, an increasing number of species will require intensive management at the level of individuals and populations to ensure their long term persistence (IUCN SSC 2014). Institutions and organizations specializing in this type of intensive management, such as professional zoos and aquariums and their regional and global associations, therefore have increased opportunities and impetus to contribute to conservation (Traylor-Holzer, 2019). These contributions can be strengthened through collaborations with governmental agencies and other partners, as has been demonstrated with the Mexican wolf, a cooperative program between zoos and the governments of the United States and Mexico. However, political terms and appointees in zoos and governmental agencies can threaten the stability of these programs, especially in Latin America. Further, in Latin America social inequities and illegal wildlife trade are additional challenges, along with regional zoo associations that have a small number of member facilities and are just putting accreditation standards and conservation program structures in place (compared to some of the larger regional zoo associations in the United States, Europe and Australia).

There have been previous attempts to jump start zoo-based conservation programs in Latin America. A few of these have been successful, unfortunately more needs to be done – and quickly – to create active, successful and sustainable conservation programs to save the richness of biodiversity in Latin America.

Process:

The workshop will be 3 hours long and will proceed as follows:

- Presentation of concept and examples of some political and governmental obstacles from the Mexican wolf program (ex situ and in situ elements).
- Brainstorming session with all working group participants, regarding their experiences with political and governmental obstacles as they relate to ex situ programs. NOTE: the focus is Latin America, but discussion could be expanded to include other zoo regions, depending on participants.
- Discuss the above obstacles in the context of challenges and opportunities for successful, long-term programs
    - Including resources/models available from other regional zoo associations and governments
- Create a list of action items (and key people to involve) that would result in positive change on this topic, considering the One Plan Approach and how Latin American ex situ programs fit into global conservation programs. Involvement in action items should include Latin American zoo associations, governmental agencies, WAZA and CPSG.
- If there is time, we may discuss species or models to test some of the methods discussed in our working group.

Outcomes:

We hope that the discussions of this working group will assist in a better understanding of the obstacles such that methods for addressing these can be developed. Specifically, these insights will provide a platform for action items our group will generate in order to increase the impact of zoo-based programs in Latin America.

Materials:

Please be familiar with the content in the following documents:

- IUCN Ex Situ Guidelines
- Mid-term report on progress towards the Aichi biodiversity targets (CBD) for Latin America and the Caribbean (UNEP, 2016)
- Global ICAP for Canids and Hyenids

IUCN

IUCN Species Survival Commission Guidelines on the Use of *Ex situ* Management for Species Conservation

International Union for Conservation of Nature

SSC
Species Survival Commission

IUCN Species Survival Commission Guidelines on the Use of *Ex situ* Management for Species Conservation

Version 2.0

Approved by the Steering Committee of the IUCN Species Survival Commission, Tallinn, Estonia, 29 August 2014

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Citation: IUCN/SSC (2014). Guidelines on the Use of *Ex Situ* Management for Species Conservation. Version 2.0. Gland, Switzerland: IUCN Species Survival Commission.

Available online at:
www.iucn.org/about/work/programmes/species/publications/iucn_guidelines_and__policy__statements/

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Contents

Drafting process and acknowledgements

A working group was established to revise the *IUCN Technical Guidelines on the Management of Ex Situ Populations for Conservation* to clarify the process and bring the guidelines into line with developments that had taken place since their publication in 2002. This process started with an analysis of decision-making steps for evaluating *ex situ* activities for conservation benefit during the Annual Meeting of the IUCN Species Survival Commission (SSC) Conservation Breeding Specialist Group (CBSG) in Cologne, Germany in October 2010. This analysis was undertaken by individuals involved in a range of taxonomic and disciplinary SSC Specialist Groups, *in situ* conservation organisations, and the zoo and aquarium community. Subsequently, a drafting team was formed under the auspices of CBSG, comprising Kristin Leus (CBSG Europe, Copenhagen Zoo), Kathy Traylor-Holzer (CBSG), and Philip McGowan (Galliformes Specialist Group). They were supported by representatives from all SSC Subcommittees, namely Mike Maunder (Plant Conservation Subcommittee), Yvonne Sadovy (Marine Conservation Subcommittee), Paul Pearce-Kelly (Invertebrate Conservation Subcommittee), Topiltzin Contreras MacBeath (Freshwater Conservation Subcommittee), and Mark Stanley Price (Species Conservation Planning Subcommittee). In addition, Mike Jordan represented the Reintroduction Specialist Group. Mike Hoffmann served as the SSC Steering Committee liaison for this project.

A first draft was presented to the 2011 CBSG Annual Meeting in Prague, Czech Republic, and a series of drafts were submitted for increasingly wide review between 2011 and 2013 to the SSC Steering Committee, its Subcommittees, all Specialist Groups and Task Force Chairs, and Red List Authority Focal Points. A consultation was held during the SSC Chairs' meeting in February 2012. The consultative and open review process was reported in the SSC e-bulletin and presented at the 2012 World Conservation Congress in Korea. The consultation included a range of non-IUCN entities, including wildlife health professionals; botanical collections and botanical gardens; national, regional and global zoo and aquarium associations; and national and international organisations, including, but not restricted to, International Fund for Animal Welfare, Royal Society for the Prevention of Cruelty to Animals, Royal Society for the Protection of Birds, Pan African Sanctuary Alliance, UN Food and Agriculture Organisation, BirdLife International, Wildlife Conservation Society, and the Leibniz Institute for Zoo and Wildlife Research. The final draft was submitted to and approved by the SSC Steering Committee on 29 August 2014.

The drafting team (Kristin Leus, Kathy Traylor-Holzer and Philip McGowan) would like to express heartfelt thanks to each and every person that contributed to the development of the guidelines. We also acknowledge the support of home institutions and organisations of all contributors for allowing them the time to carry out this work. We hope that these guidelines contribute to the evaluation and, where appropriate, application of *ex situ* management for effective species conservation.

Guidelines

Section 1: Introduction

As habitats and ecosystems become increasingly altered and populations evermore impacted by human activities, a growing number of species will require some form of management of both individuals and populations to ensure their survival. Effective species conservation planning should consider all options when assessing what actions are necessary to address the conservation pressures facing a particular species. *Ex situ* management (see Section 2 for definition) is one possible option that can contribute to the conservation of threatened species. The range of *ex situ* scenarios and tools is diverse and can target different conservation needs and roles and, therefore, serve various purposes.

Ex situ management has been used to deliver conservation benefit for threatened species. Species extinctions have been prevented and for an increasing number of species there have been conservation restorations or introductions following periods of *ex situ* management. However, the need for, and suitability of, an *ex situ* programme must be carefully evaluated as part of an integrated conservation strategy. In order to be successful, *ex situ* programmes need to be carefully planned and implemented in a way that provides conservation benefit. In addition, as conservation challenges become more complex and urgent, the need to further develop scientifically based and innovative approaches to *ex situ* conservation will increase.

Not all species will require an *ex situ* component as part of their conservation strategy, and not all *ex situ* populations will have a direct conservation purpose. These guidelines are intended to be used in situations in which *ex situ* management is being considered as part of an overall integrated species conservation strategy.

The aim of these guidelines is to provide practical guidance on evaluating the suitability and requirements of an *ex situ* component for achieving species conservation objectives. They should not be misconstrued as promoting *ex situ* management over any other form of conservation action, and specific elements should not be selected in isolation to justify *ex situ* management for conservation. Indeed they are intended to ensure that proposals for any such activities are rigorously designed and scrutinised, whatever the taxon or scale of operation. Accordingly, the need for risk assessment and sound decision making processes in all *ex situ* management for conservation is emphasised, but with the level of effort in proportion to the scale, risk and uncertainties around any such activity.

These guidelines replace the 2002 IUCN Technical Guidelines on the Management of *Ex Situ* Populations for Conservation. In addition, aspects of these guidelines merge with many other disciplines in contemporary conservation, which also have their own guidelines or policies. Within IUCN, these guidelines should be seen as complementary to, and consistent with, the following key works:

- *IUCN Guidelines for Reintroductions and Other Conservation Translocations* (2013)[1]. In those cases where individuals are used for population restoration or conservation introduction following a period of *ex situ* management, these guidelines should be consulted together.
- *IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species* (2000)[1].
- IUCN (2008). *Strategic Planning for Species Conservation: A Handbook*[1].

[1] http://www.iucn.org/about/work/programmes/species/publications/iucn_guidelines_and__policy__statements/

- IUCN (2000). *The IUCN Policy Statement on Sustainable Use of Wild Living Resources*[1]
- OIE and IUCN (2014). *Guidelines for Wildlife Disease Risk Analysis*[1]
- IUCN World Commission on Protected Areas (2012). *Ecological Restoration for Protected Areas: Principles, guidelines and best practices*[2]
- IUCN Red List[3]

It should also be noted that many other organisations have developed their own guidelines for activities in the spectrum from species reintroduction to ecosystem restoration.

These guidelines are in line with the Convention on Biological Diversity and its Strategic Plan for Biodiversity (the Aichi Biodiversity Targets).

Section 2: Scope and definitions

The term "*ex situ*" can be problematic to define in some circumstances, just as it is sometimes difficult to distinguish precisely the conditions that define "wild" or "managed" in today's increasingly altered landscapes. Consequently, in many contexts there is now a gradient of management interventions between no management at one end and intensive management of individuals at the other, and between the traditional *in situ* and *ex situ* categories. Many populations both within and outside protected areas are subject to varying intensities of management such as anti-poaching interventions, predator or pathogen control, the provision of supplementary nutrition, habitat modification (e.g. controlled burning or flooding), the application of assisted reproduction, restriction of natural migration and dispersal, meta-population management, population regulation, etc., that show some characteristics in common with those used in the intensive management of *ex situ* populations. While we encourage the evaluation of the full "*in situ* to *ex situ*" spectrum of population management options in the process of identifying the most suitable conservation strategies for a species, these guidelines are designed to provide guidance for situations towards the *ex situ* end of the spectrum.

For the purpose of these guidelines, "*ex situ*" is defined as conditions under which individuals are spatially restricted with respect to their natural spatial patterns or those of their progeny, are removed from many of their natural ecological processes, and are managed on some level by humans. In essence, the individuals are maintained in artificial conditions under different selection pressures than those in natural conditions in a natural habitat. These are generally circumstances in which humans exercise control over many of the natural dynamics of a population, including control of climate and living environments, access to nutrition and water, shelter, reproductive opportunities, and protection from predation or certain other natural causes of mortality. *Ex situ* management may take place either within or outside the species' geographic range, but is in a controlled or modified environment. This may include highly artificial environments where individuals are stored as dormant in subzero conditions (e.g. seedbanks, genome resource banks), or semi-natural conditions where individuals are subject to near natural environments.

[2] http://www.iucn.org/about/work/programmes/gpap_home/gpap_capacity2/gpap_bpg/?10734/Ecological-Restoration-for-Protected-Areas

[3] http://www.iucnredlist.org/

These guidelines are specifically intended for situations in which *individuals (or live bio-samples) of any species (or other taxonomic unit) are present* ex situ *for any period of time for a clearly defined conservation purpose.*

For simplicity, the guidelines use the terms of "individual" to represent both individuals and live bio-samples and "species" to represent any taxonomic unit of conservation interest. These guidelines apply to:

Ecological contexts

- All taxonomic groups (animals, plants, fungi, bacteria, protozoa, etc.);
- All taxonomic levels (e.g. species, subspecies or different groupings of these);
- All population levels (e.g. all individuals of a species, single population, multiple populations);
- All live entities (not only whole living organisms, but also gametes, seeds, living cell lines, etc.); and
- All geographic levels (e.g. local, national, global).

Management contexts

- Both situations in which individuals need to be taken from the wild and brought under *ex situ* management, and situations in which the management of existing *ex situ* populations may be utilized or adapted for conservation benefit;
- The complete spectrum of very short term to very long term *ex situ* phases that may or may not include all life stages or reproduction; and
- Only *ex situ* populations with clearly defined conservation goals and objectives that contribute to the viability of the species as a component of its overall conservation strategy. While many different types of *ex situ* populations exist, with many different and sometimes overlapping roles and contexts, *ex situ* management for conservation only applies to those *ex situ* populations that have conservation as their primary aim. The *ex situ* activities must benefit a population, the species, or the ecosystem it occupies and the primary benefit should be at a higher level of organisation than the individual. The conservation goals and objectives can be diverse and may include not only providing individuals for reintroduction or other conservation translocations, for genetic rescue or as insurance against extinction, but also for allowing tailored conservation education, conservation research and training that targets the reduction of threats or the accruement of conservation benefits for the species. This does not preclude these *ex situ* populations for conservation from having additional roles that are not necessarily, or only indirectly and generally, related to conservation.

Section 3: *Ex situ* management as a conservation tool

Not all species conservation strategies will require an *ex situ* component, in the same way that other management interventions may or may not be required to conserve a species. In some cases *ex situ* management will be a primary part of a conservation strategy and in others it will be of secondary importance, supporting other interventions. It is necessary, therefore, to consider how *ex situ* management may contribute to the overall conservation objectives set for the species and to document this clearly.

Often primary threats such as habitat loss, invasive species, or overexploitation lead to small isolated populations, which then in turn become highly susceptible to additional stochastic threats that can lead to a feedback loop of population decline and eventual extinction (often referred to as the 'extinction vortex'). It is in such instances that intensive management, including but not restricted to *ex situ* management, can be of particular conservation value if deemed appropriate for the species and situation.

Ex situ conservation has the potential to:

Address the causes of primary threats

Ex situ activities can help reduce primary threats such as habitat loss, exploitation, invasive species or disease when specifically designed conservation research, conservation training or conservation education activities directly and effectively impact the causes of these threats (e.g. training in the recognition of specific life stages or gender characteristics for preferential exploitation, education to limit the spread of an invasive species, or research into disease epidemiology or treatment).

Offset the effects of threats

Ex situ activities can improve the demographic and/or genetic viability of a wild population by ameliorating the impacts of primary or stochastic threats on the population. Small populations that are vulnerable to primary threats and stochastic processes may require some form of intensive management of individuals and populations to improve demographic and genetic viability and avoid extinction. Challenges faced by small populations (e.g. reduced survival, reduced reproduction, decreased population size, and genetic isolation) can be counteracted by a range of population management options, such as head start programmes to address high juvenile mortality, or population reinforcement to balance age and sex distribution.

Buy time

Establishment of a diverse and sustainable *ex situ* rescue or insurance population may be critical in preventing species extinction when wild population decline is steep and the chance of sufficiently rapid reduction of primary threats is slim or uncertain or has been inadequately successful to date. Examples include *ex situ* populations in response to severe disease threat, catastrophic events or continued habitat degradation.

Restore wild populations

Once the primary threats have been sufficiently addressed, *ex situ* populations can be used for population restoration (reinforcement or reintroduction) or conservation introduction (assisted colonisation or ecological replacement). As such, these guidelines should be seen as complementary to, and consistent with, the IUCN Guidelines for Reintroductions and Other Conservation Translocations[1], and any *ex situ* programme for conservation that includes a return of individuals from *ex situ* conditions to natural conditions must equally refer to these.

For a growing number of taxa *ex situ* management may play a critical role in preventing extinction as habitats continue to decline or alter and become increasingly unsuitable. Furthermore, it should be acknowledged that even under the most optimistic of climate change impact and adaptation scenarios, an increasing percentage of species (for example, polar and mountain species; reef corals and their dependent species) may have little likelihood of long-term persistence in the wild, despite the option of assisted colonisation in certain carefully selected cases. At present, many threat assessment processes are inadequate in predicting the complex impacts of climate change and ocean acidification on the potential persistence of a species *in situ* (either within its current or a new range).

Section 4: Integrating *in situ* and *ex situ* conservation planning

There is an increasing need to ensure the integration of *in situ* and *ex situ* conservation planning to ensure that, whenever appropriate, *ex situ* conservation is used to support *in situ* conservation to the best effect possible. These guidelines would therefore ideally be used as an integral part of, and complementary to, existing species conservation planning processes (Figure 1). Any *ex situ* conservation support should follow a logical process from initial concept to design, feasibility, risk assessment, decision-making, implementation, monitoring, adjustment and evaluation. Furthermore, the Species Survival Commission's approach to conservation planning for species[1] requires the specification of goals, objectives and actions:

- A goal is a statement of the intended result in terms of conservation benefit;
- Objectives give clear and specific details for how the goal will be realised; and
- Actions are statements of what should be done to meet the objectives.

When used strategically *ex situ* conservation can be a potent tool for species conservation that does not undermine, but complements, the imperatives of field conservation. Potential *ex situ* goals, objectives and actions should therefore be evaluated alongside potential *in situ* activities in the process of conservation planning to ensure that they are used appropriately and to best effect. More specifically, before an *ex situ* conservation programme is developed or continued, it is important to consider the roles it can play, the characteristics and dimensions it should take, and what factors will impede or likely contribute to conservation success. As is the case for conservation planning in general, these evaluations are ideally made by a multi-stakeholder group, including both *in situ* and *ex situ* expertise and experience.

These guidelines outline five steps (Figure 1) to evaluate the appropriateness of *ex situ* management as part of a comprehensive species conservation strategy. They explore the conservation role and design, feasibility, and risk assessment, and guide a final decision on whether or not to proceed with an *ex situ* programme for conservation. The five-step process also provides input for the formulation of clear goals, objectives and actions for any *ex situ* conservation programme undertaken after the decision making process.

FIVE-STEP DECISION MAKING PROCESS

to decide when *ex situ* management is an appropriate conservation tool

Ex situ management should be applied to the conservation of a species where, on balance, stakeholders can be confident that the expected positive impact on the conservation of that species will outweigh the potential risks or any negative impact (which could be to the local population, species, habitat or ecosystem), and that its use will be a wise application of the available resources. This requires an assessment of the potential net positive impact, weighted by how likely it is that this potential will be realised, given the expertise, level of difficulty or uncertainty, and available resources.

The following five-step outline provides a logical decision-making process that can be applied to evaluate the appropriateness of *ex situ* management as a tool to support the conservation of a species and to identify the form that such management would need to take. All steps of the process should be documented for transparency and clarity.

STEP 1. Compile a status review of the species, including a threat analysis.
A detailed review should be undertaken of all relevant information on the species, both in the wild and ex situ*, with the aim of assessing the viability of the population(s) and to identify and understand threats that affect the species. This is a normal step in any conservation planning process and may therefore for some species already be available in existing conservation strategies or action plans. If not, this process would ideally be conducted in the wider framework of the creation of one integrated conservation strategy for a species.*

a. The status review should contain information on all factors that are appropriate to the life history and taxonomy, current population status, and other factors that are relevant to the demographic and genetic viability and ecosystem function of the species being considered. The structure of the status review (and threat analysis – see b. below) should, wherever possible, be consistent with IUCN processes that also compile information on status, such as the IUCN Red List Assessments[3] and the IUCN/SSC Species Conservation Planning approach[1]. The character and scale of the status review will vary depending on the precise circumstances, including data availability and relevance. Important information gaps concerning the status should be noted.

b. A threat analysis should be undertaken to identify the specific historical, current and likely future primary direct and indirect threats as well as stochastic threats facing the species in the wild and the constraints limiting its viability and conservation. This analysis should, wherever possible, utilise the rapidly growing data knowledge on anticipated climate change scenarios to predict likely changes in status. This provides the framework for evaluating specifically how *ex situ* management of the species may contribute to its conservation.

c. Genetic and demographic modelling should where possible be used to assess the viability of the wild population. This can be very valuable to guide population management by identifying the effects and relative importance of threats (including stochastic processes) and the strategies that may address them effectively.

d. The status of any free-living populations living outside of the species' indigenous range, as well as the status of existing *ex situ* population(s) (if any), should be reviewed, including current population size, demographic and genetic characteristics, provenance and history, taxonomy, and any programme goals and management methods if applicable.

e. In the absence of sufficient data for a thorough assessment, other information may be considered as evidence suggestive of current or impending population decline or reduced viability, such as population trends, likelihood of future habitat loss, vulnerability to climate change, projected impact of invasive species, and restricted range to one or few locations.

STEP 2. Define the role(s) that *ex situ* management will play in the overall conservation of the species.

The potential ex situ *management strategies proposed should address one or more specific threats or constraints to the species' viability and conservation as identified in the status review and threat analysis, and target improvement of its conservation status.*

a. There should be a clear statement on how the proposed *ex situ* programme will contribute quantifiable benefits to the conservation of the species and address certain specific threat(s) and/or constraints to its viability as identified in the status review and threat analysis. This should include quantifiable goal(s) and objectives, and how success towards those objectives will be measured and assessed. When sufficient data and expertise are available, population modelling can be effective in assessing the potential impact of the *ex situ* programme on the viability of the wild population.

b. Potential roles (purpose/function) that an *ex situ* programme might serve for the conservation of a species generally fall into the four categories of *Addressing the causes of primary threats*, *Offsetting the effects of threats*, *Buying time*, *and Restoring wild populations* (see Section 3) and more specifically include but are not restricted to:

- Insurance population (maintaining a viable *ex situ* population of the species to prevent predicted local, regional or global species extinction and preserve options for future conservation strategies);
- Temporary rescue (temporary removal from the wild to protect from catastrophes or predicted imminent threats, e.g. extreme weather, disease, oil spill, wildlife trade). This could be appropriate at either local or global scale;
- Maintenance of a long term *ex situ* population after extinction of all known wild populations and as a preparation for reintroduction or assisted colonisation if and when feasible;
- Demographic manipulation (e.g. head-start programmes that remove individuals from the wild to reduce mortality during a specific life stage and then subsequently return them to the wild);
- Source for population restoration, either to re-establish the species into part of its former range from which it has disappeared, or to reinforce an existing population (e.g. for demographic, behavioural or genetic purposes);
- Source for ecological replacement to re-establish a lost ecological function and/or modify habitats. This may involve species that are not themselves threatened but that contribute to the conservation of other taxa through their ecological role;
- Source for assisted colonisation to introduce the species outside of its indigenous range to avoid extinction;
- Research and/or training that will directly benefit conservation of the species, or a similar species, in the wild (e.g. monitoring methods, life history information, nutritional requirements, disease transmission/treatment); and
- Basis for an education and awareness programme that addresses specific threats or constraints to the conservation of the species or its habitat.

c. One *ex situ* programme may serve several conservation roles – either simultaneously or consecutively.

It is recognised that an *ex situ* population can also serve to avoid extinction of a species that has no chance in the foreseeable future for persistence in the wild (for example in the face of climate change). In such circumstances a careful appraisal of the allocation of available resources should be made, and a prioritization based on conservation benefits and other values may assist in the decision making.

STEP 3. Determine the characteristics and dimensions of the *ex situ* population needed to fulfil the identified conservation role(s).
The identified conservation purpose and function of the ex situ *programme will determine its required nature, scale and duration.*

a. Biological factors that are important in assessing requirements for achieving the programme's aim and objectives include:

- The number of founders (unrelated individuals of wild origin) required to attain the genetic and demographic goals of the *ex situ* population. This may involve making use of founders (and their descendants) of existing *ex situ* populations and/or sampling (additional) individuals (and where appropriate propagules or biomaterials from individuals) from the wild, across different habitat types, populations, etc.;
- The number of individuals or bio-samples to be maintained or produced *ex situ*;
- Whether reproduction or propagation is required during the duration of the programme;
- The likely required length of programme (in generations and in years) where possible;
- The relative risk for artificial selection/adaptation (genetic, phenotypic, etc.) during consecutive generations in *ex situ* conditions;
- Whether the *ex situ* phase is envisaged to be followed by a release (which has consequences for the required characteristics of the *ex situ* environment); and
- The type of environment required to maintain the individuals in a suitable condition during the length of the programme.

b. These lead to the following practical considerations that should be evaluated:

- The most suitable geographic location and scale for the *ex situ* activities (for example, inside *vs.* outside of the current/indigenous range; a centralized *vs.* a multi-facility programme; etc.). Where possible *ex situ* management should be undertaken within the range states and under similar climatic regimes to the wild population. However, because the current distribution of *ex situ* facilities and professional capacity generally does not match with the geographic areas of greatest species loss, the need for capacity building and the availability of material resources and suitably trained and committed personnel requires consideration;
- Whether whole living organisms and/or live bio-samples (e.g. tissue or gametes/seeds/spores) will need to be maintained *ex situ*;
- Whether whole living organisms and/or live bio-samples will need to be marked and tracked and if so, how;
- Whether individuals from existing *ex situ* populations (potentially with other, or additional, roles than conservation) can be included in the *ex situ* conservation programme, thus reducing the risks to the wild population associated with the removal of individuals;
- The intensity of genetic and demographic management required to achieve the roles and goals of the *ex situ* programme;
- The potential bio-security risks associated with the project, both at the *ex situ* location(s) and in any subsequent population restoration or conservation introduction if this is planned;
- The welfare issues associated with the programme;
- The potential options for, and benefits of, maintaining individuals on public display *vs.* in non-public facilities that restrict access, visibility or disturbance;

- The degree of human proximity and interaction that can be allowed in terms of the potential for habituation of *ex situ* individuals to people, due to the management approach chosen and/or exposure to the public;
- The legal and regulatory requirements for removing individuals or biomaterials from the wild and/or transporting them regionally, nationally or internationally;
- The ownership of, and access to, individuals and bio-samples and the degree of assurance of ongoing commitment to the programme by both holding and owning parties; and
- The fate of any individuals or bio-samples remaining in the *ex situ* programme when its purpose has been achieved.

Population models may be used to determine the necessary population size, composition and level of management needed to meet the conservation role(s) of the population.

STEP 4. Define the resources and expertise needed for the *ex situ* management programme to meet its role(s) and appraise the feasibility and risks.

It is not sufficient to know the potential value of an ex situ *programme designed to meet a specific conservation role – it is also critical to evaluate the resources needed, the feasibility of successfully managing such a programme, the likelihood of success at all steps of the programme, including where relevant any subsequent return to the wild, and the risks, including risks to the species in the wild and to other conservation activities. These should be balanced against the risks of failing to take appropriate conservation action.*

a. It is essential to assess the resources required to establish and maintain an *ex situ* population with the characteristics defined in Step 3 in order to achieve the aims and objectives stated in Step 2. These should be considered in detail at this stage. Some of the practical factors that will determine the overall scale of resources required include:

- The facilities, infrastructure and space required;
- The staffing required (in terms of numbers, skills and continuity);
- The risk for the spread of disease (need for biosecurity, quarantine, diagnostics, research on pathogens and disease, etc.).
- The risk of catastrophes impacting the *ex situ* programme (natural or human-caused catastrophes, such as fire, civil unrest, etc.); and
- The finances required for all essential activities over an adequate period of time (in proportion to the expected total length of the programme).

b. Other factors that need to be determined to investigate the feasibility and risks of the proposed project include:

- The probability of obtaining the required resources, including technical experts and project managers with the required skill sets. Effective *ex situ* management for conservation will require effective multidisciplinary teams within the biological, technical and social skill sets;
- Competition for resources with other programmes for the same or other taxa as well as opportunities for cost sharing;
- Available expertise in husbandry/disease control/cultivation/propagation/banking for relevant life stages for this and/or for related/comparable taxa. In some areas of the world, particularly in regions facing the highest rates of biodiversity loss, the capacity for skills in *ex situ* conservation may need to be strengthened. Similarly, the increasingly diverse range of candidate species and challenges to be addressed may require additional tools and techniques;
- The degree of stability in, or level of agreement about, the taxonomy of the taxon in question and the degree of knowledge on evolutionary significant units, genetic population structure and risks for inbreeding and outbreeding depression;
- The critical governmental and non-governmental partner institutions and the probability of successful collaboration among these (including partners responsible for field conservation);
- The degree of compatibility of the ecological, demographic, behavioural or other characteristics of the species with the type of *ex situ* management proposed;
- Requirements to ensure the welfare of any living individuals *ex situ*. *Ex situ* conservation programmes should adhere to internationally accepted standards for welfare, and efforts should be made to reduce stress or suffering;
- All legal and regulatory requirements for the project (so that the intended *ex situ* management is approved and supported by all relevant agencies) and how likely

they can be fulfilled. An *ex situ* conservation programme may need to meet regulatory requirements at any or all of the international, national, regional or sub-regional levels. This may among others involve regulations for the capture or collection of individuals from the source populations, for the movement of individuals across international borders (e.g. CITES) and across jurisdictional or formally recognised tribal boundaries, for dealing with benefits arising from the use of genetic resources and/or traditional knowledge (e.g. Nagoya Protocol), for veterinary and phyto-sanitary aspects, and for the holding of wild individuals in *ex situ* conditions;

- Any formal endorsements required for the project from relevant *in situ* and/or *ex situ* entities, and how likely they can be obtained;
- Where relevant, assessment of the impact of the removal of individuals from the wild on the remaining wild source population (e.g. through modelling);
- The likely impact on the remaining wild population and its habitat of establishing, or not establishing, an *ex situ* population. Special consideration may be given to situations in which all remaining wild individuals may need to be removed due to a very high probability of extinction in the wild that cannot be mitigated in time;
- The ecological risks (e.g. containment of potentially invasive species, hybridisation risks) and what is required to minimise them;
- Any health and safety risks (for people and/or other species) and what is required to minimise them; and
- Any potential political, social or public conflicts of interest and how they can be dealt with. A review of the cultural status of the species should be conducted to ensure that any *ex situ* conservation management is compatible with local traditions and values and supported by local communities at the source location(s) and/or the *ex situ* location(s). Mechanisms for communication, engagement and problem-solving between the public (especially key individuals most likely affected by or concerned about the removal of individuals from nature or the maintenance of individuals *ex situ*) and *ex situ* managers should be established.

A review of the factors mentioned above will allow the assessment of an overall probability of the *ex situ* programme achieving the intended results in terms of conservation benefit.

The scope of the risk assessment should be proportional to the level of identified risk. Where data are poor, the risk assessment may only be qualitative but it is necessary, as lack of data does not indicate absence of risk.

STEP 5. Make a decision that is informed (i.e. uses the information gathered above) and transparent (i.e. demonstrates how and why the decision was taken).

The decision to include ex situ *management in the conservation strategy for a species should be determined by weighing the potential conservation benefit to the species against the likelihood of success and overall costs and risks of not only the proposed* ex situ *programme, but also alternative conservation actions or inaction.*

The relative importance (weight) of potential conservation benefit *vs.* likelihood of success, costs and risks will vary for each species and situation, according to factors such as, but not limited to:

- The severity of threats and/or risk of extinction of the wild population;
- The significance of the species (ecological, cultural, sociological, economic or evolutionary distinctness, value of the species in leveraging large scale habitat conservation, etc.); and
- Legal and political mandates.

In general, any conservation management strategy including *ex situ* management is warranted when potential conservation benefit is both high and likely to be achieved. Similarly, *ex situ* management is not warranted if there is little conservation benefit, feasibility is low, and costs and risks (especially to the wild population) are high.

If the decision to implement *ex situ* management of a species is left until extinction is imminent, it is frequently too late to implement effectively, thus increasing the chance of failure and risking permanent extinction of the species. This reinforces the need for comprehensive strategic planning for species to be undertaken as early as possible.

Documentary evidence of information gathered and decisions made for Steps 1 through 5 is highly important, *regardless of whether the decision to proceed with the* ex situ *management is positive or negative*. Archiving of documents in publicly accessible libraries and on public web sites is recommended.

SECTION 5: Programme implementation, monitoring, adjustment and evaluation

Implementation

If a decision is made to establish or continue an *ex situ* management programme, further considerations that are important in the development of this programme include:

- Actions needed to achieve the identified goals and objectives of the programme should be formulated and implemented (including actions to mitigate the most important risks identified in Step 4). Actions should be specific, measurable, have time schedules attached, and indicate the resources needed and parties responsible for their implementation;
- Data collection and management protocols for all important aspects of the programme should be developed in order to enable adequate monitoring;
- Any *ex situ* management programme should be developed within national, regional and international conservation infrastructure, recognizing the mandate of existing agencies, legal and policy frameworks, organisational conservation strategies, national biodiversity action plans or existing species recovery plans. Of noteworthy mention in the context of these guidelines are the Convention on Biological Diversity (CBD), the International Agenda for Botanic Gardens in Conservation, the Global Strategy for Plant Conservation, the International Treaty on Plant Genetic Resources for Food and Agriculture, the World Zoo and Aquarium Conservation Strategy, the Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration;
- Any *ex situ* conservation programme should adhere to national and international obligations with regard to access and benefit sharing (as outlined in the CBD);
- The *ex situ* programme should consult during its planning, implementation, monitoring and evaluation stages with all relevant stakeholder groups, professional associations and organisations, both with regard to the indigenous range of the species and the location of the *ex situ* programme;
- The *ex situ* programme personnel should stay up to date with relevant scientific work and scientific publications;
- Where multiple bodies such as government agencies, non-government organisations, academia, private organisations, informal interest groups, etc. all have statutory or legitimate interests in an *ex situ* programme, it is essential that mechanisms exist for all parties to play constructive roles. This may require establishment of special teams working outside formal, bureaucratic hierarchies that can guide, oversee and respond swiftly and effectively as management issues arise. Different parties involved in an *ex situ* project may have their own mandates, priorities and agendas that need to be aligned through effective facilitation and leadership in order not to undermine the success of the project. A memorandum of understanding with appropriate parties defining the collaboration structure, ownership issues and responsibilities may be beneficial. Inter-project, inter-regional or international communication and collaboration is encouraged as relevant. The programme should consult with external experts as needed;
- The *ex situ* project should have a clear and appropriate time frame established.

Monitoring, adjustment and evaluation

There should be regular evaluations of the *ex situ* programme, not only of its own success, but also of its role within the overall conservation strategy for the species, which is likely to change over time.

The management of an *ex situ* programme is a cyclical process of implementation, monitoring, feedback and adjustment of both biological and non-biological aspects until either the goals are met or the *ex situ* programme is deemed unsuccessful. Despite thorough planning and design, inherent uncertainty and risk will lead to both expected and unexpected situations. The monitoring is the means to measure the performance of the *ex situ* programme against objectives, to assess conservation impacts, and provide the basis for adjusting objectives or adapting management regimes or activating an exit strategy. In addition to refining an ongoing *ex situ* programme, the conclusions from monitoring may guide other *ex situ* programmes.

Adequate resources for monitoring should be part of financial feasibility and commitment. The purpose and duration of monitoring of the *ex situ* populations and the species' situation in the wild (especially those aspects that that the *ex situ* population is trying to address) should be appropriate to each situation.

Learning from *ex situ* conservation programme outcomes can be improved through application of more formal adaptive management approaches, whereby alternative models are defined in advance and are tested through monitoring. This process means that the models used to decide management are based on the best possible evidence and learning.

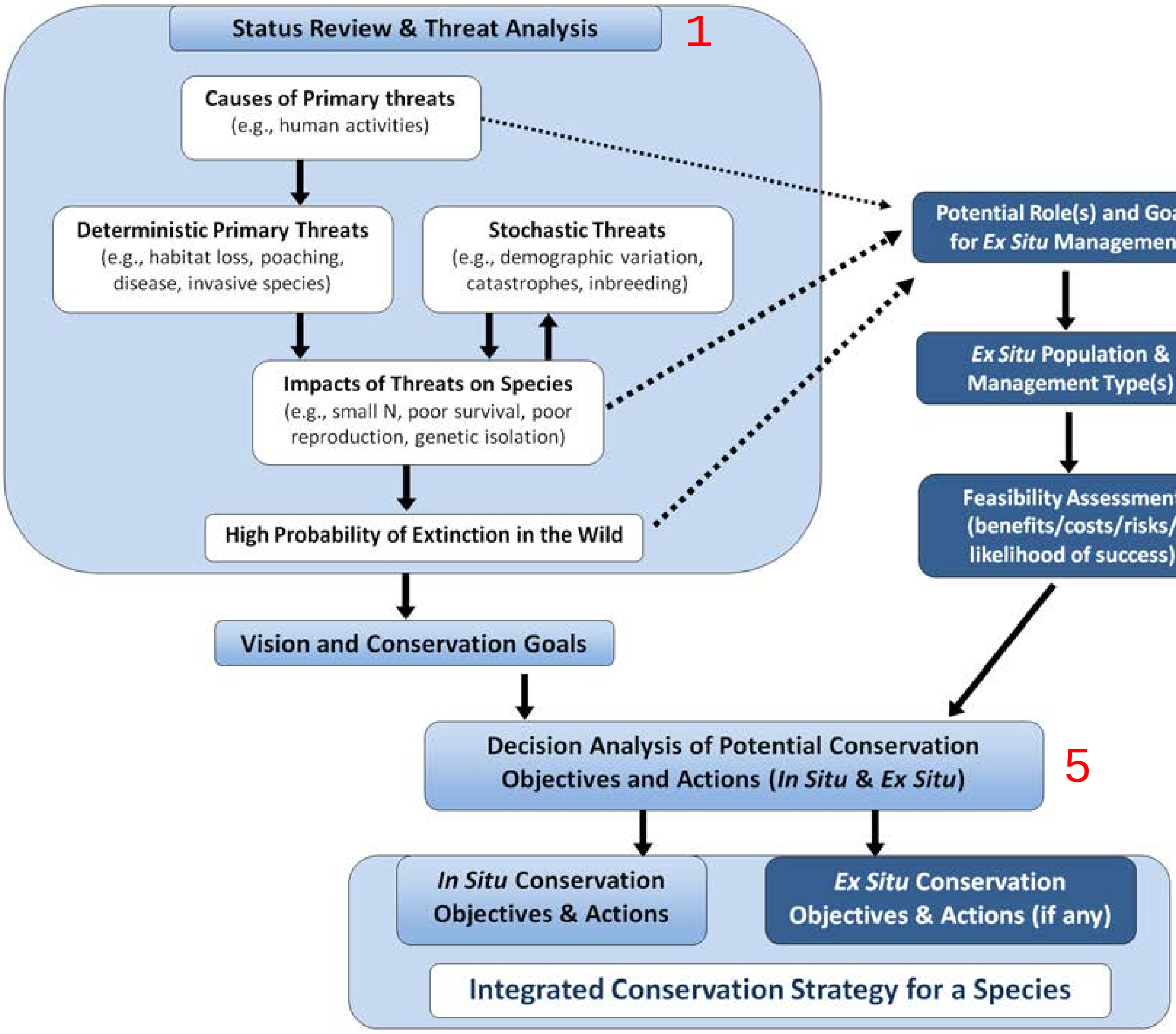
SECTION 6: Dissemination of information

Regular reporting and dissemination of information should start from the intention to initiate *ex situ* activities for conservation and throughout subsequent progress. It serves many purposes both for each *ex situ* project and collectively:

1. To create awareness and support for the *ex situ* programme amongst all parties;
2. To meet any statutory requirements; and
3. To contribute to the body of information on, and understanding of, *ex situ* management for conservation. Collaborative efforts to develop *ex situ* management science are helped when reports are published in peer-reviewed journals (as an objective indicator of high quality), and include well-documented but unsuccessful *ex situ* projects or methods as well as successful ones.

The means of dissemination are many (e.g. publications, press, interpretation in public institutions). The media, formats and languages used all should be appropriate for the target audience.

Figure 1: Incorporation of the five-step decision process outlined in these guidelines (red numbers) into the species conservation planning process to develop an integrated conservation strategy for a species.



The State of Biodiversity in Latin America and the Caribbean

Technical Report · May 2016

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THE STATE OF BIODIVERSITY IN LATIN AMERICA AND THE CARIBBEAN

A MID-TERM REVIEW OF PROGRESS TOWARDS THE AICHI BIODIVERSITY TARGETS

UNEP

Convention on Biological Diversity

2011-2020 United Nations Decade on Biodiversity

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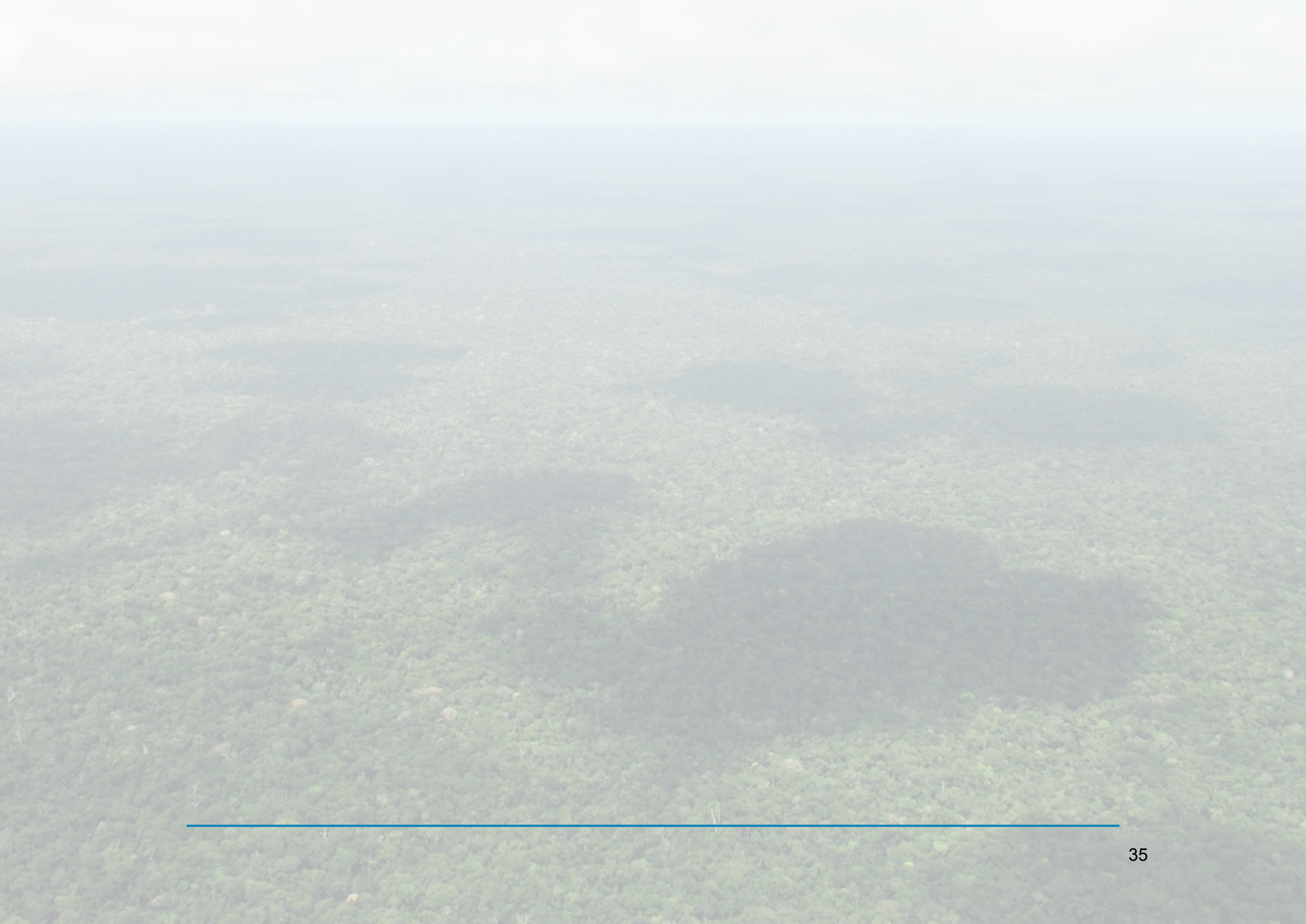

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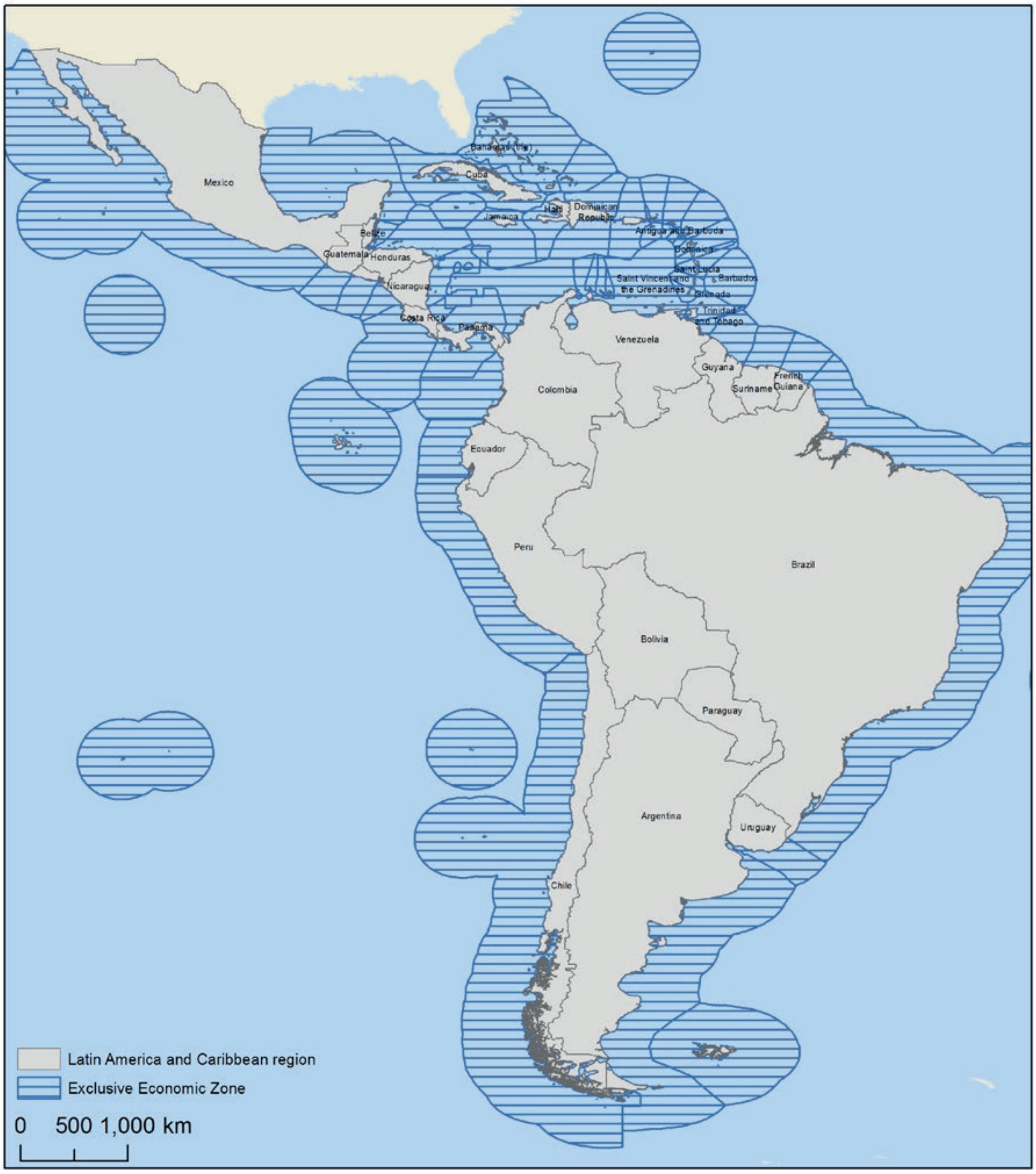
Map of Biogeographical Realms and Biomes derived from the WWF Terrestrial Ecoregions dataset (map produced by UNEP-WCMC using data from Olson et al. 2001).



Map of countries and their Economic Exclusive Zone (EEZ) in the Latin America and Caribbean region, based on the UNEP Live regional classification (UNEP 2015a).

FOREWORD

The Latin America and Caribbean (LAC) region supports rich biological diversity, with around sixty per cent of global terrestrial life found within it, alongside diverse freshwater and marine flora and fauna. The LAC region's biomes extend from wetlands and coastal ecosystems to deserts, tropical forests, extensive savannah grasslands and high altitude Andean habitats. The lowland forests are amongst the most species-rich on Earth, and the mountain forests and moorlands (*páramos*) of the Andes host a wide range of endemic and narrow range species. This regional diversity is driven by a number of environmental factors, including a complex evolutionary history and highly variable geography, geology and climate. Large areas of LAC remain in a natural or semi-natural state, but there has also been considerable transformation of habitats to serve national, regional and global economies. Although these national economies have improved over recent decades, and the governance of many countries has been transformed, further progress is required to build more fair and equitable societies, while continuing to consider biodiversity and ecosystem services in decision-making. This is a challenge for the future development and conservation trajectories of the region.

In 2010, the Parties to the Convention on Biological Diversity (CBD) adopted the *Strategic Plan for Biodiversity 2011-2020* (the *Strategic Plan*), a global ten-year framework for action to conserve biodiversity and enhance its benefits for people. An assessment of the implementation of the plan, at the global scale, was published in the fourth edition of the *Global Biodiversity Outlook* (GBO-4) in 2014. This second edition of *The State of Biodiversity in Latin America and the Caribbean* complements the global GBO-4 by analysing and assessing the status and trends of the environment in this region, against the twenty Aichi Biodiversity Targets. This report is primarily a synthesis of existing material, although it does include some new analyses. It also forms a contribution towards the development of two other regional environmental assessments; the first, focusing on biodiversity and ecosystem services, was recently initiated by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and the second resulting from broader environmental concerns will feed into the Sixth Edition of the *Global Environment Outlook* (GEO-6).

This report identifies opportunities and challenges in implementing the *Strategic Plan for Biodiversity 2011-2020* in Latin America and the Caribbean and looks ahead to actions which need to be taken by national governments and other decision makers to enhance and accelerate progress towards its attainment. There are many examples of success and innovation in the conservation of LAC's biodiversity, yet the region is also experiencing high rates of urbanization and industrial and agricultural development. Balancing the promotion of human and economic development with the preservation and sustainable use of natural resources is a huge challenge in the LAC region.

Responding to and tackling the challenges presented in this assessment requires a collaborative effort across governments and many stakeholders within the LAC region. UNEP has a significant role to play in catalysing such action through stimulating trans-boundary action, South-South cooperation and joint efforts across the region, building capacity within governments and organisations to promote sustainable development, fostering innovation, piloting new ideas and encouraging the mobilisation of resources.

Leo Heileman

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1. EXECUTIVE SUMMARY

Global Biodiversity Outlook-4, the mid-term review of the *Strategic Plan for Biodiversity 2011-2020*, provided a global assessment of progress towards the attainment of the Plan's global biodiversity goals and associated Aichi Biodiversity Targets, but contained limited regional information. This report builds on and complements the global GBO-4 assessment. It is the second edition of the State of Biodiversity in the Latin America and the Caribbean report and serves as a near mid-term review of progress towards the *Strategic Plan for Biodiversity 2011-2020* for the Latin America and the Caribbean region.

This report draws on a set of regional indicators, information from fifth national reports to the Convention on Biological Diversity (CBD), other national and regional reports, case studies and published literature, to provide a target-by-target review of progress towards the twenty Aichi Biodiversity Targets. As much as possible, global indicators for Aichi Biodiversity Targets have been broken down to regional level and some additional analyses of existing global information have been undertaken with key national institutions in the region. However, limitations in data have meant that some datasets, which do not extend past 2011, have been included to illustrate that relevant information exists, but further efforts to update this information are needed.

Tracking regional progress can help identify where regional and national efforts are most needed to enhance and accelerate progress towards the attainment of the Aichi Biodiversity Targets. Responding to the opportunities and challenges requires a collaborative effort so this report has been produced to help inform regional and national dialogue across governments and many stakeholders throughout the Latin America and Caribbean region, and the promotion of co-operation and actions especially through legal and policy frameworks at different scales.

The key messages about the state of biodiversity in the Latin America and Caribbean region, and the pressures upon it, which have emerged from this assessment are:

- Declines in species abundance and high risks of species extinctions continue.
- Rates of habitat loss in Latin America and the Caribbean have slowed but remain high.
- Certain pressures associated with rapid economic growth and social inequities are impacting the region's natural resources.
- Agricultural expansion and intensification to increase both livestock, arable and commodities production continue.
- The region is undergoing major infrastructure development of dams and roads.
- The impacts on biodiversity of high concentrations of population in urban areas are particularly significant within the region.
- Country economies within the region are very highly dependent on natural resources.
- Resource extraction for minerals and hydrocarbons has, in some cases, led to locally devastating direct and indirect impacts on biodiversity such as vegetation removal, water and soil pollution and contamination.
- Transboundary and local air pollution is now recognised as an environmental factor in human health in the region.
- Climate change induced impacts on coral reefs and montane habitats within the region are now being observed.

Nonetheless, the report identifies a number of important responses that have taken place since 2010:

- The region has implemented a range of low carbon sustainable development approaches (Target 3, 5, 11, 15).
- Regional efforts continue to be made to control illegal trade in wildlife (Target 4).
- Protected area coverage has expanded significantly in recent years, including government managed, community managed and privately managed reserves (Target 11).
- Regional support for conserving migratory species has increased (Target 12).
- Implementation of targeted species management and recovery programmes has resulted in several success stories (Target 12).
- Sustainable financing mechanisms are improved but have faced set-backs in recent years (Target 20).

A dashboard of progress towards each of the Aichi Biodiversity Targets has been developed, based on consideration of regional analysis of global datasets (mainly from the Biodiversity Indicators Partnership, BIP), analyses of the fifth national reports to the CBD and relevant literature.

Overall progress towards the implementation of the Aichi Biodiversity Targets in the LAC region is similar to the global picture. However, in LAC, some countries lack information and reporting around progress towards specific targets, and some countries report that they are currently not on track to meet specific targets. The most positive trends in the region are seen in Target 11 (protected areas), Target 17 (adoption and implementation of policy instruments) and to a lesser extent Targets 18 (acknowledgement of traditional knowledge) and 19 (improved biodiversity information sharing).

Looking to the future, it is clear that attaining most of the Aichi Biodiversity Targets will require implementation of a package of actions, including legal, policy and institutional frameworks that are coherent across government ministries, and the mainstreaming of biodiversity into productive sectors, such as agriculture, fisheries, tourism and forestry. Furthermore, actions must be taken on the identification of applicable socio-economic incentives that engages all stakeholders, and a general strengthening of monitoring and enforcement. Finally, it is important to undertake measures to encourage active participation of other actors, local governments, the private sector, indigenous peoples and local communities, civil society and social movements, as well as new forms of social organization according to national realities.

Proposed actions in the short and longer term include:

- Mainstream biodiversity across governments and productive sectors (such as, agriculture, fisheries, tourism and forestry).
- Mainstream biodiversity into business practices.
- Build forest carbon conservation partnerships.
- Sharing expertise on water payment schemes in the region.
- Sustainably develop the water resources in the region.
- Link tourism to development planning in coastal nations.
- Invest in raising public awareness of biodiversity values.
- Strengthen the effectiveness of protected area networks and biological corridors.
- Enhance the implementation of biodiversity-related Conventions to build institutional capacity.
- Enhanced regulation and enforcement of environmental laws and policies.
- Increase available resources for biodiversity.
- Increase and promote multi-sectoral coordination, and South-South and Triangular cooperation.
- Promote the gathering of appropriate data to measure progress towards the Aichi Biodiversity Targets in the region, using regional and national datasets.

1. RESUMEN EJECUTIVO

La Perspectiva Mundial sobre la Diversidad Biológica 4, la evaluación de progreso del primer período del *Plan Estratégico para la Biodiversidad 2011-2020*, facilitó una perspectiva global del progreso para conseguir los objetivos del Plan y las Metas de Aichi para la Diversidad Biológica asociadas, pero contenía información regional limitada. Este reporte está basado y complementa 'La Perspectiva Mundial sobre la Diversidad Biológica 4'. Es la segunda edición del Reporte del Estado de la Biodiversidad en América Latina y el Caribe y sirve como una evaluación cercana a la mitad del término sobre el progreso hacia el *Plan Estratégico para la Biodiversidad 2011-2020* para la región de América Latina y el Caribe.

Este reporte utiliza información de diferentes indicadores regionales, información de los quintos informes nacionales para el Convenio sobre la Diversidad Biológica (CBD), otros reportes nacionales y regionales, casos de estudio y literatura publicada, para proveer una revisión meta-por-meta del progreso hacia las veinte Metas de Aichi de Biodiversidad. Los indicadores globales para las Metas de Aichi de biodiversidad fueron analizadas de manera regional lo más detalladamente posible y algunos análisis adicionales con información global fueron revisados con instituciones nacionales claves en la región. Sin embargo, limitaciones en la información disponible hizo necesario utilizar datos previos a 2011, para mostrar que la información relevante existe, pero se deben hacer esfuerzos para actualizar esta información.

Rastrear el progreso regional puede ayudar a identificar donde esfuerzos regionales y nacionales son más necesarios para incrementar y acelerar el progreso para alcanzar las Metas de Aichi de Biodiversidad. Responder a las oportunidades y a los desafíos requiere de esfuerzos colaborativos y, es por esto que este reporte ha sido producido para ayudar a informar el diálogo entre los gobiernos y las partes interesadas en la región de América Latina y el Caribe, y a la promoción de la cooperación y acciones especialmente a través de marcos legales y políticas en diferentes escalas.

- Los mensajes clave que han surgido de esta evaluación sobre el estado de la biodiversidad en la región de América Latina y el Caribe y las presiones a las que se enfrenta son:
- La disminución de la abundancia de especies y los altos riesgos de extinción continúan.
- El ritmo de pérdida de hábitats en América Latina y el Caribe ha disminuido, pero sigue alto.
- Algunas presiones asociadas con crecimientos económicos rápidos y desigualdades sociales están impactando los recursos naturales de la región.
- La expansión e intensificación de la agricultura para incrementar áreas para el ganado, tierras cultivables y para materias primas continúan.
- La región experimenta gran desarrollo de la infraestructura en rutas y diques.
- Los impactos en la biodiversidad de las grandes concentraciones de población en áreas urbanas son de particular importancia en la región.
- Las economías de los países dentro de la región son comprensiblemente dependientes de los recursos naturales.
- La extracción de recursos para minerales e hidrocarburos, en algunos casos, ha llevado a la devastación local con impactos directos e indirectos en la biodiversidad como la extracción de la vegetación, la contaminación de las aguas y de la tierra.
- La contaminación transfronteriza y local es ahora reconocida como un factor ambiental en la salud humana de la región.
- El cambio climático indujo impactos en los arrecifes de coral y hábitats montañosos dentro de la región que ahora están siendo observados.

Sin embargo, el reporte identifica un número de respuestas importantes que han ocurrido desde 2010:

- La región ha implementado varios abordajes de desarrollo sostenibles y bajos en carbón (Meta 3, 5, 11, 15).
- Esfuerzos regionales para controlar el tráfico ilegal de vida silvestre se siguen llevando a cabo (Meta 4).
- El área protegida se ha expandido de manera significativa recientemente, incluyendo reservas manejadas por gobiernos, por comunidades y de manera privada (Meta 11).
- El apoyo regional para la conservación de especies migratorias ha incrementado (Meta 12).
- La implementación del manejo y programas de recuperación de especies determinadas ha resultado en varias historias de éxito (Meta 12).
- Los mecanismos de financiamiento sostenible han mejorado, pero han visto un retroceso en los últimos años (Meta 20).

Un tablero del progreso hacia cada uno de las metas Aichi de Biodiversidad fue desarrollado, basado en la consideración de análisis regionales del conjunto de datos globales (mayormente de la Asociación de Indicadores sobre Biodiversidad, BIP, por sus siglas en inglés), análisis del quinto reporte para la CBD y literatura relevante.

En general el progreso hacia la implementación de las Metas de Biodiversidad de Aichi en la región de América Latina y el Caribe es similar al retrato global. Sin embargo, en América Latina y el Caribe, algunos países no tienen información ni reportes sobre metas específicas y algunos países reportan que no están encaminados para cumplir con determinadas metas. Las tendencias más positivas en la región se ven en la Meta 11 (áreas protegidas), Meta 17 (adopción e implementación de instrumentos políticos) y, en menor medida, Metas 18 (reconocimiento a los conocimientos tradicionales) y 19 (mejora en el compartir de la información sobre biodiversidad).

Mirando hacia el futuro, está claro que el cumplimiento con la mayoría de las Metas de Aichi de Biodiversidad va a requerir la implementación de un paquete de acciones, incluyendo legales, políticas y marcos institucionales que sean coherentes en los diferentes ministerios de gobierno e integración de la biodiversidad en los sectores productores como la agricultura, pescadería, turismo y de bosque. Adicionalmente, se deberán tomar acciones en la identificación de incentivos socio-económicos aplicables que involucren a todos los accionistas, y un fortalecimiento del monitoreo y de la ejecución. Finalmente, es importante tomar medidas para incentivar la participación activa de otros actores, gobiernos locales, el sector privado, comunidades indígenas y locales, la sociedad civil y movimientos sociales, como también las nuevas formas de organización social de acuerdo con las realidades nacionales.

Acciones propuestas a corto y largo plazo incluyen:

- Integrar la biodiversidad en los gobiernos y sectores productivos (como agricultura, pescadería, turismo y bosques).
- Integrar la biodiversidad en las prácticas de negocios.
- Construir alianzas para la conservación de bosques como sumideros de carbono.
- Compartir buenas prácticas sobre esquemas de pago del agua en la región.
- Desarrollar usos sostenibles de los recursos hídricos en la región.
- Asociar el turismo con los planes de desarrollo en las naciones costeras.
- Invertir en incrementar la conciencia del público en general sobre los valores de la biodiversidad.
- Fortalecer la efectividad de los corredores de áreas protegidas y de las redes.
- Incrementar la implementación de convenciones relacionadas a la biodiversidad para construir capacidad institucional.
- Fortalecer el derecho ambiental y reforzar las regulaciones.
- Aumentar los recursos disponibles para la biodiversidad.
- Promover la cooperación Sur-Sur y Triangular.
- Promover la recopilación de información apropiada para medir el progreso hacia las metas de Biodiversidad en la región, usando bases de datos regionales y nacionales.

1. RÉSUMÉ

Les *Perspectives mondiales de la diversité biologique 4*, évaluation à mi-parcours du *Plan stratégique pour la diversité biologique 2011-2020*, constituent une évaluation globale des progrès accomplis vers la réalisation des objectifs mondiaux Plan stratégique pour la diversité biologique et les Objectifs d'Aichi qui y sont associés; elles ne contiennent toutefois que des informations limitées au niveau régional. Le présent rapport s'appuie sur l'évaluation des *Perspectives mondiales de la diversité biologique 4* et la complète. Il s'agit de la seconde édition du rapport intitulé *L'état de la biodiversité en Amérique Latine et dans les Caraïbes*, qui sert d'évaluation presque à mi-parcours des progrès accomplis vers la réalisation du *Plan stratégique pour la diversité biologique 2011-2020* au sein de la région Amérique latine et Caraïbes.

Le présent rapport s'appuie sur un ensemble d'indicateurs régionaux, d'informations tirées des cinquièmes rapports nationaux publiés dans le cadre de la Convention sur la diversité biologique, d'autres rapports nationaux et régionaux, d'études de cas et autres publications, en vue d'examiner, objectif par objectif, les progrès accomplis vers la réalisation des 20 objectifs d'Aichi pour la biodiversité. Dans la mesure du possible, les indicateurs mondiaux de ces objectifs ont été ventilés au niveau régional, et les informations disponibles au niveau international ont fait l'objet d'analyses complémentaires en collaboration avec d'importantes institutions nationales de la région. En revanche, l'existence de données limitées signifie que des ensembles de données n'allant pas au-delà de 2011 ont été utilisés afin de montrer que des informations pertinentes existent, mais qu'il est nécessaire de les actualiser.

Le suivi des progrès à l'échelle régionale peut permettre d'identifier dans quelle région ou dans quel pays il est indispensable de déployer des efforts visant à renforcer et à accélérer les progrès vers la réalisation des objectifs d'Aichi. Seule une collaboration permettra de tirer profit des opportunités et de faire face aux difficultés rencontrées, aussi le présent rapport a été rédigé de manière à éclairer le dialogue qu'entretiennent, au niveau régional et national, les gouvernements et un grand nombre de parties prenantes de l'ensemble de la région Amérique latine et Caraïbes, et à encourager la coopération et les efforts à différentes échelles, en particulier à l'aide de cadres législatif et politique.

Les principaux enseignements relatifs à l'état de la biodiversité en Amérique latine et dans les Caraïbes, et aux pressions qu'elle subit, qui ressortent de cette évaluation sont les suivants :

- On observe toujours une diminution de l'abondance des espèces et un risque élevé d'extinction.
- Le rythme de la destruction des habitats naturels en Amérique latine et dans les Caraïbes a ralenti, mais il reste élevé.
- Une certaine pression, liée à une croissance économique rapide et aux inégalités sociales, fait sentir ses effets sur les ressources naturelles de la région.
- L'extension et l'intensification de l'agriculture se poursuivent, afin d'accroître le cheptel, les terres arables et la production agricole.
- La région voit la construction d'infrastructures majeures, telles que des barrages et des routes.
- Les conséquences pour la biodiversité des fortes concentrations de population en zone urbaine sont particulièrement importantes dans la région.
- L'économie des pays de la région dépend entièrement des ressources naturelles.
- L'extraction des minerais et des hydrocarbures a parfois eu des conséquences directes et indirectes dévastatrices pour la biodiversité locale, telles que l'enlèvement de la végétation, la contamination et la pollution des eaux et des sols.
- La pollution de l'air, au niveau local et international, est à présent reconnue comme une menace environnementale pour la santé des populations de la région.
- On peut désormais constater les effets des changements climatiques sur les récifs coralliens et les habitats montagnards de la région.

Le présent rapport décrit néanmoins un certain nombre de mesures importantes qui ont été prises depuis 2010 pour pallier ces problèmes :

- La région a mis en place différentes méthodes de développement durable à faible émission de carbone (objectifs 3, 5, 11, 15).
- Les efforts se poursuivent dans la région afin de contrôler le commerce illicite d'espèces sauvages protégées (objectif 4).
- Ces dernières années, les zones protégées ont été étendues de manière notable, aussi bien celles gérées par les États, les collectivités ou le secteur privé (objectif 11).
- La conservation des espèces migratrices a fait l'objet d'un engagement plus marqué à l'échelle de la région (objectif 12).
- La mise en œuvre de programmes de gestion et de rétablissement d'espèces ciblées a abouti à plusieurs réussites (objectif 12).
- Les dispositifs de financement durable se sont améliorés, mais ils ont subi des contretemps ces dernières années (objectif 20).

Un tableau de bord destiné à mesurer les progrès accomplis vers la réalisation de chaque objectif d'Aichi a été élaboré à partir de l'analyse régionale des ensembles de données mondiaux (provenant principalement du Partenariat relatif aux indicateurs de biodiversité), des analyses présentées dans les cinquièmes rapports nationaux élaborés dans au titre de la Convention sur la diversité biologique et de publications à ce sujet.

La progression de l'Amérique latine et des Caraïbes vers la réalisation des objectifs d'Aichi est de même ordre que les avancées observées à l'échelle internationale. Certains pays de cette région ne documentent toutefois pas les progrès concernant des objectifs spécifiques et n'en rendent pas compte, et d'autres pays signalent qu'ils sont actuellement loin de les atteindre. Les évolutions les plus positives observées dans la région concernent la objectif 11 (zones protégées), la objectif 17 (adoption et mise en œuvre d'instruments de politique générale), et dans une moindre mesure les objectifs 18 (reconnaissance des savoirs traditionnels) et 19 (amélioration du partage des informations relatives à la biodiversité).

À l'avenir, il est évident que la réalisation de la plupart des objectifs d'Aichi nécessitera la mise en œuvre d'un ensemble de mesures, y compris de cadres législatif, politique et institutionnel, qui soient cohérentes d'un ministère à l'autre, et la prise en compte de la biodiversité par les secteurs productifs, en particulier l'agriculture, la pêche, le tourisme et la sylviculture. Des mesures doivent par ailleurs être prises en vue d'identifier les incitations socio-économiques à même de garantir l'engagement des parties prenantes et de renforcer, de manière générale, le contrôle et l'application de la loi. Il faut enfin prendre des mesures visant à encourager la participation active d'autres acteurs (administrations locales, secteur privé, peuples autochtones et communautés locales, société civile et mouvements sociaux), et les nouvelles formes d'organisation sociale, en fonction des réalités de chaque pays.

Figurent au nombre des mesures envisagées à court et à long terme les éléments suivants :

- Sensibiliser les administrations et les secteurs productifs (tels que l'agriculture, la pêche, le tourisme et la sylviculture) à la biodiversité ;
- Intégrer la biodiversité aux pratiques des entreprises ;
- Établir des partenariats en faveur de la conservation du carbone forestier ;
- Diffuser dans la région l'expertise en matière de régimes de paiement de l'eau ;
- Développer durablement les ressources en eau de la région ;
- Associer tourisme et planification du développement dans les pays côtiers ;
- Investir dans les activités de sensibilisation à l'importance de la biodiversité ;
- Renforcer l'efficacité des réseaux de zones protégées et des couloirs biologiques ;
- Améliorer l'application des conventions relatives à la biodiversité afin de renforcer les capacités institutionnelles ;
- Durcir la législation et renforcer le respect des politiques et des lois environnementales ;
- Augmenter les ressources disponibles jouant en faveur de la biodiversité ;
- Développer la coordination multisectorielle ;
- Encourager la collecte de données pertinentes afin de mesurer les progrès accomplis vers la réalisation des objectifs d'Aichi dans la région, en utilisant des ensembles de données régionaux et nationaux ;
- Favoriser la coopération Sud-Sud et triangulaire.

1. РЕЗЮМЕ

В четвертом издании «Глобальной перспективы в области биоразнообразия», промежуточном обзоре *Стратегического плана по биоразнообразию на 2011-2020 годы,* приводилась глобальная оценка прогресса в достижении предусмотренных Планом глобальных целей в области биоразнообразия и выполнении соответствующих Айтинских задач в области биоразнообразия, однако региональная информация содержалась там в ограниченном объеме. Настоящий доклад основывается на глобальной оценке, приведенной в ГПОБ-4, и дополняет ее. Это второе издание доклада «Состояние биоразнообразия в Латинской Америке и Карибском бассейне», выступающее в качестве промежуточного обзора прогресса в осуществлении *Стратегического плана по биоразнообразию на 2011-2020 годы для* региона Латинской Америки и Карибского бассейна.

В настоящем докладе приводится обзор прогресса в выполнении каждой из двадцати Айтинских задач в области биоразнообразия. С этой целью используются набор региональных индикаторов, информация из пятых национальных докладов в рамках Конвенции о биологическом разнообразии (КБР), других национальных и региональных докладов, тематических исследований и опубликованных материалов. По мере возможности глобальные индикаторы по Айтинским задачам в области биоразнообразия приводятся в разбивке по регионам, при этом был проведен определенный дополнительный анализ существующей глобальной информации совместно с основными национальными учреждениями в регионе. Вместе с тем, ограниченный характер данных означал, что были включены некоторые массивы данных, не охватывающие период после 2011 года, чтобы показать, что соответствующая информация существует, но для ее обновления необходимы дополнительные усилия.

Отслеживание прогресса на региональном уровне может способствовать выявлению тех областей, в которых наиболее востребованы региональные и национальные меры по активизации и ускорению хода работы по выполнению Айтинских задач в области биоразнообразия. Реагирование на открывающиеся возможности и актуальные проблемы требует совместных усилий, в связи с чем был подготовлен настоящий доклад в целях обеспечения информационной поддержки регионального и национального диалога между правительственными органами и различными заинтересованными сторонами во всех странах Латинской Америки и Карибского бассейна, а также содействия сотрудничеству и практическим действиям, особенно посредством установления правовых и политических рамок на различных уровнях.

Ниже приводятся основные выводы о состоянии биоразнообразия в регионе Латинской Америки и Карибского бассейна и воздействующих на него нагрузках, которые были получены в результате этой оценки.

- Продолжается сокращение относительной численности видов и сохраняются высокие риски их исчезновения.
- Темпы утраты мест обитания в Латинской Америке и Карибском бассейне замедлились, но остаются высокими.
- На природные ресурсы региона оказывают воздействие определенные нагрузки, связанные со стремительным экономическим ростом, и проявления социального неравенства.
- Продолжаются расширение сельскохозяйственных угодий и интенсификация сельского хозяйства с целью увеличения поголовья скота, пахотных площадей и товарного производства.
- В регионе осуществляются крупные проекты по развитию инфраструктуры, например строительству плотин и дорог.
- В этом регионе особенно заметное воздействие на биоразнообразие оказывает высокая степень концентрации населения в городских районах.
- Экономика стран региона во всех аспектах зависит от природных ресурсов.
- Добыча минерального и углеводородного сырья в некоторых случаях оказала опустошительное прямое и косвенное воздействие на биоразнообразие на местном уровне, выражающееся, в частности, в удалении растительности, загрязнении и отравлении воды и почвы.
- Трансграничное и локальное загрязнение воздуха в настоящее время признается в качестве одного из экологических факторов, влияющих на здоровье людей в регионе.
- В настоящее время наблюдается воздействие изменения климата на коралловые рифы и горные места обитания в регионе.

Несмотря на это, в докладе определен ряд важных мер реагирования, которые принимались с 2010 года:

- В регионе реализован ряд подходов к устойчивому развитию, обеспечивающих низкий уровень углеродосодержащих выбросов (Целевые задачи 3, 5, 11, 15).
- Продолжается принятие мер на региональном уровне по борьбе с незаконной торговлей дикими видами флоры и фауны (Целевая задача 4).
- За последние годы значительно расширился охват охраняемыми природными территориями, в том числе заповедниками, находящимися под управлением государства, общин и частных организаций (Целевая задача 11).
- Усилилась поддержка мер по сохранению мигрирующих видов на региональном уровне (Целевая задача 12).
- Реализация целевых программ регулирования и восстановления численности видов в ряде случаев увенчалась успехом (Целевая задача 12).
- Совершенствовались механизмы устойчивого финансирования, однако в последние годы в их работе наблюдался определенный регресс (Целевая задача 20).

Была разработана информационная панель, показывающая прогресс в выполнении каждой из Айтинских задач в области биоразнообразия и созданная на основе анализа глобальных массивов данных в разбивке по регионам (главным образом, полученных от Партнерства по индикаторам биоразнообразия), анализа пятых национальных докладов в рамках КБР и соответствующих опубликованных материалов.

Общий прогресс в выполнении Айтинских задач в области биоразнообразия в регионе Латинской Америки и Карибского бассейна аналогичен общемировой картине. Вместе с тем, в некоторых странах ЛАК отсутствуют информация и отчетность в части прогресса в выполнении конкретных целевых задач, а некоторые страны сообщают, что они в настоящее время не обеспечивают выполнение конкретных целевых задач. Наиболее положительные тенденции в регионе наблюдаются по Целевой задаче 11 (охраняемые природные территории), Целевой задаче 17 (принятие и реализация политических инструментов) и, в меньшей степени, по Целевым задачам 18 (признание традиционных знаний) и 19 (совершенствование обмена информацией о биоразнообразии).

Если заглянуть в будущее, становится ясно, что для выполнения большинства Айтинских задач в области биоразнообразия потребуется реализация комплекса мер, включающего правовые, политические и организационные рамки, согласованные между правительственными ведомствами, а также включение вопросов биоразнообразия в основную деятельность производственных секторов, таких как сельское хозяйство, рыбный промысел, туризм и лесное хозяйство. Кроме того, необходимо принять меры по определению применимых социально-экономических стимулов, обеспечивающих вовлечение в проводимую работу всех заинтересованных сторон, и общему укреплению функций мониторинга и обеспечения выполнения. Наконец, важно принять меры по стимулированию активного участия других субъектов деятельности, органов местного самоуправления, частного сектора, коренных народов и местных общин, гражданского общества и общественных движений, а также новых форм общественных организаций в соответствии с национальными реалиями.

Предлагаемые меры в кратко- и долгосрочной перспективе включают:

- Учет вопросов биоразнообразия в основной деятельности правительственных органов и производственных секторов (таких как сельское хозяйство, рыбный промысел, туризм и лесное хозяйство).
- Учет вопросов биоразнообразия в хозяйственной практике.
- Создание партнерских отношений в области сохранения запасов углерода, накопленных в лесах.
- Обмен опытом применения системы платежей за воду в регионе.
- Устойчивое развитие водных ресурсов в регионе.
- Увязывание туризма с планированием развития в прибрежных государствах.
- Инвестиции в повышение осведомленности общественности о стоимостной ценности биоразнообразия.
- Повышение эффективности сетей охраняемых природных территорий и биологических коридоров.
- Совершенствование реализации конвенций, касающихся биоразнообразия, с целью укрепления институционального потенциала.
- Совершенствование регулирования и обеспечения выполнения экологических законов и политических установок.
- Увеличение доступных ресурсов для сохранения биоразнообразия.
- Совершенствование межсекторальной координации.
- Содействие сбору соответствующих данных для количественной оценки прогресса в выполнении Айтинских задач в области биоразнообразия в регионе с использованием региональных и национальных массивов данных.
- Содействие сотрудничеству по линии Юг-Юг и трехстороннему сотрудничеству.

وعلاوة على ذلك، يجب أن يتم اتخاذ الاجراءات بُغية تحديد المحفّزات الاجتماعية والاقتصادية السارية والتي تضمن مشاركة كل الأطراف ذات الصلة، وتعزيزعام للمراقبة والتنفيذ. وأخيراً، من المهم اتخاذ التدابير لتشجيع المشاركة الفعالة للقطاعات الأخرى والحكومات المحلية والقطاع الخاص والسكان الأصليين والمجتمعات المحلية والمجتمع المدني والحركات الاجتماعية بالإضافة إلى الأشكال الجديدة من المنظمات الاجتماعية وفقاً للحقائق الوطنية.

وتتضمن الإجراءات المقترحة على المدى القصير والبعيد ما يلي:

- تعميم التنوع البيولوجي عبر الحكومات والقطاعات الإنتاجة مثل: الزراعة والثروة السمكية والسياحة والغابات).
- تعميم التنوع البيولوجي في الممارسات التجارية.
- بناء شراكات لصون كربون الغابات.
- المشاركة بتجربة خطة مدفوعات المياه في المنطقة.
- التنمية المستدامة للموارد المائية في المنطقة.
- ربط السياحة بالتطوير المُمنهَج في الدول الساحلية.
- الاستثمار في رفع مستوى الوعي العام لقيم التنوع البيولوجي.
- تعزيز فاعليّة شبكات المناطق المحمية والممرات البيولوجية.
- تعزيز تنفيذ الاتفاقيات المتعلقة بالتنوع البيولوجي من أجل بناء القدرات المؤسسية.
- تعزيز ضبط القوانين والسياسات البيئية وتنفيذها.
- زيادة الموارد المتاحة للتنوع البيولوجي.
- زيادة التنسيق المتعدد القطاعات.
- الحث على جمع البيانات المناسبة لقياس تقدم سير العمل نحو أهداف أيشي للتنوع البيولوجي في المنطقة مستخدمين مجموعات البيانات الإقليمية والوطنية.
- تعزيز التعاون ما بين مبادرتي الدول الثلاثية والجنوب-جنوب.

ومع ذلك فإن هذا التقرير يشير إلى عدد من حالات الاستجابة الهامة التي حدثت منذ عام 2010:

- قامت المنطقة بتنفيذ مجموعة من منهجيات التنمية المستدامة المنخفضة الكربون (الأهداف 3، 5، 11، 15).
- استمرار بذل الجهود الإقليمية لضبط التجارة الغير قانونية للحياة الفطرية (الهدف 4).
- توسيع نطاق المناطق المحمية بشكل كبير في السنوات الراهنة بما يتضمن المحميات التي يتم إدارتها من قبل الجهات الحكومية والمجتمع والتي تُدار بشكل فردي أيضاً (الهدف 11).
- ازدياد الدعم الإقليمي بُغية صون وحماية الأنواع المهاجرة (الهدف 12).
- إن تنفيذ كل من إدارة الأنواع المستهدفة وبرامج الإنعاش نتج عنها حالات نجاح عديدة (الهدف 12).
- تتطور آليات التمويل المستدامة إلا أنها تعرضت لانتكاسات في السنوات الأخيرة (الهدف 20).

وقد تم تطوير منظومة قياس تقدم سير العمل نحو كل هدف من أهداف أيشي للتنوع البيولوجي اعتماداً على أهمية التحليل الإقليمي لمجموعة البيانات العالمية (وبشكل رئيسي من شراكة مؤشرات التنوع البيولوجي-BIP)، وعلى تحليلات التقارير الوطنية الخامسة للاتفاقية المتعلقة بالتنوع البيولوجي (CBD)، وعلى الكتابات المنشورة ذات الصلة.

ويُعتبر تقدم سير العمل الكلي نحو تنفيذ أهداف أيشي للتنوع البيولوجي في أمريكا اللاتينية ومنطقة الكاريبي مشابه للصورة العالمية. ومع ذلك فإن بعض الدول في أمريكا اللاتينية ومنطقة الكاريبي تعاني من نقص في المعلومات وفي تقديم التقارير حول تقدم سير العمل إزاء أهداف محددة، وتقدم بعضها أيضاً تقارير بأنها حالياً ليست على المسار الصحيح لتحقيق الأهداف المحددة. وقد لُوحِظت معظم الاتجاهات الإيجابية في المنطقة في الهدف 11 (المناطق المحميّة)، والهدف 17 (تبني وتنفيذ الأدوات السياسية)، وإلى حد أقل في الهدفين 18 (التسليم بالمعرفة التقليدية) و19 (تحسين مبدأ تبادل المعرفة حول التنوع البيولوجي).

وبالنظر إلى المستقبل، فإنه يبدو جليّاً أن تحقيق معظم أهداف أيشي للتنوع البيولوجي يتطلّب تنفيذ حزمة من الإجراءات والتي تتضمّن الأطر القانونية والسياسية والمؤسساتية المتعارف عليها عبر الوزارات الحكومية، ويتطلب أيضاً تعميم التنوع البيولوجي على القطاعات المُنتِجة مثل: الزراعة والثروة السمكية والسياحة والغابات.

1. ملخص تنفيذي

1نشرة التوقعات للتنوع الإحيائي - الإصدار الرابع، تُقدّم المراجعة النصف سنوية للخطة الاستراتيجية للتنوع البيولوجي للفترة 2011 – 2020 تقييم عالمي لسير العمل نحو تحقيق أهداف الخطة للتنوع البيولوجي العالمي المرتبطة مع أهداف أيشي العشرين للتنوع البيولوجي، ولكنها تتضمن معلومات إقليمية محدودة. ويستند هذا التقرير على التقييم العالمي لنشرة التوقعات للتنوع البيولوجي العالمي - الإصدار الرابع ويتممه، وهذا التقرير هو النسخة الثانية من تقرير وضع التنوع البيولوجي في أمريكا اللاتينية ومنطقة الكاريبي، حيث يُعتَبر بمثابة مراجعة نصف سنوية لتقدّم سير العمل نحو الخطة الاستراتيجية للتنوع البيولوجي 2011 – 2020 في أمريكا اللاتينية ومنطقة الكاريبي.

إن العبر الرئيسية المستوحاة حول وضع التنوع البيولوجي في أمريكا اللاتينية ومنطقة الكاريبي والضغوطات التي يتعرض لها والمستخلصة من هذا التقييم هي:

- الانخفاض في وفرة الأنواع وازدياد خطر انقراضها بشكل كبير.
- إن معدل خسارة الموائل الطبيعية في أمريكا اللاتينية ومنطقة الكاريبي قد انخفضت حدته ولكنه ما زال مرتفعاً.
- تؤثر الضغوط المعينة المرتبطة بالنمو الاقتصادي السريع والظلم الاجتماعي على الموارد الطبيعية للمنطقة.
- استمرار التوسع الزراعي وتكثيف الجهود من أجل زيادة أعداد المواشي والأراضي الصالحة للزراعة وإنتاج السلع.
- تخضع المنطقة لتطوير البنى التحتية الرئيسية من سدود وطرقات.
- إن آثار الازدياد السكاني الكبير على التنوع البيولوجي في المناطق المدنية ذات حدة شديدة في هذه المنطقة.
- تعتمد اقتصاديات الدولة في هذه المنطقة بشكل شامل على الموارد الطبيعية.
- إن استخراج الموارد من أجل الحصول على المعادن والنفط والغاز قد أدى في بعض الحالات إلى آثار محلية مدمرة مباشرة وغير مباشرة على التنوع البيولوجي مثل: إزالة الغطاء النباتي وتلوث الماء والتربة.
- في الوقت الراهن تم اعتبار تلوث الهواء المحلي والعابر للحدود على أنه عامل بيئي مضر بالصحة البشرية في المنطقة.
- إن الآثار الناجمة عن التغير المناخي والتي تؤثر على الشعاب المرجانية والموائل الجبلية في المنطقة قد تم ملاحظتها وأخذها بعين الاعتبار.

يعتمد هذا التقرير على مجموعة من المؤشرات الإقليمية وعلى المعلومات الواردة في التقارير الوطنية الخامسة حول الاتفاقية المتعلقة بالتنوع البيولوجي (CBD) والتقارير الحكومية الأخرى والحالات القيد الدراسة والكتابات المنشورة، وذلك بُغية تأمين مراجعة لكل هدف على حدى لتقدّم سير العمل نحو تحقيق أهداف أيشي العشرين للتنوع البيولوجي. ولقد تمّ قدر المستطاع تقسيم المؤشرات العالمية لأهداف أيشي إلى المستوى الإقليمي، كما تمّ إجراء بعض التحليلات الإضافية للمعلومات العالمية المتاحة مع مؤسسات وطنية رئيسية في المنطقة. ومع ذلك، فإن محدودية البيانات تعني أنه قد تم تضمين بعض من مجموعات البيانات، والتي لا تتعدّى سنة 2011 الماضية، وذلك من أجل تبيان أن المعلومات ذات الصلة موجودة ولكنها بحاجة إلى جهود إضافية لتحديثها.

إن تتبّع تقدم سير الأعمال الإقليميي يساعد على تحديد المواضع التي تحتاج أكثر من غيرها إلى جهود إقليمية ووطنية إضافية لتعزيز وتسريع تقدم سير العمل نحو تحقيق أهداف أيشي للتنوع البيولوجي. إن الاستجابة للفرص والتحديات تتطلب جهوداً جماعية، لذا فقد تم إعداد هذا التقرير للمساعدة في تأمين المعلومات للنقاش الإقليمي والوطني الدائر بين الحكومات والأطراف ذات المصلحة في جميع أنحاء أمريكا اللاتينية ومنطقة الكاريبي، وأيضاً لتشجيع التعاون والعمل المشترك وبالأخص عبر الأطر الرسمية والسياسية على مستويات مختلفة.

1. 执行摘要

第四版《全球生物多样性展望》是对执行《2011-2020年生物多样性战略计划》所取得进展的中期评估，提供了对实现该计划中的全球生物多样性目标和与之相关的“爱知生物多样性目标”所取得进展的全球评估，但包含的区域信息有限。本报告建立在全球第四版《全球生物多样性展望》评估的基础之上，并对其进行了补充。这是第二版《拉丁美洲和加勒比地区生物多样性状况》报告，也是对实现拉丁美洲和加勒比地区的《2011-2020年生物多样性战略计划》目标所取得进展的中期评估。

本报告借鉴了来自《生物多样性公约》（CBD）第五次国家报告、其他国家和区域报告、案例研究和已发表文献的一套区域指标和信息，逐个审查了实现20个“爱知生物多样性目标”取得的进展。本报告尽可能地把“爱知生物多样性目标”的全球性指标分解到区域层面，并与区域的主要国家机构一起对现有的全球信息进行了一些额外分析。然而，数据的局限性意味着为了说明相关信息的存在，已将2011年以前的某些数据集列入报告，但更新此类信息还需进一步努力。

跟踪区域进展有助于确定为促进并加速“爱知生物多样性目标”的实现而最需要区域和国家付出努力的方面。应对机遇和挑战需要协同努力，而编制本报告有助于为拉丁美洲和加勒比地区各国政府和众多利益相关方的区域对话提供依据，特别是通过不同规模的法律和政策框架促进合作和行动。

本次评估得出的有关拉丁美洲和加勒比地区的生物多样性状况及其所面临压力的关键信息是：

- 物种丰富度持续下降，物种灭绝的高风险继续增加。
- 在拉丁美洲和加勒比地区，栖息地丧失的速度已经放缓，但丧失的数量仍然很大。
- 与经济快速增长和社会不平等有关的某些压力正在影响该地区的自然资源。
- 农业扩张和增加家畜、耕地和商品生产的集约化仍在继续。
- 该地区正在修建大坝和公路等重要基础设施。
- 该地区密集的城镇人口对生物多样性的影响尤为显著。
- 该区域内的国家经济体全面依赖自然资源。
- 在某些情况下，为提取矿物和碳氢化合物而进行的资源开采对该地区的生物多样性造成了毁灭性的直接和间接影响，例如植被丧失、水污染和土壤污染。
- 跨境空气污染和本地空气污染目前被公认为该地区影响人类健康的环境因素。
- 人们现在正观察到气候变化对该区域内的珊瑚礁和山地栖息地产生的影响。

尽管如此，本报告梳理出了一些自2010年以来已经采取的重要对策：

- 该地区已经实施了一系列低碳可持续发展的方法（目标3、5、1、15）。
- 区域继续努力控制野生动物的非法贸易（目标4）。
- 保护区覆盖面积近年来显著扩大，包括政府管理的、社区管理的和私人管理的保护区（目标11）。
- 区域为保护迁徙物种提供的支持有所增加（目标12）。
- 目标物种管理和恢复方案的实施产生了一些成功案例（目标12）。
- 可持续的融资机制有所改善，但近年来面临着挫折（目标20）。

在考虑了对全球数据集（主要来自于生物多样性指标伙伴，BIP）进行的区域分析，并对CBD的第五次国家报告和相关文献进行了分析的基础上，开发了实现每一个“爱知生物多样性目标”所取得的进展仪表板。

在拉丁美洲和加勒比地区，实现“爱知生物多样性目标”的总体进展情况和全球的情况类似。然而，在拉丁美洲和加勒比地区，一些国家缺乏围绕着实现具体目标取得进展的信息和报告，还有一些些国家报告说它们目前没有步入实现特定目标的正轨。该地区最积极的趋势出现在目标11（保护区）和目标17（通过和实施政策工具）中，并在较小范围出现在了目标18（传统知识的确认）和目标19（改进的生物多样性信息共享）中。

展望未来，实现大部分“爱知生物多样性目标”显然将需要实施一揽子行动，包括在各政府部门的协调一致的法律、政策和制度性框架、并使生物多样性被生产部门，如农业、渔业、旅游业和林业的多数人所接受。此外，必须采取行动确定适用的使所有利益相关方参与的社会经济激励，以及普遍加强监督和执法。最后，重要的是要采取措施鼓励其他行动者、地方政府、私营部门、土著居民和当地社区、民间团体和社会运动的积极参与，并根据各国国情鼓励社会组织的新形式。

建议采取的短期和长期行动包括：

- 使生物多样性被各政府部门和生产部门（如农业、渔业、旅游业和林业）的多数人接受。
- 使生物多样性成为商业行为的主流。
- 建立森林碳储量合作伙伴关系。
- 在该地区分享关于水支付方案的专业知识。
- 可持续地开发该区域的水资源。
- 在沿海国家把旅游和发展计划联系起来。
- 对提高公众对生物多样性价值的认识进行投资。
- 加强保护区网络和生物走廊的有效性。
- 加强与生物多样性有关公约的执行，以建设制度能力。
- 加强环境法律和政策的监管和执法。
- 增加可用的生物多样性资源。
- 加强多部门协调。
- 利用地区和国家数据集，促进适当数据的收集以衡量该地区实现“爱知生物多样性目”标取得的进展。
- 促进南南合作和三方合作。

2. KEY MESSAGES ABOUT THE STATE OF BIODIVERSITY IN LATIN AMERICA AND THE CARIBBEAN

This report presents a mid-term review of progress towards the implementation of the *Strategic Plan for Biodiversity 2011-2020* and the achievement of the Aichi Biodiversity Targets by countries in the Latin America and the Caribbean region, as defined by UNEP Live (UNEP 2016c). It builds on and complements the assessment undertaken in the fourth edition of the Global Biodiversity Outlook (GBO-4) (SCBD 2014). For this report the UNEP definition of the Latin America and Caribbean (LAC) region (Figure 1) is applied, which includes 33 countries in four sub-regions: Mesoamerica, the Caribbean, the Andean region and the Southern Cone (UNEP 2016b).

For many of the analyses, global datasets and indicators brought together by the Biodiversity Indicators Partnership (BIP) have been disaggregated to the regional or national scale and used to illustrate status and trends in the LAC region. Where post-2010 data are lacking, the most recent data have been used, generally ending in the 2008-2009 period. Where data are available after 2010, these provide a better representation of progress towards the 2020 end point for the Aichi Biodiversity Targets.

This report also synthesises the national information contained in the fifth national reports from countries in the Latin America and the Caribbean region that were submitted to the Convention on Biological Diversity by November 2015 (CBD 2015). It uses case study material derived from these reports to illustrate progress towards specific Aichi Biodiversity Targets in different countries. Other case studies, used to further enrich the text, are based on the work of UNEP and other regionally and nationally based organisations such as the 'Comisión Nacional para el Conocimiento y Uso de la Biodiversidad' (National Commission for the Knowledge and Use of Biodiversity, CONABIO) in Mexico, the Caribbean Natural Resources Institute (CANARI) and Fundação Oswaldo Cruz from Brazil.

The report recognises that Latin America and the Caribbean is large and diverse politically, geographically, economically and in terms of biodiversity. Information is summarised in a balanced way, and highlights the main trends in the region, but also uses examples that illustrate the variation in habitats, ecosystems and demographic characteristics of different countries and areas.

The following section presents summary messages for policy makers, arranged under the broad headings of the state of biodiversity, pressures on biodiversity and societal responses to the crisis of biodiversity loss.

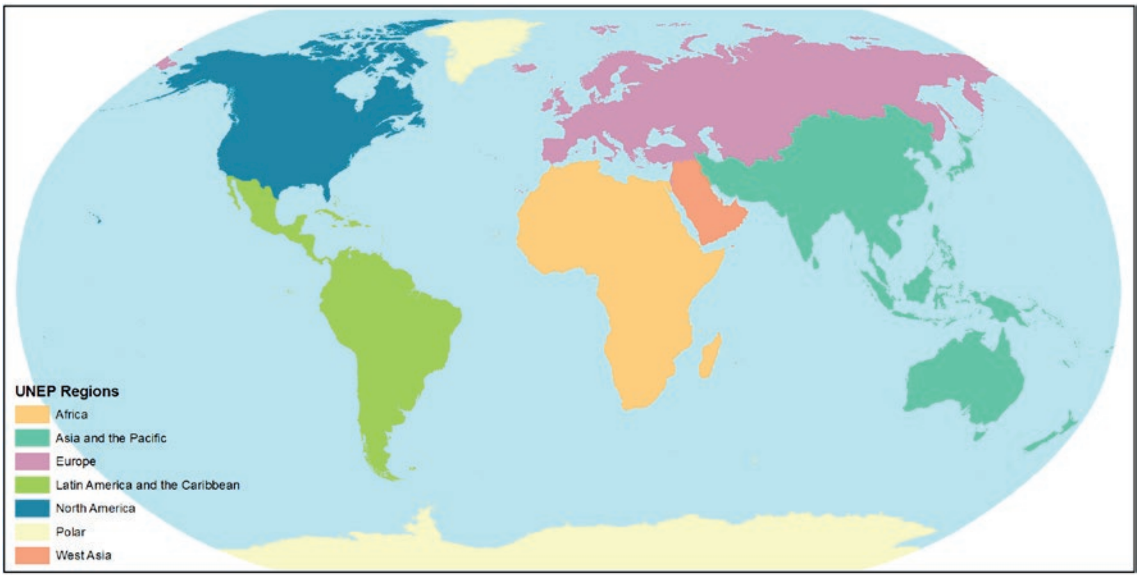

Figure 1: Global distribution of UNEP regions showing the location of the LAC region in bright green (map produced by UNEP-WCMC using data from Brooks et al. 2016).

STATE

Rates of habitat loss in Latin America and the Caribbean have slowed but remain high

Latin America and the Caribbean (LAC) currently retains much of its biodiversity. Six of the world's most biodiverse countries are within this region; Brazil, Colombia, Ecuador, Mexico, Peru and Venezuela. It is also home to the world's most biodiverse habitat, the Amazon rainforest (UNEP 2012). Over 40 per cent of the Earth's biodiversity is held within the South American continent, as well as over a quarter of its forests (UNEP 2010). Tropical forests, savannahs, grasslands and xeric communities originally covered vast areas of the LAC region (Olson et al. 2001), but there has been considerable loss of some habitats. Habitat loss due to agriculture and pasture for livestock is the most important threat to biodiversity in the region, and even though the rate of loss has decreased during the past decade, the total area transformed per year remains high (Aguiar et al. 2016).

Forest loss is continuing globally, however rates of forest loss for some countries in the LAC region are declining; Peru currently has the lowest national loss rate (0.08 per cent/year) within the three regions evaluated by Han et al. (2014) (the Tropical Andes, the African Great Lakes and the Greater Mekong) and rates of forest loss in Brazil have also declined significantly. In other areas of the region, forest cover is declining more rapidly, and forest habitats and natural savannahs have particularly seen an increase in loss rates in recent years (García et al. 2014).

The Atlantic coastal forest ecosystems of tropical South America are highly diverse; they hold around 20,000 plant species, of which 40 per cent are endemic, as well as around 24 critically endangered vertebrate species and almost 950 bird species (CEPF 2004). However, this region is fast becoming deforested due to the growth in plantations, such as sugarcane and coffee, with only 10 per cent of the forest remaining. The forest of Central America are also highly diverse, especially within the Mesoamerican hotspot which covers parts of Mexico, Panama and all of Costa Rica, Belize, El Salvador, Guatemala, Honduras and Nicaragua (CEPF 2004). These forests have lost more than 70 per cent of their original area. In the Andes region, the *Polylepis* forests that are confined to the high altitude Andean habitats are also a highly diverse ecosystem, holding some of the most threatened Neotropical vegetation and biodiversity on Earth (Kessler 1995; Jameson and Ramsay 2007; Gareca et al. 2010a; Gareca et al. 2010b).

Twelve per cent (22,000 km^2) of the world's mangrove forests are found in the Caribbean (Spalding et al. 2010). Extensive mangrove forests are also found on the Pacific and Atlantic coasts of Latin America, including mangrove ecoregions extending 3,400 km^2 between Ecuador and Peru, 2,500 km^2 in northern Colombia, and 2,200 km^2 in north-western Venezuela (WWF 2016b). Some datasets suggest that mangrove extent had been in decline in many countries in the LAC region in the past decades (Valiela et al. 2001). However, more recent datasets point out that mangrove extent has increased in some parts of the region in recent years after extensive earlier declines (FAO, 2015c). The Atlantic and Pacific coasts of Central America are particular areas of concern, with as many as 40 per cent of the mangroves species present listed on the IUCN Red List as 'threatened with extinction' (Polidoro et al. 2010).

Latin America and the Caribbean is the wettest continent on Earth, and contains the world's most extensive wetlands (e.g. the Pantanal in Brazil), with wetlands accounting for around 20 per cent of its area (Wittmann et al. 2015). These wetlands are some of the most biologically diverse on Earth, home to endemic species and essential for providing water-related ecosystem services: clean drinking water; water for the agricultural and energy sectors; flood regulation; erosion control; sediment transport and storm protection. Wetland habitats also have an important role in sustaining cultural practices (Finlayson and Van der Valk 1995).

The LAC region also supports large areas of temperate grasslands. The Rio de la Plata grasslands are the largest complex of temperate grasslands ecosystems in South America, covering approximately 750,000 km^2 within the Pampas of Argentina and the Campos of Uruguay, northeastern Argentina and southern Brazil. The highest rates of endemism in the grasslands of the region are found in the *páramo* and *puna* systems, covering the upper parts of the tropical Andes from southern Venezuela to northern Peru CEPF 2015; WWF 2016a). The Patagonian steppes occupy a vast area in the southern tip of the continent, covering more than 800,000 km^2 of Chile and Argentina (Michelson 2008).

In the marine realm, the coral reefs of the Caribbean are diverse and important on the global scale: 10 per cent (26,000 km^2) of the world's coral reefs are found in the western Atlantic Ocean, primarily in the Caribbean, and 90 per cent of the species there are endemic to the region (Burke et al. 2011). However, they are being damaged by sea temperature rise and the combined effects of sediment run off, alien species, human population increase, land-based pollution and destructive unsustainable fishing practices (Mumby et al. 2014b; Jackson et al. 2014). Changes in the health and distribution of coral reefs in the LAC region are most noticeable in the Caribbean, where average coral cover declined from 34.8 per cent in 1970 to 16.3 per cent in 2011 for 88 sample points, with the greatest changes overall occurring between 1984 and 1998 (Jackson et al. 2014).

Biodiversity declines continue

The LAC region as a whole presents a rising trend in all major pressures on biodiversity: land degradation and land use change; climate change; land-based pollution; unsustainable use of natural resources and invasive alien species (UNEP 2010). Regional biodiversity declines are most dramatic in the tropics. A recent analysis by Brooks et al. (2016), using the UNEP regional and sub-regional classification as employed in this report and the IUCN global red list database, found that 13,835 species occur within the LAC region, and that 12 per cent of these are threatened with extinction. At the more local scale, within the Tropical Andes sub-region, encompassing the eastern slope of the Andes and containing eight watersheds of headwater rivers across Venezuela, Colombia, Ecuador, Bolivia and Peru, Han et al. (2014), found high species extinction risk when compared to the baseline Red List Index for all regional taxa (0.89). In addition, in Mexico, a megadiverse country, at least 127 plants and animals have gone extinct (Sarukhán et al. 2015). Numerous threatened species have also been assessed in Colombia, but these are not yet in the global IUCN red list database. This illustrates the high pressure on endemic and threatened species in this highly diverse region, and the importance of recording and documenting these trends.

Across the planet, the tropical Living Planet Index (LPI) shows a 56 per cent decrease across 3,811 populations of more than 1,000 different species (WWF 2014). This same report, using a weighted index, estimated a reduction of 83 per cent in populations in the Neotropical realm between 1970 and 2010. The main factors causing this decline were identified as pollution, invasive alien species, habitat loss and climate change (WWF 2014).

PRESSURES

Rapid economic growth and social inequity have created certain associated pressures on the region's natural resources

The natural resources of the LAC region are facing a number of pressures, often associated with economic growth of countries such as Brazil, Chile, Colombia and Panama, which are among the most rapidly developing countries on Earth (Magrin et al. 2014). As a result, urban development and economic growth, together with social and economic inequity, threaten the region's biodiversity in many areas (Pauchard and Barbosa 2013). Correlations have been found between poverty and biodiversity decline in tropical regions (WWF 2014), and in the LAC region, over 25 per cent of the urban population lives in extreme poverty, with the richest 20 per cent earning 20 times more than the poorest 20 per cent (UN-HABITAT 2012).

Agricultural intensification and expansion of arable land for commodity production continues

Latin America has seen rapid agricultural growth in recent decades and these trends look set to continue. LAC is regarded as second only to sub-Saharan Africa in terms of the potential for further arable expansion (Lambin et al. 2013), and despite droughts and water scarcity in some parts, it also holds the highest share of global renewable water resources (UNEP 2010). Growth in sugarcane and coffee plantations as well as expansion of livestock production continues, often leading to deforestation, fragmentation, and overgrazing of the converted pasturelands (Michelson 2008). In particular, the Atlantic coastal forests, as well as tropical savannahs, for example in the Cerrado, are the most rapidly changing biomes in the region, threatened by advancing agricultural frontiers and rapidly growing cattle production (Magrin et al. 2014). This expansion and intensification of agriculture and pastureland is resulting in the decline in area and quality of habitats and associated pollution of water courses and loss of biodiversity. Small scale agriculture expansion is also affecting natural habitats in other regions, including in the biodiversity hotspots of the Andes and Mesoamerica, with evidence of agriculture moving into protected areas (PAs) in some places (CEPD 2015; CPEF 2005).

The region is undergoing major infrastructure development

The region contains one of the world's most biodiverse river basins, the Amazon, which is undergoing major infrastructure development with 416 dams operational or under construction, and a further 334 dams planned or proposed (Winemiller et al. 2015). Within the LAC region, Brazil, Chile and Ecuador are the countries with the highest density of new dam projects being developed in the past decade (Kereiva 2012). New road expansion, into areas of the Amazon that previously remained a wilderness, is driven by the development of infrastructure for trade and transportation, as well as the search for valuable materials, including timber, minerals and oil, for extraction. The development of roads into wilderness areas is known to be a major driver of environmental degradation, including loss and fragmentation of habitats, and an increase in wildfires (Laurance et al. 2014).

Other major pressures on habitats in the region include land cover change (forest and savannah conversion to large scale agriculture) (Piquer-Rodríguez 2015), land-based pollution and sediment runoff from industrial agriculture and cities into major water courses and ultimately the ocean, infill of wetlands for urbanisation, and logging of high value timber species (Pauchard and Barbosa 2013). Underlying some of these pressures is an expanding human population and the development of an export economy providing agricultural, livestock, timber and mineral products to other parts of the world (UNEP 2010).

High concentrations of population in urban areas continue to impact biodiversity

The LAC region has an estimated 640 million people, with around 38 million living on the Caribbean islands and the rest on the mainland, with an annual growth rate for the region of around 1.15 per cent (Pauchard and Barbosa 2013). Over 75 per cent of LAC's population is found in cities, the highest proportion anywhere on Earth (World Bank 2016), and the impacts of urbanisation on biodiversity are especially significant due to the high proportion of cities located in or around areas with high species richness and/or endemism (Liu et al. 2003).

On the mainland, around 80 per cent of the population lives in urban areas (UNEP 2012). This includes 62 cities with more than a million inhabitants, and two megacities – Mexico City and Sao Paulo – with around 20 million people each. Central Chile has the highest national population density and agricultural expansion within the region (Tognelli et al 2008; Patricio and Fuentes-Castillo 2011; Duran et al. 2013). On Latin American and Caribbean islands, over 65 per cent of the population lives in towns. Around 30 per cent of the population lives in coastal areas in countries such as El Salvador, Ecuador, Costa Rica, Nicaragua and Panama (Magrin et al. 2014) (Figure 2).

Although population growth continues in the region, the growth rate on the mainland has slowed in recent years, and the population is expected to stabilize at 800 million people by 2050 (World Bank 2016). However, some of the small islands and Island Nations in the Caribbean are experiencing high rates of population growth and increased economic activity, which can cause strains on the natural resource management of these areas (CEPF 2011).

Alongside this increase in urbanisation, linguistic diversity has been declining steeply across the LAC region since the 1970s (Loh and Harmon 2014), indicating an accompanying loss of the traditional knowledge that would have been passed down the generations orally in the mother tongue (Larsen et al. 2012).

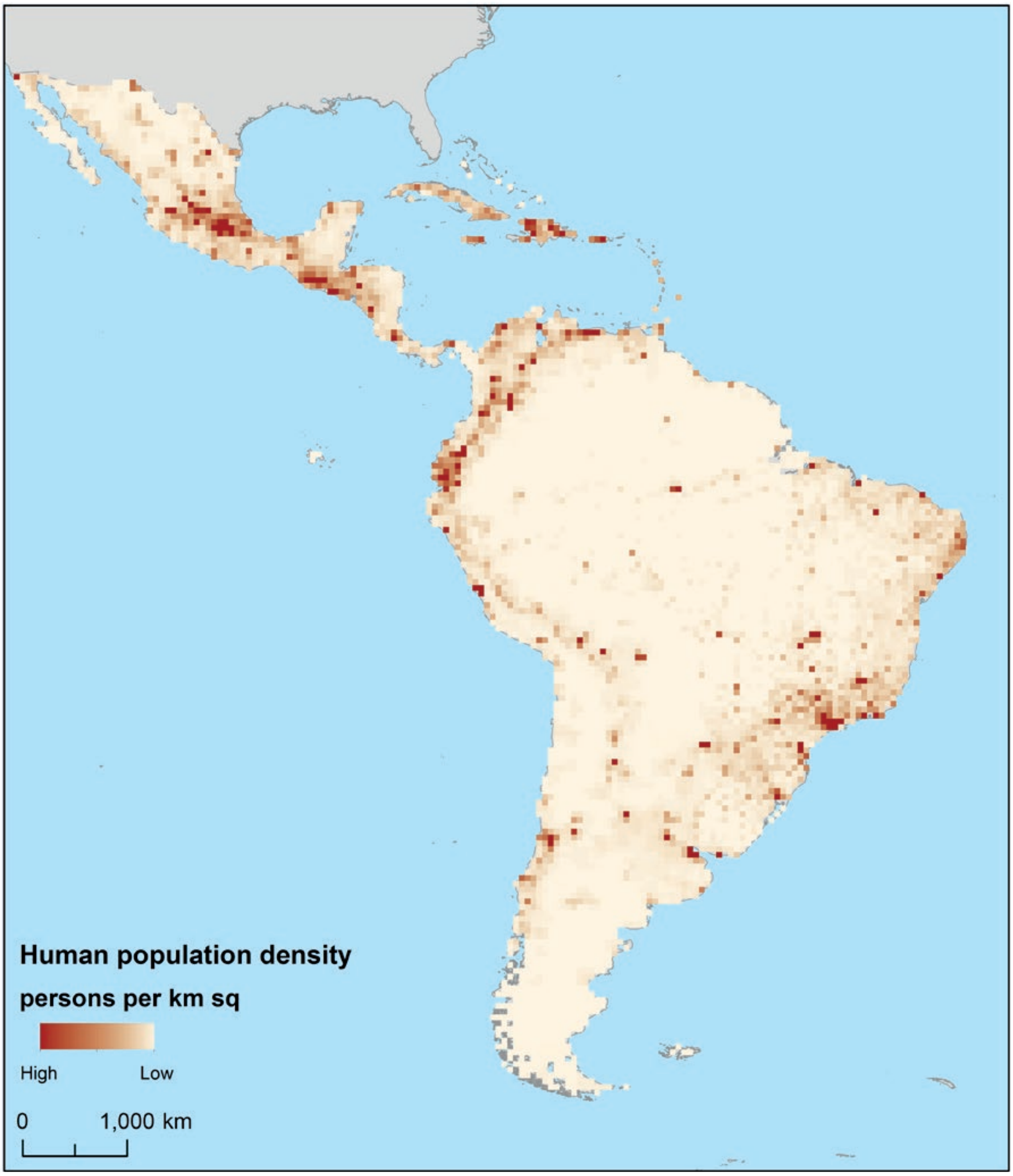

Figure 2: Human population density in the Latin America and Caribbean region (map produced by UNEP-WCMC using data from WorldPop 2010).

Country economies within the region are very highly dependent on their natural resources

Countries in the LAC region are dependent on natural resources to provide the basis of much of their economies, with significant resources being obtained from natural habitats (Magrin et al. 2014). For example, hydropower accounts for over two-thirds of Brazil's energy supply, and this will increase as new dams have been proposed in the Amazon basin (Zarfl et al. 2015). Oil extraction is also helping the development of many countries in the region. In the past decade, Ecuador's economy has grown to become the seventh largest on the South American continent, partly due to the government's policies and investment in natural resources, but also due to the country's large oil reserves (World Finance 2012).

Logging is also a major industry in the LAC region (Finer et al. 2014), exploiting the large timber resources, especially those with a high value on the global market. For example, Big Leaf Mahogany or Brazilian Mahogany (*Swietenia macrophylla)* faces severe threats, with a population reduction of over 70 per cent since 1950 in El Salvador, Costa Rica and other tropical forest areas such as Mato Grosso in Brazil and Beni in Bolivia; deforestation has reduced the species' range by over 60 per cent in Central America and 20 per cent in South America (WWF 2015). The region's forests also provide clear socio-economic benefits, both in terms of consumption and production (Table 1).

Table 1. Summary of socio-economic benefits received from forests in 2011 in the LAC region (FAO 2014).

PRODUCTION BENEFITS	LAC	WORLD
Income generation (billion USD)		
All formal sector activities	49.4	606.0
All informal sector activities	9.0	33.3
Medicinal plants	NA	0.7
Plant-based NWFPS(*)	3.0	76.8
Animal-based NFWPS	0.6	10.5
Payments for ecosystem services (PES)	0.2	2.4
Total (as % of GDP)	62.2 (1.2)	729.6 (1.1)
Consumption benefits (billion USD)		
Total food supply from forests	15.7	16.5
Energy supply (forests and forest process)	108.8	772.4
Human benefits (millions of people)		
Use of wood-fuel to boil and sterilize water	38.6	765.0
Use of forest products for house walls	68.5	1,026.1
Use of forest products for house floors	25.3	268.3
Use of forest products for house roofs	43.6	481.8
Number of people using charcoal to cook	5.4	169.1
Energy supply (forests and forest process)	108.8	772.4

(*) Non wood forest products.

Throughout the region, tourism and eco-tourism in particular are of considerable importance to national and local economies. Latin America and the Caribbean offer a wide range of ecotourism activities and wilderness areas, such as coastal tourism and tropical forest activities in Central America, biodiversity-related tourism in the Amazon Basin, cultural tourism in the Andes and adventure tourism in Patagonia. Although there is a lack of quantitative evidence to assess the profitability of the tourism sector, Kirkby et al. (2011) estimated that the annual revenue flow from ecotourism to developing countries globally could be as high as USD 29 billion, and in areas of the LAC region such as the Tambopata province (Peruvian Amazon) ecotourism was responsible for USD 11.6 million in spending in 2005. The LAC region benefits greatly from its protected area network and national parks; Balmford et al. (2015) estimated 4,000 visits per year (median rate averaged over countries) per protected area. However, these average figures mask the fact that many reserves receive no tourists and have no management plans in place, which is a significant challenge for their sustainable management (Guerrero and Sguerra 2009).

In Central American and Caribbean countries, eco-tourism benefits are largely linked to marine and coastal ecosystems, with a significant eco-tourism industry in the Caribbean islands focussing on diving, snorkelling, and additional Caribbean cruise tourism (Wood 2000). The Florida-Caribbean Cruise Association (2013) highlighted the success of this industry in the Caribbean, ranked as the dominant cruise destination and accounting for 37.3 per cent of all global itineraries in 2013.

The region has 134 properties inscribed in the World Heritage List, of which 36 are UNESCO Natural World Heritage sites, 93 are Cultural Heritage sites, most in historical centres, and five are mixed properties recognized for the outstanding value and contribution to the local economy (UNESCO 2016). In the Andes region, the impact from tourism in coastal areas of Patagonia is also high, particularly in the UNESCO World Heritage site, Valdés Peninsula, and its biggest city, Puerto Madryn (Schlüter 2001).

Finally, although the mining industry is severely detrimental to many natural habitats in the region, it can also provide benefits in terms of socio-economic development. In Chile, the mining sector provides 12 per cent of gross domestic product (GDP) and contributes to 60 per cent of the country's total exports. Renewable natural resources such as from the forestry, aquaculture and tourism sectors also contribute to GDP (around 10 per cent) and provide an estimated 1 million jobs (Banco Central del Chile, 2015).

Resource extraction for minerals and hydrocarbons has led, in some cases, to locally devastating direct and indirect impacts on biodiversity

Mining and oil and gas production can create significant pollution that affects biodiversity (Bebbington and Bury 2013). Almost all countries in the region have small-scale mining activities, which extract minerals such as gold, copper, silver and zinc (Finer et al. 2008; Veiga 2002). The LAC region currently provides 45 per cent of global copper production and 50 per cent of global silver production, attracting 25 per cent of global investments in mining (UNEP 2016a). Impacts on biodiversity and habitats from mining activities range from direct impacts, such as removal of vegetation, to indirect but equally devastating impacts, such as acid drainage, high metal concentrations in rivers and soil pollution, which in turn affects species structure and composition (Miranda et al. 2003). Mining activities and industrial accidents can have devastating effects on habitats; since November 2015, Brazil has been facing the consequences of a serious environmental disaster that took place in the State of Minas Gerais (Southeast region). The disruption of two dams of the Samarco mining company released a torrent of mud that caused great destruction in the district of Mariana, with waves of sludge carrying pollutants such as silica and iron traveling up to 850 km, and affecting the coast of the Espirito Santo district of Brazil (Generation Transition 2015).

In the past decade, large reserves of oil and gas have been discovered in the region, with the extraction of oil from the interior of the Amazon basin posing particular environmental challenges and regularly resulting in pollution events (Finer et al. 2013; Mulligan et al. 2013). The western Amazon continues to be a hotspot for hydrocarbon exploration and production (Finer et al. 2015; Finer et al. 2013), and international bids to develop new oil and gas blocks in Colombia, Ecuador and Peru demonstrate the region's continued interest in exploration activities which expand deeper into some of the world's most biodiverse habitats, putting ecosystems at risk of industrial accidents and pollution. In the Loreto region of Brazil, all three active oil producing blocks have had recent major leaks and spills, and evidence of contamination in many mining sites throughout the Amazon has been found, with toxic production waters dumped into local waterways for decades before indigenous communities forced the practice to be halted in 2009 (Finer et al. 2013).

Natural habitats are being affected by mining activity, with illegal gold mining being a particular threat to biodiversity in many countries. Across the tropical moist forests of South America, around 1,680 km2 habitat was lost due to mining between 2001 and 2013 (Alvarez-Berríos and Aide 2015). Forest loss was concentrated in four major biodiversity hotpots: the Guianan moist forest ecoregion (41 per cent), Southwest Amazon moist forest ecoregion (28 per cent), Tapajós–Xingú moist forest ecoregion (11 per cent), and the Magdalena Valley montane forest and Magdalena–Urabá moist forest ecoregions (9 per cent) (Alvarez-Berríos and Aide 2015).

Another example is the challenge of overlapping mining concessions and designated Natural Protected Areas, put in place to conserve ecosystems and habitats. Even before extraction takes place, seismic lines, straight paths of one to 12 metres wide, are cleared of vegetation and used for surveying during exploration for fossil fuels. These are thought to be the most significant driver of habitat fragmentation caused by the petroleum sector, with examples of more than 104,000 km seismic lines cut in the Peruvian Amazon between 1970 and 2010 (Harfoot et al. 2016).

Transboundary and local air pollution is recognised as an environmental factor in human health in the region

Recent reports from the Global Monitoring Plan of the Stockholm Convention help to better understand and address transboundary pollution and impacts from intercontinental transport of dust, such as African dust clouds (UNEP 2016a). In Trinidad, links between African dust clouds and childhood asthma have already been documented (Gyan et al 2005). In addition to consequences for human health, Saharan dust has a range of impacts on ecosystems downwind, and an estimated 40 million tonnes of dust are delivered to the Amazon River Basin every year (UNEP 2016a). Another source of air pollution is indoor air pollution caused by the burning of solid fossil fuels. In the LAC region, typical levels of PM10 (particulate matter 10 micrometres or less in diameter) in homes which use biomass for fuel are 300-3,000 mg/m^3, and can be as high as 10,000 mg/m^3 during cooking times (UNEP 2016a). The US Environment Protection Agency (EPA) standard for annual mean PM10 levels in outdoor areas is 50 mg/m^3.

Within the LAC region, Santiago de Chile (Chile) is one of the cities most affected by air pollution and smog due to a combination of its geographic location within a high Andean valley and its topographic and meteorological patterns which restrict ventilation and dispersion of pollutants (Molina and Molina 2004). Various studies have found links between presence of particulate matter (PM) and premature mortality amongst the population (Sanhuenza et al. 1991; Cifuentes et al. 2000; Ochoa-Acuña and Roberts 2003). The growing economy and urban expansion within the city and the high density of diesel fuelled vehicles means air pollution levels are still very high (Molina and Molina 2004).

Finally, population growth and its associated effects on pollution remains another major risk in the region. For example the clearance of vegetation for infrastructure development on hillsides during construction of informal settlements causes pollution and run-off, affecting ground water and aquifers (Miller and Spoolman 2013).

Climate change induced impacts on coral reefs and montane habitats within the region are intensifying

The consequences of rising ocean temperatures and ocean acidification, caused by climate change, pose a serious threat to coral reefs, their biodiversity and the people who depend on them (Burke et al. 2011). Bleaching events and a higher incidence of disease in corals across the Caribbean have been observed. The IPCC reported a warming of the upper layer of the ocean of 0.11 °C per decade globally (Stocker et al. 2013). Both of these climate change impacts can slow down coral growth as well as cause damage to existing corals by reducing their ability to produce calcium carbonate skeletons. Higher temperatures are linked to an increased frequency of coral bleaching events, with mass coral bleaching events in 1998 and 2005 (Mumby et al. 2014b). In addition, an increase in hurricane frequency and intensity can cause severe damage to corals (IPCC 2013; Gardner et al. 2003). The impact still varies throughout the Caribbean, however, as temperature increases are not uniform, and some coral species appear to be better able to adapt to increasing temperatures than others (Gardner et al. 2003).

In addition to effects on coral reefs, other habitats and other biodiversity components in the LAC region are vulnerable to climate change. The melting of Andean glaciers and changes in rainfall patterns in the Amazon basin and surrounding areas may have massive effects on the region's ecosystems (Malhi et al. 2009; Betts et al. 2008), and also on local farming and agricultural practices which are key sources of income and food security for local communities. A study, which integrated historical and current biodiversity data at a coarse spatial resolution in Mexico, found that historical temperature change in the twentieth century had significant impacts on endemic avifaunal turnover (Peterson et al. 2015).

RESPONSES

Low carbon sustainable development approaches (Target 3, 5, 11, 15)

In recent years there has been a considerable growth in interest in developing payment for ecosystem service (PES) schemes to finance conservation (Pagiola et al. 2005), with initiatives underway or in development in many LAC countries. Costa Rica has been leading in the implementation of PES schemes in the LAC region, establishing the first nationalised PES programme in 1996 (the "*Pago por Servicios Ambientales*" programme operated by the National Fund for Forest Financing, FONAFIFO) (FONAFIFO 2000), and is seen globally as a pioneer of this type of programme. Four ecosystem services are explicitly recognised by the programme: capturing and storing atmospheric carbon, protecting water sources, conserving biodiversity and conserving scenic beauty (Porras et al. 2013). The scheme included measures for the protection of water for rural, urban and hydroelectric use; greenhouse gas mitigation; and biodiversity protection for conservation scientific and pharmaceutical uses (UNEP ROLAC 2012).

Nearly 45 per cent of the LAC region currently has forest cover (FAO 2010). However, significant threats to forests exist throughout the region due to factors such as agricultural and population expansion. PES mechanisms, such as REDD+, which is based on forest carbon, have the potential to conserve forests and provide opportunities for biodiversity conservation, amongst other social and environmental benefits. In some countries in the region considerable progress has been made on low carbon initiatives. There are numerous initiatives underway to create a financial value for the carbon stored in forests within the REDD+ framework, which offers incentives for developing countries to reduce emissions from deforestation and forest degradation, as well as to conserve forest carbon stocks, sustainably manage forests and enhance forest carbon stocks (Forest Carbon Partnership Facility 2015; the REDD desk 2016a; UN-REDD 2016).

Most other PES schemes in the region focus on water services. For example, in the Andes region of Chile, water payment schemes have been established using fog capture systems to help provide reliable water supplies to the drier lowland cities (Goldman et al. 2010). In Brazil, state governments such as São Paulo have established regulations for the payment for ecosystem services and have been implementing PES schemes relating to water and to the ecosystem services provided by Private Reserves of the Natural Heritage (RPPNs – Reservas Particulares do Patrimônio Natural) (UNEP ROLAC 2012). Mexico also created a Payment for Hydrological Environmental Services programme (Pago por Servicios Ambientales Hidrológicos, PSAH) in 2003, as a way to finance forest conservation which lies within hydrologically critical watersheds, using revenue from a water tax (The World Bank 2005).

Regional efforts continue to be made to control illegal trade in wildlife (Target 4)

Wildlife trade is the second biggest threat to species survival, after habitat destruction, around the world (WWF 2016c). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has been very active in the region in trying to control the causes of legal and illegal wildlife trade. CITES has certainly helped control the trade in wildlife but challenges remain. Over the past 10 years there has also been a major trade route from countries in the region to Mexico, and there are known illegal trade routes into the USA from Mexico (Defenders of Wildlife 2016), and into Europe mainly from the Central American sub-region (Engler and Parry-Jones 2007). Much of the illegal trade is in skins of reptiles and mammals, but there is also considerable trade in live birds, reptiles and other species. Illegal trade in species such as jaguar, sea cucumber, sea turtle eggs and shark fins continues in the region (Scherer 2015). Efforts are being made to control this illegal trade, mainly through enhanced enforcement of CITES regulations, and different initiatives that are aimed at building on the region's environmental rule of law, including building the capacities of prosecutors to address environmental crimes.

In addition to illegal wildlife trade of animal species, the illegal trade in timber is worth around 30 billion dollars per year globally (TRAFFIC 2016), with around 13 million ha of natural forest logged illegally every year (The Nature Conservancy 2016). In the LAC region illegal trade in timber and wood is widespread. Mexico's Ministry of Environment and Natural Resources estimated that over half of the country's industrial timber production was through illegal activity (WRI 2012). Considerable effort is being made to control the illegal trade in timber, with certification schemes helping to ensure that timber on global markets comes from well managed and sustainable sources. Illegal trade in animal species is also a major threat to biodiversity. In the Caribbean there is a high demand for wildlife to serve international markets in the United States, Europe and within the Caribbean islands. This includes species of parrot, macaws and spider monkeys which are sold as pets, as well as reptile meat from green and black iguanas (Humane Society International 2009).

Protected Area coverage has expanded significantly in recent years especially on government managed and community managed forest reserves (Target 11) Overall, good progress has been made towards the development of a network of reserves of different types that encompass the diversity of biomes, habitats and species (Butchart et al. 2015). The Andes is a particularly challenging region to develop protected area networks, simply because the biodiversity of this region is so high that many, often small, reserves are required to cover all species living here (Swenson et al. 2012).

Government managed protected areas have expanded significantly in the region over the past two decades (Figure 11.5) (UNEP-WCMC 2015) with 23 per cent of the region protected by 2010. In addition to government managed areas, there are also large numbers of community managed reserves and traditional lands that can provide effective protection to habitats and species (e.g. Ricketts et al. 2010). When comparing the effectiveness of different categories of protected areas in the Brazilian Amazon, "indigenous lands" was one of the most effective category for inhibiting deforestation (Soares-Filho et al. 2010), which is supported by a meta-analysis that found that in general "community managed forests presented lower and less variable annual deforestation rates than protected forests" (Porter-Bolland et al. 2012). A successful community forest example from Mexico shows how gains in social and economic justice stemming from Community Forest Enterprises (CFEs) can result in sustainable forest management practices and biodiversity protection (Bray et al. 2003). These CFEs use social capital and invest it to implement community timber management initiatives. In contrast, however, Vuohelainen et al. (2012) found in a similar study in Peru that "native community areas" were the least effective type of protected area for forests, suggesting that a mix of different management strategies is desirable.

In southern parts of the region private protected area networks have also developed, for example in Argentina, Brazil and Chile. In some LAC countries these privately owned protected areas benefit conservation activities, as they do not experience the same pressures or challenges faced by other forms of protected areas and can act as a beneficial supplement (not a substitute) for state owned protected areas in the region (Holmes 2013). The Brazil private reserve network is especially strong, with hundreds of Private Natural Heritage Reserves (RPPN) spanning over nearly 480,000 ha. These private protected areas serve to raise awareness within communities to realise the potential benefits of partaking in biodiversity conservation schemes within their property, and the Brazilian government is actively supporting the creation of more of these private reserves (ICMBio 2016; de Souza et al. 2015). Reviews of the effectiveness of protected areas in Mexico have found mixed results. Figueroa and Sánchez-Cordero (2008) found that over 54 per cent of Natural Protected Areas were effective, but that 23 per cent were regarded as not effective. Furthermore, Rayn and Sutherland (2011) found that the size and design of protected areas in Mexico was important, with the centre of large protected areas showing a lower rate of forest loss than elsewhere, although forest cover did decline both inside and outside the designated protected areas.

Within the Atlantic Forest biodiversity hotspot, Argentina, Brazil and Paraguay all contain both public and private protected areas. Both Argentina and Paraguay have more protected areas under private ownership according to Galindo-Leal and Camara (2003).

In Bolivia, detailed studies have looked at protected area impacts on levels of poverty in the surrounding communities (Canavire-Bacarreza and Hanauer 2012). This study found no evidence to suggest that the implementation of protected areas had any negative impacts on poverty levels in the affected communities but rather, that in general, such communities experienced poverty reduction.

Regional support for conserving migratory species has increased (Target 12)

Migratory species are an important element of biological diversity in the LAC region. As well as their intrinsic value, migratory species provide many benefits and services to people and ecosystems. Many are essential for subsistence and for the cultures of numerous human populations and they form the basis of activities of economic, cultural and social value. The Convention on Migratory Species (CMS) has the sole objective of conserving, protecting and ensuring sustainable use of terrestrial, aquatic and avian migratory species, and provides the means necessary to achieve this. Since its entry into force on 1 November 1983, the number of Parties to it has risen steadily and has now reached 122 countries from Africa, Latin America and the Caribbean, Asia, Europe and Oceania (with the accession of Brazil on 1st February 2015). Migratory species most in need of international cooperation or which could benefit greatly from such cooperation are listed on Appendix II of the Convention. CMS instruments have direct effects on local populations by promoting access to benefits arising from the use of natural resources.

Implementation of targeted species management programmes has resulted in several success stories (Target 12)

The region supports many iconic species, including many exotic and endemic species of birds such as parrots and parakeets which have become highly threatened due to over-collection in species trade and habitat loss. However, examples exist of some species being brought back from the brink of extinction due to targeted – species-specific – conservation programmes in the region, particularly in the Caribbean islands. These include the Echo Parakeet (*Psittacula eques*), the Imperial Amazon parrot (*Amazona imperialis*) and the Puerto Rican Amazon Parrot (*Amazona vittata*), the White-capped Tanager (*Loro orejimarillo*) or the Californian Condor (*Gymnogyps californianus*) (BirdLife International 2016a). Similar trade related issues have affected southern American camelid populations, for example the vicuña, and these have required targeted conservation interventions to reverse negative population trends such as the CONACS programme in Peru which implements "Módulos de Uso Sustentable de la Vicuña" (Modules for the Sustainable use of Vicuña) within community managed farmlands of up to 1,000 ha (Lichtenstein et al. 2002). Legislation in Mexico allows landowners and managers to benefit from the exploitation of wildlife as an incentive for the conservation of biodiversity while meeting the needs of local communities. This market-driven approach has proved popular, but in some cases has led to unintended and undesirable consequences (Sisk et al. 2007). Though challenges remain, Mexico also has successful examples of wildlife recovery for the bighorn sheep (*Ovis canadensis*), pronghorn (*Antilocapra americana*) and the Texas white-tailed deer (*Odocoileus virginianus texanus*).

As a national example of the development of targeted action plans – in December 2014, the Chico Mendes Institute for Biodiversity Conservation (ICMBio) finalised a national assessment of the risk of extinction of Brazilian fauna. In four years they evaluated 12,256 taxa of fauna, using the criteria of the IUCN, including all vertebrates described for the country (Nascimento and Campos 2011). A total of 8,924 vertebrate species were assessed, including 732 mammals, 1,980 birds, 732 reptiles, 973 amphibians and 4,507 fish. In addition, 3,332 invertebrates were evaluated, including crustaceans, molluscs, insects, porifera, and millipedes, among others. The results were used in the development of 54 National Action Plans for the conservation of threatened fauna or areas of occurrence of multiple endangered species. For plants, the Red Book of Brazilian Flora was published in 2013 by the Botanical Garden of Rio de Janeiro (Martinelli and Moraes, 2013) and the official list of endangered species, launched in 2014, includes 4,617 species of flora and 323 National Action Plans for plant conservation. The National Centre of Flora Conservation and the Biodiversity Portal by Brazil Ministry of the Environment provides online information (Centro Nacional de Conservação da Flora 2016; Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) 2016b).

Other countries in the region have also improved conservation efforts, achieving progress in promoting national biodiversity assessment. In 2010, Chile incorporated the IUCN criteria in national legislation, thus incorporating international standards for future assessments (Squeo et al. 2010). Similarly, as part of the National Environmental System, Colombia has enacted legislation that calls for the production of an annual report on the state of biodiversity.


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3. THE STRATEGIC PLAN FOR BIODIVERSITY 2011-2020 AND ITS REVIEW

The *Strategic Plan for Biodiversity 2011-2020* was adopted at the tenth meeting of the Conference of the Parties (COP-10) to the Convention on Biological Diversity (CBD) in Nagoya, Japan, in October 2010. The Strategic Plan is comprised of a shared vision, a mission, strategic goals and twenty ambitious yet achievable targets, collectively known as the Aichi Biodiversity Targets. It serves as a flexible framework for the establishment of national and regional targets with the overall aim of saving biodiversity and enhancing its benefits for people.

The strategic plan contains five independent Strategic Goals (CBD 2010):

- Addressing underlying causes or direct drivers of biodiversity change.
- Pressures or direct drivers.
- Safeguarding ecosystems, species and genetic diversity.
- Safeguarding and enhancing the benefits of biodiversity and ecosystem services.
- Providing the means to enhance the implementation of other goals through relevant national strategies.

The GBO-4 report, its underlying reports (SCBD 2014; Leadley et al. 2014), and an associated paper in the Journal *Science* (Tittensor et al. 2014), provided a mid-term review of process towards the Aichi Biodiversity Targets, with a detailed assessment of trends, status, and projections of biodiversity worldwide. Some other biodiversity conventions, such as the Convention on the Conservation of Migratory Species of Wild Animals (CMS), have also used the targets as a basis to develop their own strategic plans, thus ensuring that actions under such conventions also support the Aichi Biodiversity Targets.

SUMMARY OF THE FINDINGS OF THE GBO-4

GBO-4 brought together multiple lines of evidence derived from a wide range of sources. It drew upon targets, commitments and activities of countries as reported in National Biodiversity Strategies and Action Plans (NBSAPs) and national reports, as well as Parties' own assessments of progress towards the Aichi Biodiversity Targets. It took into account information on the status and trends of biodiversity reported by Parties and in the scientific literature, and made use of indicator based statistical extrapolations to 2020 (Figure 3) as well as longer term model based scenarios.

Statistical extrapolations for a range of indicators suggest that, based on current trends, pressures on biodiversity will continue to increase until 2020 at least, and that the status of biodiversity will continue to decline. This decline is despite the fact that society's responses to the loss of biodiversity are increasing, based on national plans and commitments, and are expected to continue to increase for the remainder of this decade. This disparity may be partly due to time lags between positive actions and discernible positive outcomes, but it could also be that responses may be insufficient relative to pressures, such that they may not overcome the growing impacts of the drivers of biodiversity loss.

The overall conclusion from GBO-4 was that, while there has been significant progress towards meeting some components of the majority of the Aichi Biodiversity Targets, for example, conserving at least seventeen per cent of terrestrial and inland water areas, in most cases progress was not sufficient to achieve the targets set for 2020. Additional action by governments and others is required to keep the *Strategic Plan for Biodiversity 2011–2020* on course and deliver the Aichi Biodiversity Targets. These efforts are also relevant to achievement of the new Sustainable Development Goals (SDGs), which were agreed at the end of 2015 and will be in place until 2030.

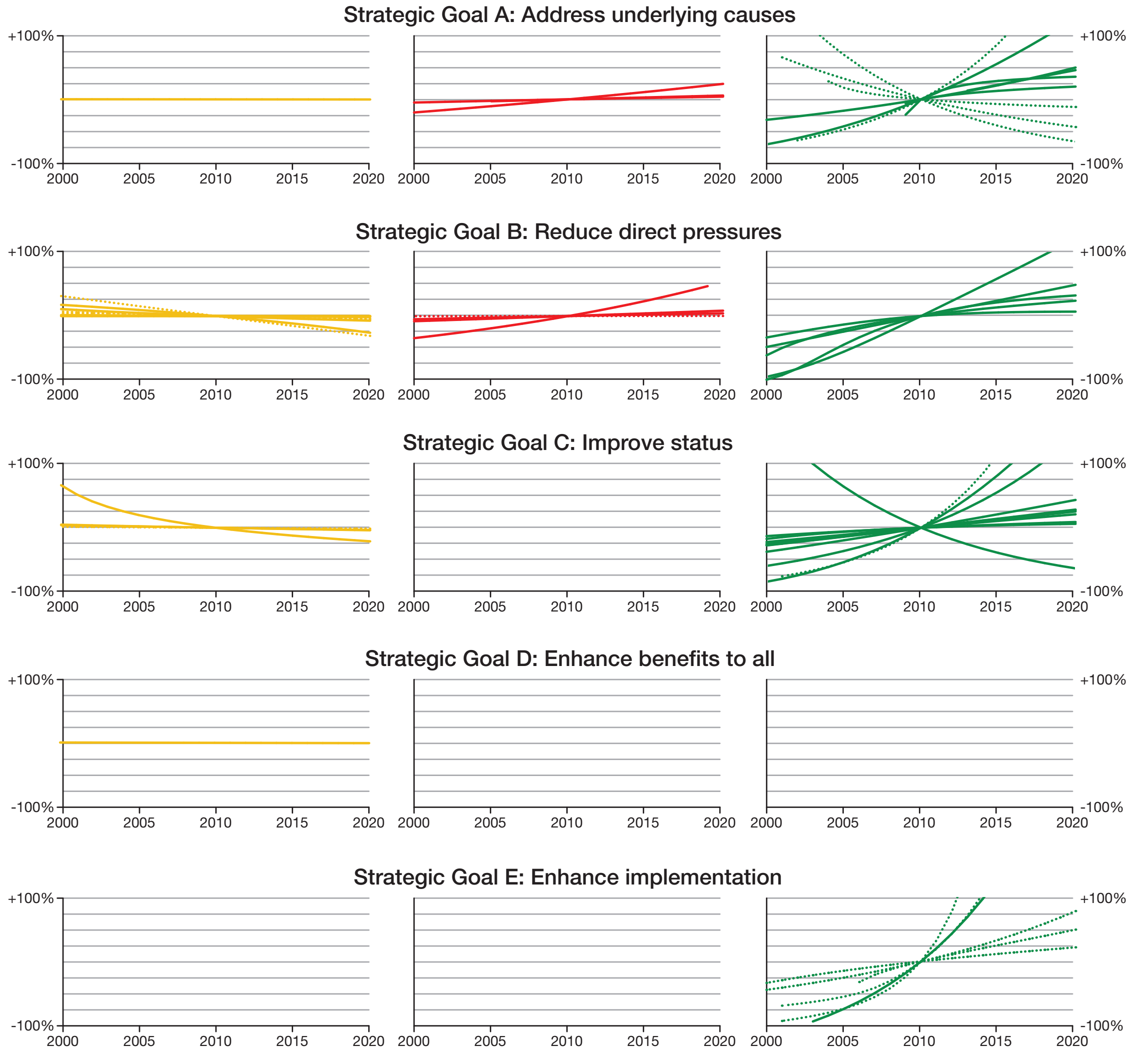


Figure 3: Trends in normalized indicators from 2000 and projected to 2020 for the five different Strategic Plan for Biodiversity 2011-2020 goals (Tittensor et al. 2014).

State measures are coloured orange, Pressure measures are coloured red, and Response measures are coloured green. The horizontal dotted line represents the modelled indicator value in 2010. For state and response indicators, a decline over time represents an unfavourable trend (falling biodiversity, declining response) whereas for the pressure indicators a decrease over time represents a favourable trend (reducing pressure). A dashed coloured line represents no significant trend, whereas a solid coloured line represents a significant projected change between 2010 and 2020. Values are normalized by subtracting the modelled mean then dividing by the modelled standard deviation. For individual extrapolations on their original scale see target by target chapter in GBO-4 (SCBD 2014). Note that many time series continue prior to the year 2000; the x-axis has been limited to this date.

4. OVERVIEW OF PROGRESS ACROSS THE LATIN AMERICA AND CARIBBEAN REGION

While the global assessment and data provided by GBO-4 give an overall picture of the world's biodiversity status, it does not contain regional breakdowns of this information. Here we provide a more specific and detailed assessment of the changes in the state of biodiversity, pressures and human responses to the biodiversity crisis in Latin America and the Caribbean.

The overall progress towards the achievement of the twenty Aichi Biodiversity Targets in the Latin America and Caribbean region, in comparison with the global progress, has been determined from the fifth national reports to the CBD. Of the 33 countries in the region, 26 had submitted their fifth national reports as of January 2016, and reports from 24 countries are included in this assessment (SCBD unpublished data) (Figure 4).

Overall progress towards the Aichi Biodiversity Targets in the LAC region is similar to the global picture. However, in LAC, some countries are reporting "no information" around progress towards specific targets, and a trend across many targets shows countries reporting that they are not currently on track to meet specific targets. The most positive trends in the region are seen in Target 11 (protected areas), Target 17 (adoption and implementation of policy instruments) and to a lesser extent Targets 18 (acknowledgement of traditional knowledge) and 19 (improved biodiversity information sharing).

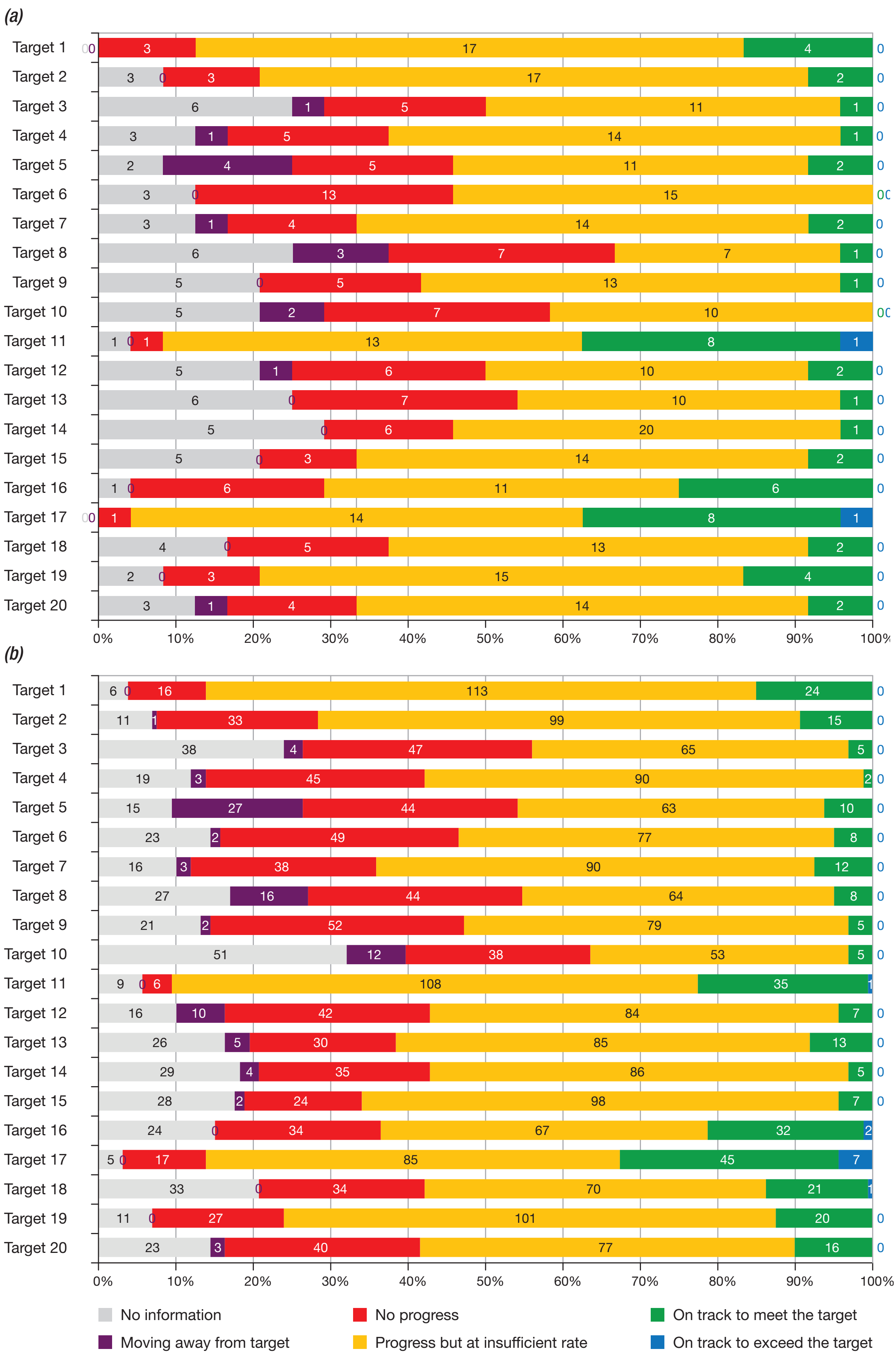


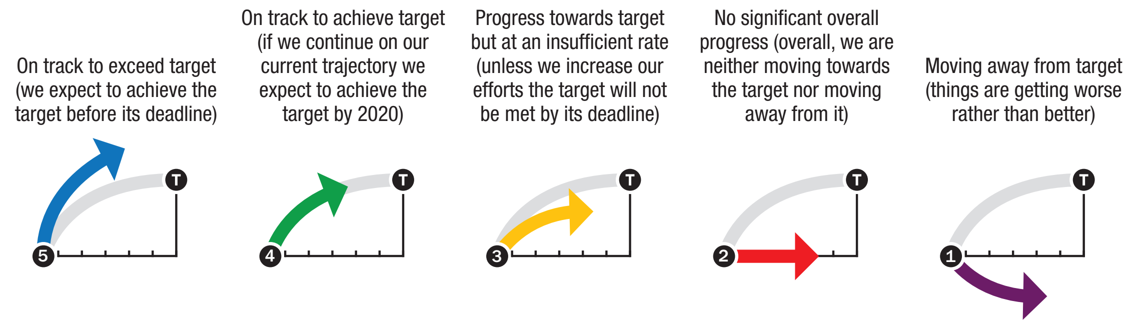
Figure 4: Synthesis of progress towards the achievement of the twenty Aichi Biodiversity Targets a) in the Latin America and Caribbean region (n=24) and b) globally (n=159). Numbers in the columns indicate the number of country reports within each category, of the 24 country reports analysed for each Target.

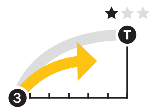
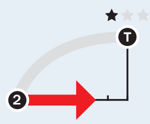
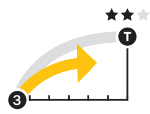
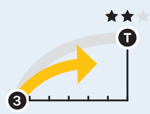
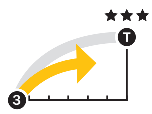
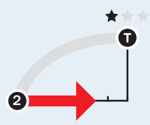
AICHI BIODIVERSITY TARGET DASHBOARD

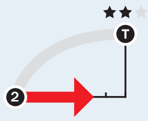
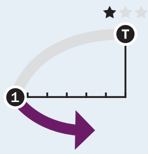
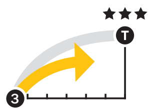
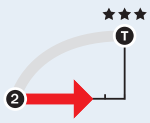
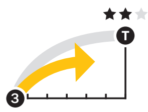
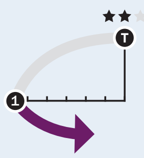
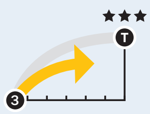
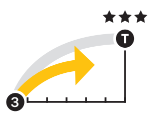
A dashboard of progress towards each of the Aichi Biodiversity Targets has been developed, based on consideration of regional analysis of global datasets (mainly from the Biodiversity Indicators Partnership, BIP), analyses of the fifth national reports to the CBD and relevant literature.

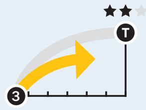
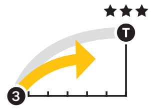
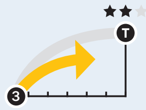
Table 2: A dashboard of progress towards the Aichi Biodiversity Targets in Latin America and the Caribbean.

The table below provides an assessment of progress made towards each of the Aichi Biodiversity Targets as well as the level of confidence (***) based on the available evidence. It aims to provide summary information on whether or not we are on track to achieve the targets. The assessment uses a five-point scale.



Target	Notes	Progress
Target 1 - Awareness increased	Available information in the region is not sufficient to make a definitive analysis of progress towards this target. However, it is known that there is significant effort in some countries; for example about half of the country reports analysed by the CBD show evidence of implementing environmental education programmes.	
Target 2 - Biodiversity values integrated	The integration of biodiversity values in decision making is variable in the region. Although countries do report some progress and environmental impact assessment (EIA) legislation is widely developed, the reality on the ground is often favouring development decisions. Data to accurately measure progress are, however, often lacking.	
Target 3 - Incentives reformed	Some countries are involved in payment for ecosystem services (PES) schemes such as REDD+ and water PES, and are developing "green economy" or natural resource accounting initiatives which aim to provide positive incentives for conservation. There is less evidence of reforms of negative incentives for conservation in the region. It seems unlikely that this target will be fully achieved unless additional actions are taken.	
Target 4 - Sustainable production and consumption	There are few available data on the progress towards sustainable consumption and production in the region, although around half of the countries report they are making progress. However, it seems unlikely that progress is sufficient to meet the target.	
Target 5 - Habitat loss halved or reduced	Within the region there has been significant progress in terms of reducing the rates of forest loss, for example rates of tropical forest loss have been falling in Brazil and Peru. However, rates of habitat loss in other biomes are still high. In comparison, mangrove cover has increased in the region.	
Target 6 - Sustainable management of marine living resources	There are very few data to track this target in the region. The total catch from certified fisheries increased up to 2012, but has declined in recent years. There is also evidence of significant illegal fishing in the marine areas in the region. Although data are poor it seems that this target is not currently on track to be met.	

Target	Notes	Progress
Target 7 - Sustainable agriculture, aquaculture and forestry	The development of schemes for sustainable agriculture, aquaculture and forestry have been progressing, although slowly, in the region. Forest certification increased up to 2010, but has been stable since that time. For agriculture and aquaculture information is not available across the whole region.	
Target 8 - Pollution reduced	The region faces challenges to meet this target in large urban areas where pollution is severe and also impacts on local rivers and downstream marine areas. Water treatment facilities are often inadequate to cope with the scale of the challenge. Nutrient loading is also causing damage in agricultural areas of the region.	
Target 9 - Invasive alien species prevented and controlled	Invasive alien species are an issue in the region; with plants invading some offshore islands and introductions of mussels and fish. Considerable programmes of eradication of invasive aliens are taking place, but prevention and control is hard to achieve.	
Target 10 - Pressures on vulnerable ecosystems reduced	Coral reefs are vulnerable to climate change and the other pressures have not been mitigated in the region. Given the multiple threats to coral reefs and the ongoing climate change in the region, it seems that the region is probably moving away from the target.	
Target 11 - Protected areas increased and improved	The region has developed an extensive protected area network, consisting of state and community and private reserves. This protected area network is also increasing in effectiveness in many countries in the region.	
Target 12 - Extinction prevented	The IUCN Red List Index shows that species are moving towards extinction in the region, with a worrying increase between 2008 and 2012. This is despite considerable effort being made by countries to improve the conservation status of threatened species, and a number of local successes – especially on islands.	
Target 13 - Genetic diversity maintained	There are important centres of crop and animal diversity in the region (especially in areas of ancient human civilisation). This diversity is somewhat threatened by modernisation of agriculture, but there are many actions underway to safeguard the genetic diversity of domesticated species in the region.	
Target 14 - Ecosystems and essential services safeguarded	Although rates of forest carbon loss are being reduced, the region is still losing natural capital and the service of climate stabilisation. Water services from the major rivers are highly valued, but extensive plans for dams will affect some of the natural regulating ecosystem services provided by rivers, and water resources are declining. There has been a general increase in agricultural area, a decrease in undernourished people, driven by the replacement of natural capital by anthropomorphic capitals.	
Target 15 - Ecosystems restored and resilience enhanced	There is very little information from the region to allow this target to be tracked. As such we are not able to say if progress is being made and we have left the target progress blank.	Insufficient data to assess progress
Target 16 - Nagoya Protocol in force and operational	Countries in the region are making good progress towards the ratification and implementation of national legislation around the Nagoya protocol. Although not every country in the region will meet the target, many will.	
Target 17 - NBSAPs adopted as policy instrument	Some countries in the region produced their NBSAPs within the 2015 deadline. However, the majority did not, although they are expected to complete them in the coming years.	

Target	Notes	Progress
Target 18 - Traditional knowledge respected	This region contains numerous indigenous people's groups with considerable traditional knowledge. There is legal protection of many of these indigenous groups and their knowledge. However, many indigenous languages – the main transmission mechanism for traditional knowledge – are threatened with extinction due to the dominance of teaching and use of Spanish, English and Portuguese.	
Target 19 - Knowledge improved, shared and applied	The region has an increasing capacity for creating and sharing knowledge on biodiversity and applying it in the field. Various data sharing platforms have been created and these are being incorporated into the global GBIF platform.	
Target 20 - Financial resources from all sources increased	The region receives considerable funding from the international community based on its very high rates of biodiversity and expanding protected area network, although this has declined in recent years. In addition the countries in the region also provide significant conservation finance, although this is harder to track. Overall there is progress towards this target, although additional funding is always required.	

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5. TARGET BY TARGET ANALYSIS OF PROGRESS TOWARDS AICHI BIODIVERSITY TARGETS IN LATIN AMERICA AND THE CARIBBEAN (LAC)

This section provides a mid-term assessment of progress towards the Aichi Biodiversity Targets in the LAC region. Where possible, we have used the most up to date information and data, from 2010 onwards as this best reflects the objectives of the Aichi Biodiversity Targets. However, in many cases, such data are lacking and hence we have used the most recent available data to suggest trends in the likely achievement of the relevant Aichi Biodiversity Target.

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TARGET 1: AWARENESS OF BIODIVERSITY INCREASED

By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.

"Addressing the direct and underlying drivers of biodiversity loss will ultimately require behavioural change by individuals, organizations and governments. Understanding, awareness and appreciation of the diverse values of biodiversity underpin the willingness of individuals to make the necessary changes and actions and to create the "political will" for governments to act. Given this, actions taken towards this target will greatly facilitate the implementation of the *Strategic Plan* and the fulfilment of the other nineteen Aichi Biodiversity Targets, particularly Target 2." (CBD 2016c)

Global trends suggest that people are aware of biodiversity values, but do not "view biodiversity protection as an important contribution to human well-being" (SCBD 2014). Improving awareness of the values of biodiversity and enhancing the knowledge of what people can do to conserve and use it sustainably are vital to reduce biodiversity loss in all regions, including LAC.

The fifth national reports to the CBD indicate that although progress has been made towards meeting Target 1 in all but three countries in the LAC region, this will not be sufficient to meet the target by 2020. The information reported highlights actions being taken to improve awareness of biodiversity, with 50 per cent of countries reporting implementation of an environmental education program. Awareness events, online resources and information disseminated through the media are also used to increase knowledge of biodiversity. Only four countries (Belize, Brazil, Dominican Republic, and Guatemala) are using indicators to measure environmental awareness, therefore, little is known about the impacts of the initiatives implemented. The only quantitative information provided is from Brazil, where polls indicate that 50 per cent of Brazilians were aware of biodiversity loss in 2012, an increase from 43 per cent in 2006. Generally, less focus is placed on raising awareness of the importance of conservation across the region, and more effort is placed on improving the basic educational needs of the population (CBD 2015).

Ipsos[1] carries out annual surveys of the public's knowledge of biodiversity for the Union for Ethical Biotrade (UEBT) (UEBT 2015). In 2015, 1,000 people were surveyed in nine countries globally, including Brazil, Ecuador, and Mexico from the region. Results show there seems to be more understanding of the importance of biodiversity in Latin America and the Caribbean than in other regions of the world, as 74 per cent of respondents agreed that 'biodiversity is essential' compared to just 50 per cent globally. Over 95 per cent of respondents in Latin America and the Caribbean stated that 'it is important to personally contribute to biodiversity conservation' compared to 87 per cent globally. However, respondents overall were generally unsure about actions they could take to contribute themselves (UEBT 2015).

[1] http://www.ipsos.com/

Information from the global database, AidData, on investments in environmental education from 1995 to 2010 provides an indication of the commitment to increase awareness of environmental issues (Tierney et al. 2011). Actual investment in projects related to environmental education has varied over time, from a high of USD 137 million in 1997, to a low of USD 6.1 million in 1999. With the exception of a peak in 1997, the proportion of development assistance funds related to environmental education in LAC was consistently less than 1 per cent of the total during this period (Figure 1.1). The only data point within the Aichi Biodiversity Target time period is from 2010, indicating that around USD 80 million was invested in environmental education by foreign donors in the region in that year. However, as some projects included in this analysis target other activities as well as education, these data are a proxy and not a direct measure of the funds allocated to environmental education. AidData only contains information on the funding provided by conservation donors and does not reflect the funding to enhance awareness that has been provided by the countries in the region using their own resources. As this region contains many medium income countries there will be considerable national investment in this issue, which are reflected in the statements in the fifth national reports to the CBD.

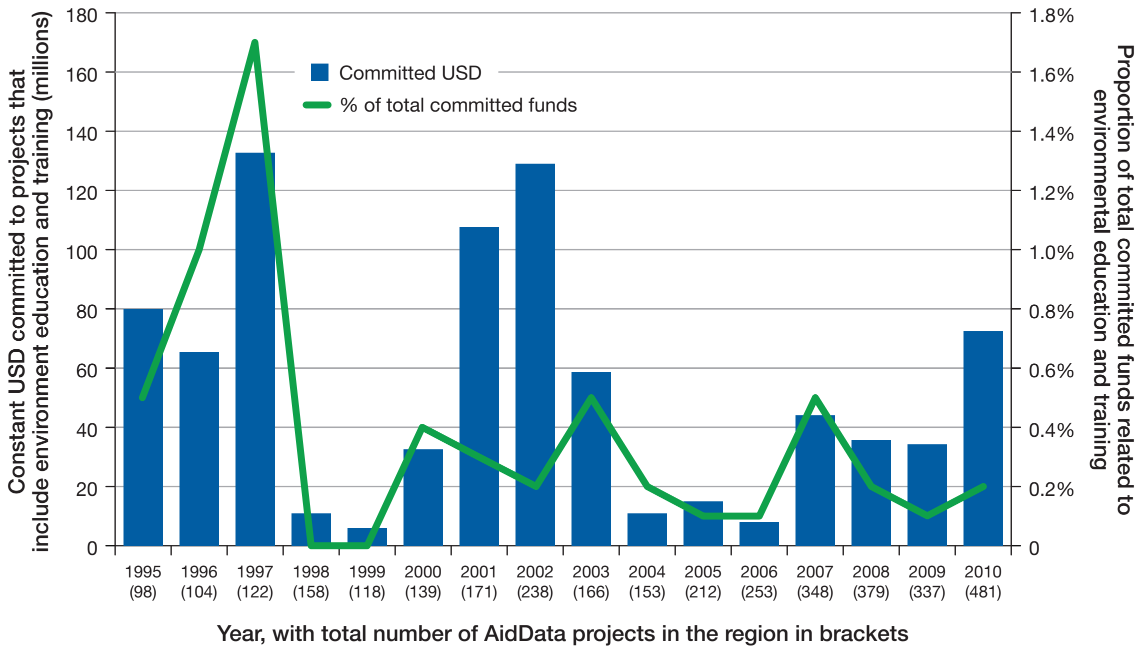

Figure 1.1: Absolute and proportional investment in environmental education in Latin America and the Caribbean by donors on AidData between 1995 and 2010 (source: Tierney et al. 2011)

In conclusion, progress is being made towards Target 1. In particular, there has been much effort in the region to build an environmental understanding, which compliments the traditionally strong awareness and education in some countries in the region about the value of nature. Although the protection and respect for biodiversity and its habitat is part of the culture and 'ethos' of some areas in the LAC region, it is unlikely that sufficient progress will be made, or quantified, to meet Target 1 by 2020.

TARGET 2: BIODIVERSITY VALUES INTEGRATED

By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.

"The values of biodiversity are not widely reflected in decision making, and holds true in the context of development and poverty reduction strategies. Integrating and reflecting the contribution of biodiversity, and the ecosystem services it provides, in relevant strategies, policies, programmes and reporting systems is an important element in ensuring that the diverse values of biodiversity and the opportunities derived from its conservation and sustainable use are recognized and reflected in decision making. Similarly, accounting for biodiversity in decision making is necessary to limit unintended negative consequences of local development and poverty reduction strategies." (CBD 2016c)

Balancing the imperatives of economic gain from resource extraction with conserving biodiversity is a serious challenge in rapidly developing regions such as Latin America and the Caribbean. The integration of biodiversity into economic and social development strategies requires an understanding of the precise aspects of biodiversity that support poverty alleviation, as well as other development and sector-specific activities. Such knowledge can assist mainstreaming biodiversity goals into sectoral decision making across productive sectors and governmental agencies, such as Ministries of Finance, Health, Planning and Economic Development, Agriculture, Tourism and Education, amongst others.

Within the LAC region, the fifth national reports to the CBD indicate that the majority of countries have made efforts towards carrying out biodiversity and ecosystem services valuations, and integrating them into government process. Most countries in the region also report some progress towards incorporating biodiversity and ecosystem services into planning processes, particularly within the environmental and land planning sectors. This is presents challenges in some countries, where planning happens at the municipal level. Less progress has been made within the development agenda, although several countries (Brazil, Cuba, Dominican Republic, Ecuador, Guatemala, and Nicaragua) have taken concrete actions to incorporate biodiversity values into their development policies (CBD 2015). To date, there have been few attempts within the region to integrate biodiversity values into national accounting, although countries including Brazil, Colombia, Ecuador, Guatemala and Panama have initiated projects to consider this (CBD 2015).

Investment in environmental impact assessments (EIA) can serve as an indication of the consideration of biodiversity values in development decision making, if activities are undertaken following the requirements of the law and appropriate qualitative and quantitative assessments of biodiversity are undertaken. AidData shows that with the exception of a large peak in 1997, and a smaller peak in 2002, less than 1 per cent of annual funds invested in Latin America and the Caribbean were used for EIA between 1995 and 2010 (Figure 2.1). No AidData funds were allocated to EIA in 1996, 2000 or 2001 (Tierney et al. 2011). However, it must be stated that these figures will fail to capture the significant investment in EIA - which are not available in any compiled form - which could have been made by governments and businesses in the region using their own resources.

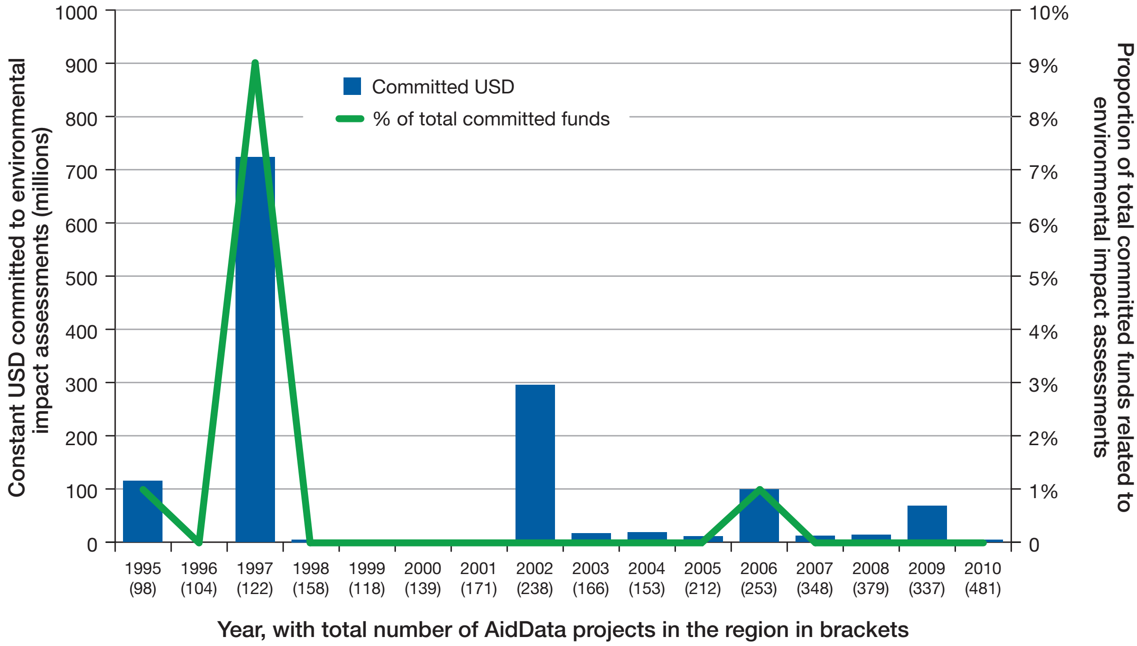

Figure 2.1: Absolute and proportional investment in Latin America and the Caribbean in environmental impact assessments by donors on AidData between 1995 and 2010 (source: Tierney et al. 2011).

In conclusion, progress is being made towards Target 2, but this will not be sufficient to meet the target by 2020. There are some initiatives in the region to make progress with this target, but these are not yet widespread. Gathering data to track progress on the target is not easy and more will need to be done in the lead up to 2020 to fully assess the achievements of the countries in the region against this target.

Box 2.1: Antigua and Barbuda.

The enactment of the Sustainable Island Resource Management Zoning Plan (SIRMZP) serves as the National Physical Development Plan (NPDP; GENIVAR Trinidad and Tobago 2011).

The SIRMZP is a critical master-planning tool that converts national environmental priorities into spatial form, which will assist in reducing development pressures on natural resources. The SIRMZP prescribes strategic development guidelines that enhance and preserve critical ecosystem functions. It also enables policy and decision makers to assess the appropriateness of development proposals in Antigua and Barbuda. The SIRMZP advocates for developments that are compatible with the surrounding habitat while maintaining environmental integrity. For instance, the SIRMZP recommends light recreational development for education in conservation and forest areas. Such development should avoid the use of hard structures.

Box 2.2: Argentina Includes Forestry Sector Activities in GDP.

Argentina is exploring the possibility to include the value of biodiversity and ecosystem services in its constitutional mandates and policies. The ecosystem services provided by the country's native forests have been quantified in relation to GDP and the activities of the forestry sector have been re-valued to be included in the new total GDP value. Thus, the share of the forestry sector in GDP has increased from 0.05 to 3.07 per cent (approximately 60 times the initial value) (Secretaría de Ambiente y Desarrollo Sustentable, República Argentina 2015).

TARGET 3: INCENTIVES REFORMED

By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.

> "Substantial and widespread changes to subsidies and other incentives that are harmful to biodiversity are required to ensure sustainability. Ending or reforming harmful incentives is a critical and necessary step that would also generate net socio-economic benefits. The creation or further development of positive incentives for the conservation and sustainable use of biodiversity, provided that such incentives are in harmony with the Convention and other relevant international obligations, could also help in the implementation of the Strategic Plan by providing financial resources or other motives to encourage actors to undertake actions which would benefit biodiversity." (CBD 2016c)

This target aims to reduce the impact of harmful incentives, including subsidies, on biodiversity and enhance the development and application of positive incentives for better conservation practice. GBO-4 reports limited progress toward this target globally, particularly in terms of non-financial incentives. Thus far, limited action has been taken to remove harmful subsidies, although there is increasing recognition of the need to do so (SCBD 2014).

The fifth national reports to the CBD provide limited evidence of progress towards Target 3 in the LAC region. Most attention has been placed on establishing positive incentives within the region, including implementation of PES schemes, for example Ecuador's Rural Land Tax, and subsidies to small and medium farmers for the sustainable management of natural resources in Uruguay. According to the CBD, only five countries in the region (Argentina, Bolivia, Brazil, Colombia, and Guatemala) report any progress towards the reform of negative incentives, although three others (Chile, El Salvador, and Suriname) have initiated projects to identify them. Colombia reports that it has an efficient framework in place, backed up by legislation, to eliminate harmful incentives (CBD 2015). However, there are still examples of new laws being passed in the region, which promote land and agricultural management in ways, which could have negative effects on the environment and local communities.

The development mitigation hierarchy (avoid, minimize, restore, and offset) is increasingly being applied to the development of policy designed to protect biodiversity in this region. A review of environmental licencing policy frameworks in seven countries across Latin America (Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela) found that all seven have a strong policy foundation in place. However, most countries place more emphasis on offsetting (the least desirable action from the mitigation hierarchy), and have less consistent requirements to avoid or minimise damage (Villarroya et al. 2014).

Costa Rica first implemented a nationalised PES programme in 1996, and is regarded as a pioneer of this type of programme. Four ecosystem services are explicitly recognised by the programme: capturing and storing atmospheric carbon, protecting water sources, conserving biodiversity and conserving scenic beauty. The programme is multi-faceted, using both legislation and economic instruments to achieve its aims. Payments are made for different actions including protection, reforestation, sustainable management and regeneration. The programme has adapted over its lifetime in response to changes in Costa Rica's economy, and limitations that have become apparent. For example, the programme moved from a 'first come first served' approach, to one, which prioritises areas of importance for conservation. Also as a result of these adaptations, the involvement of indigenous communities increased from 3 per cent of the budget allocation initially to 26 per cent in 2012. An average of 60,000 ha of forest are included in the programme annually, and forest cover is used as a key proxy indicator to monitor the success of the programme. In 2013, forest cover in Costa Rica reached 50 per cent, an increase from a low of just 20 per cent in the 1980s (Porras et al. 2013).

Some countries in the LAC region are working to implement REDD+ mechanisms. These actions are not only relevant to Aichi Biodiversity Target 3 but also to a range of other targets, including Aichi Biodiversity Targets 5, 11 and 15 (Miles et al. 2013). The intention of REDD+ is to provide incentives for countries to conserve and sustainably manage their forest resources as a contribution towards the mitigation of global climate change, largely caused by the emissions of carbon dioxide and other green-house gases released when forests are cleared, often as a result of agricultural expansion. This in turn has positive effects on the protection of the region's biodiversity.

In addition to REDD+, individual country initiatives to develop environmental incentives have become more common, such as Brazil's Ecological VAT and Conservation Units initiative (Medeiros et al. 2011). This Ecological VAT, known as "ICMS Ecológico", is an innovative tax revenue-sharing scheme which acts as an intergovernmental tax incentive based on a "Protector-Recipient" principle, introducing environmental criteria in the calculation of 25 per cent of the natural resource transfer fares that municipalities are entitled to (Medeiros et al. 2011; ICMS Ecológico 2016; Grieg-Gran 2000).

In the marine areas, a FAO review of coastal fisheries in Latin America and the Caribbean found that government incentives and subsidies, including grants for new vessels and equipment, or for the modernisation of fleets, are contributing to the growth of the fishing industry in the area (FAO 2011). With the exception of a USD 55.9 million investment by the World Bank in an Aquaculture Development Project in 1997, AidData shows that no funding was invested in Latin America and the Caribbean in support of sustainable fisheries between 1995 and 2010 (Tierney et al. 2011). As with the EIA data in Target 2, these figures will fail to capture investments made by governments and businesses in the region using their own resources.

In conclusion, some countries in this region have made significant progress in developing and implementing positive incentives for conservation through payment for ecosystem services projects. National systems in Mexico and Costa Rica provide good examples of positive outcomes from investment in environmental incentives, such as the implementation of sophisticated PES schemes for water, carbon and other environmental services. In other countries in the region, substantial progress has been made around developing incentives for forest conservation, mainly linked to the development of the REDD+. Progress around removing negative incentives has been slow, and it is unlikely that the region will meet Aichi Biodiversity Target 3 by 2020.

Box 3.1: Colombia Environmental Policy Incentives (Secretaría General del Senado, República de Colombia 2015).

Colombia has created positive incentives to improve the national environmental legislation. These include:

- Charges for water use (L. 99/93, art. 43); the use of water for personal or public affairs will include a water tax set by national government which will be used for the payment of protection and renovation of water resources, as dictated in the "Política Nacional para la Gestión Integral del Recurso Hídrico (National Policy for the Integrated Management of Water Resources)" (Ministerio de Ambiente, Vivienda y Desarrollo Territorial, República de Colombia 2010).
- Polluter-pay principle for pollutant discharges (L. 99/93, art. 42); the direct or indirect use of the atmosphere, water or land for the disposal of waste or discarded material from agricultural, mining or industrial activities will be subject to the payment of a tax for the negative consequences of these activities.
- Fees for utilization and transport of wood.
- Payment for ecosystem services (PES) schemes (L. 99/93, art. 111) were put in place to guarantee the conservation of biodiversity and ecosystem services, and the equal and fair distribution of the benefits derived from them to contribute towards the improvement of the Colombian population's quality of life.

Regional Autonomous Corporations (CARs) hold key authorities and responsibilities for water management in Colombia. In 1997, a CAR enacted water regulations in the Eastern Antioquia region of Colombia, which, in effect, allowed businesses to pay to pollute fresh-water systems. If businesses chose not to reduce emissions, they could stay in operation, but the costs of polluting would rise steadily over time. If they reduced their pollution, the costs would come down. The new regime produced immediate positive results, where previous enforcement action in the form of fines and closing down factories, had not. Companies invested in infrastructure to treat and recycle their waste and began to use less polluting inputs and equipment. Municipal authorities were also subject to the charges, and invested in water-treatment facilities. By 2000, in the region's seven principle watersheds, organic waste had been reduced by 26 per cent, and suspended solids in fresh water had declined by 52 per cent (Ambrus 2000).

Box 3.2: Mexico Monitoring and Evaluation of Payment for Ecosystem Services Programmes.

The Federal Government of Mexico has been implementing payment for ecosystem services programmes for a number of years, aiming to create incentives to halt and reverse biodiversity loss. To evaluate the impact of these programmes, Mexico is implementing a national monitoring programme for particular aspects of biodiversity, such as ecosystem structure, functions and composition.

The National Commissions on Forestry (CONAFOR), National Commissions on Protected Areas (CONANP) and the National Commissions on Biodiversity (CONABIO) jointly operate these monitoring programmes. The data are gathered, analysed and distributed via data management systems designed and operated by CONABIO, and are collected by tools such as: photo traps, microphones in the field, observations and camera aided registries.

The data are collected from a total of 8,200 locations in the country and will be processed to showcase indicators reflecting temporal changes in composition, structure and functions of biodiversity and ecosystems.

The indicators will be used by CONAFOR and CONANP to assess the performance of land, forest and biodiversity management tools over time and adjust these tools to reflect maximum impact per investment.

Box 3.3: Dominican Republic Establishes its First Private Reserve and Sells the Caribbean's First Forest Carbon Offsets.

Through a multi-stakeholder partnership, the Dominican Republic established its first private reserve, Reserva Privada Zorzal when a consortium of private investors purchased 469 ha of land which expanded the existing protected areas of two scientific reserves, Loma Quita Espuela and Loma Guaconejo.

A Dominican non-profit organisation, Consorcio Ambiental Dominicano (CAD) recognised an opportunity to strengthen the country's environmental law (64-00) and resolution No. 012-2011 which provided a framework for the creation of private reserves. Through support from the Critical Ecosystem Partnership Fund (CEPF) and the Caribbean Natural Resources Institute (CANARI) in its role as the Regional Implementation Team for CEPF in the Caribbean region, CAD worked in close partnership with local communities, other Non-Governmental Organizations (NGOs), the government, academia and private investors to create the business plan, land use plan, biological inventory, and management plan for Reserva Privada Zorzal which were subsequently adopted by the Ministry of Environment and Natural Resources. These model documents can be replicated by other conservation-minded investors and landowners who want to register their land as a private reserve in the future.

An innovative aspect of the private reserve is that it is home to a rare bird, the Bicknell's Thrush, which migrates from the US to the Dominican Republic. This attracted support for the landmark purchase from investors in both countries. To date, USD 650,000 in private capital has been invested in the private reserve.

Another innovative sustainable funding mechanism supporting this important biological area is the country's first forest carbon offset project which allows companies to offset their climate change impacts. CAD completed the carbon quantification, initial planting system and what has become the sale of the Caribbean's first forest carbon offset credits to chocolate making companies in North America. Importantly, the carbon offset sales are a new source of income for small-scale farmers as the project is registered with international carbon standard, Plan Vivo, which has a strong emphasis on supporting sustainable livelihoods. The secured revenue from the sale of forest carbon credits was approximately USD 14,000 in one year, expected to yield at least USD 250,000 within 10 years.

TARGET 4: SUSTAINABLE CONSUMPTION AND PRODUCTION

By 2020, at the latest, Governments, businesses and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

"The unsustainable use or overexploitation of resources is one of the main threats to biodiversity. Currently, many individuals, businesses and countries are making efforts to substantially reduce their use of fossil fuels, with a view to mitigating climate change. Similar efforts are needed to ensure that the use of other natural resources is within sustainable limits. This is an integral part of the Vision of the Strategic Plan." (CBD 2016c)

Target 4 seeks to keep the use of natural resources within sustainable limits and improve production methods to make them more sustainable. Natural resources exported and produced within the LAC region, including crops, minerals, metals and fossil fuels, are significant contributors to economies across Latin America and the Caribbean (World Integrated Trade Solution 2013). However these industries are placing significant pressures on habitats and biodiversity, with land facing increasing pressures from food production, cattle and bioenergy production (Magrin et al. 2014). The need for sustainable land management is reflected in a focus on sustainable production over sustainable consumption in the fifth national reports to the CBD. Fifteen countries across the region report having policies in place to promote sustainable use and production, including certification schemes, organic farming, and regulation of the fishing industry. There is, however, scattered information available about the impacts of such policies, and the region is not on track to keep the use of natural resources within sustainable limits by 2020 (CBD 2015). Latin America and the Caribbean are also working to develop National Sustainable Consumption and Production programmes, with the support of UNEP.

The Human Appropriation of Net Primary Production (HANPP) is one way to measure the impact of human consumption on the world's biotic resources. HANPP is an indicator that assesses the extent to which biomass harvest and land use change affect flows of trophic energy (biomass) in ecosystems, namely net primary production (NPP), a key process in the Earth system (Haberl et al. 2013). In 2005, HANPP in Latin America and the Caribbean amounted to 17 per cent of the potentially available Net Primary Production (NPP). Whilst this is still below the global average of 23 per cent (Krausmann et al. 2013), there has been a consistent increase in HANPP in the region since 1960 (Figure 4.1). The greatest increases in HANPP results from an expansion or intensification of croplands and grasslands in the region, and human induced fires also contributed significantly to HANPP in Latin America and the Caribbean between 1960 and 2005 (Figure 4.2).

Green tea plantation, Colombia

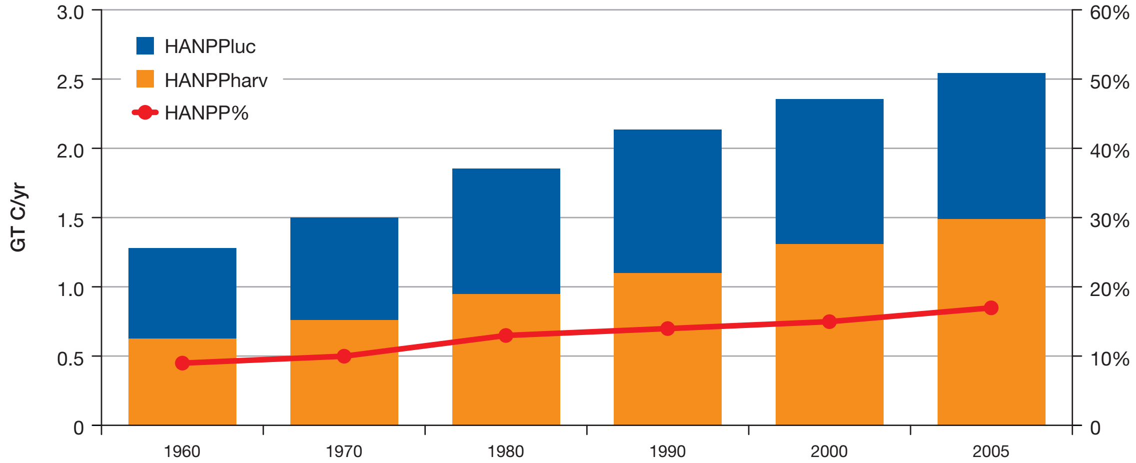

Figure 4.1: Human Appropriation of Net Primary Production (HANPP) in Latin America and the Caribbean, an aggregated indicator of land use intensity. It measures to what extent land conversion ($HANPP_{luc}$) and biomass harvest ($HANPP_{harv}$) alter the availability of net primary production (biomass) in ecosystems. Measured in GtC/yr and % of potentially available NPP (HANPP%) (source: Krausmann et al. 2013).

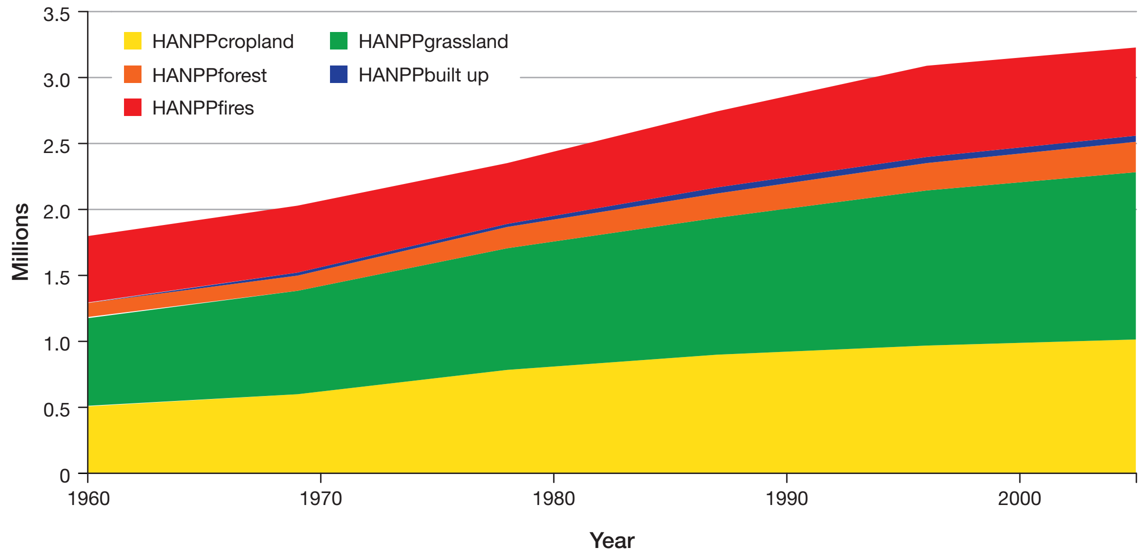

Figure 4.2: Human Appropriation of Net Primary Production (HANPP) in Latin America and the Caribbean by land use type (cropland, grassland, forest, built up land) and due to human induced fires in Gt C/yr (source: Krausmann et al. 2013).

Another way to measure impact is the Ecological Footprint (EF), which is a measure of the biocapacity required by a country or region to sustain its consumption and production patterns (Global Footprint Network 2012). The global EF has been rising steadily for the past 50 years, with a slight decrease of 3 per cent between 2008 and 2009 (Figure 4.3). This was due mostly to a decline in fossil fuel demand and, therefore, a decrease in carbon footprint (WWF 2014). In Latin America and the Caribbean, between 1961 and 2011 there was a slight upward trend in EF per capita, with an increase of 0.03 global ha per person over that time period (Figure 4.3) (Global Footprint Network 2012), and the per capita EF is similar to global levels (Figure 4.3).

In contrast to the global pattern of consumption, in which carbon has been the largest contributor to the global EF since 1961 (Figure 4.4a), in Latin America and the Caribbean, grazing land and cropland have historically been the major components of the total EF from consumption (Figure 4.b). Carbon consumption has grown rapidly over this period however, and in 2007 carbon became the region's largest contributor to the ecological footprint (Figure 4.4b). There are examples of the human footprint being downscaled to individual nations in South America, for example in Colombia (Etter et al. 2011).

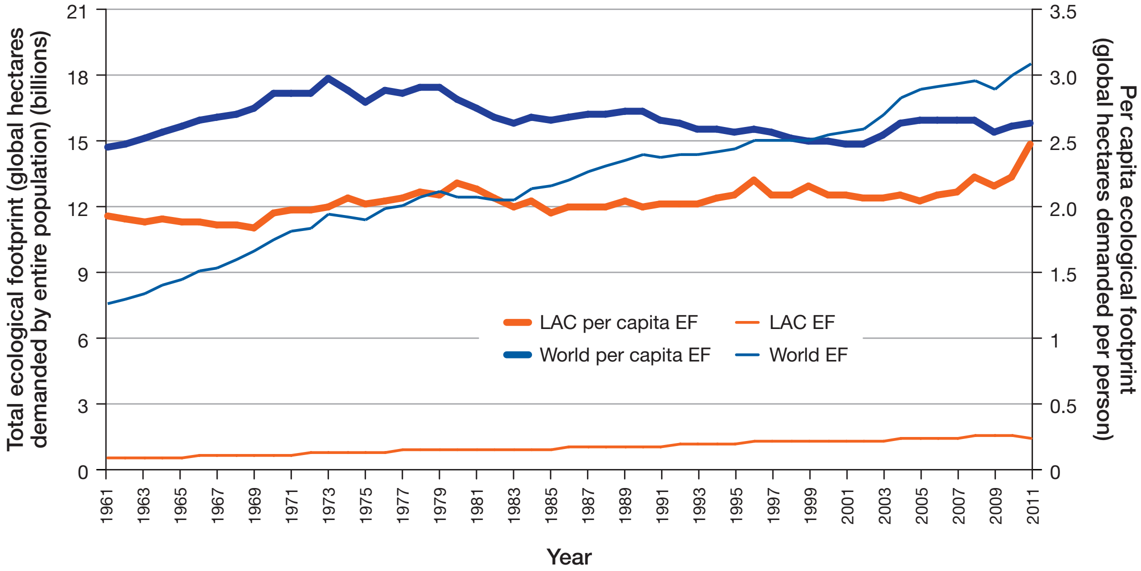

Figure 4.3: Combined graph showing the total and per capita Ecological Footprint (EF) for the World and Latin America and the Caribbean between 1961 and 2010 (source: Global Footprint Network 2015). EF per capita, measured in global ha demanded per person, reflects the goods and services used by an average person in the region, and the efficiency of the resources used to provide those good and services (WWF 2014).

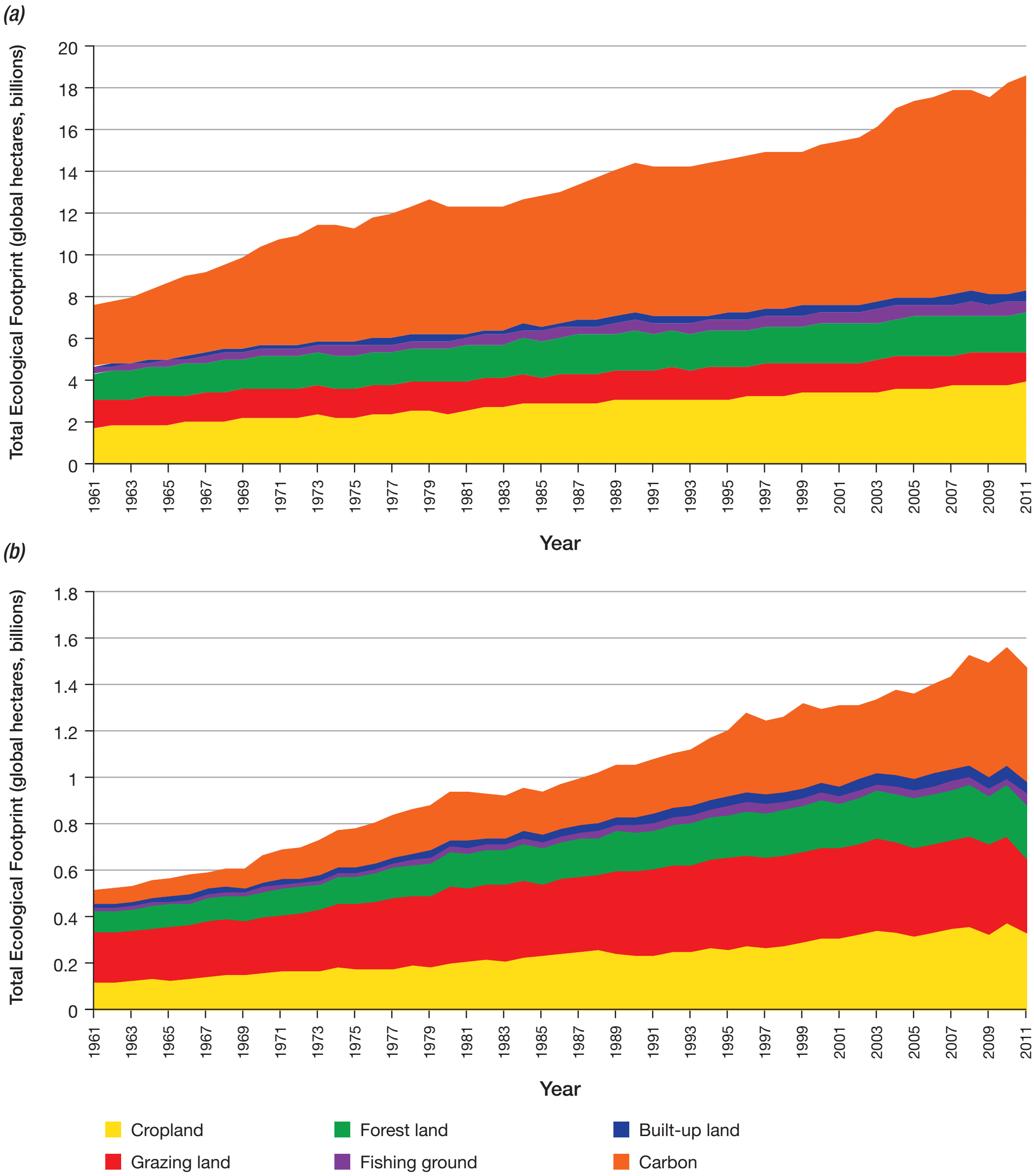

Figure 4.4: Area chart showing the Ecological Footprint by component (a) globally, and (b) in Latin America and the Caribbean (1961-2011) (source: Global Footprint Network 2015).

The LAC region supplies 27 per cent of global biofuels. Over 220 organisations working in biofuel production and processing in the region have signed up for voluntary certification schemes, however it is not clear that this is sufficient to ensure the sustainability of the industry (Bailis et al. 2015). Although conversion of land-use to growing sugarcane or soy beans for biofuels (often in conjunction with animal fodder) does not necessarily have a direct impact on biodiversity in the region, it may have a substantial indirect impact by displacing livestock breeding which can in turn lead to deforestation for cattle pasture (Janssen & Rutz, 2011).

In conclusion, the LAC region has been developing rapidly over the past decades and consequently increasing its global footprint and placing challenges on sustainable consumption and production. However, the region has implemented some innovative actions for reducing its footprint – for example, the extensive use of biofuel and innovative production and design practices. These innovations and the dynamic nature of the region offers hope that the development pathway can become more sustainable in the lead-up to 2020.

Box 4.1: The Sustainable Agriculture Network Standard and Rainforest Alliance Certification.

The Sustainable Agriculture Network (SAN) Standard sets out the requirements for certification of farms by the Rainforest Alliance. Requirements are grouped under ten principles: social and environmental management system; ecosystem conservation; wildlife protection; water conservation; fair treatment and good working conditions for workers; occupational health and safety; integrated crop management; soil management and conservation; and integrated waste management. In Latin America and the Caribbean, certificates have been awarded for crops including coffee, bananas, palm oil and cattle.

Latin America and the Caribbean accounts for over half (58 per cent) of certificates awarded, and 26 per cent of certified land globally. Seven of the top ten countries by number of certificates awarded are in Latin America and the Caribbean (Guatemala, Colombia, El Salvador, Chile, Ecuador, Brazil and Costa Rica). Brazil has the third largest area of land under certification of any country (after Côte d'Ivoire and Kenya), with 235,586 ha under certification distributed among 339 farms, most of which are coffee growers (Milder and Newsom 2015).

Box 4.2: Quantifying Carbon Emissions by Clean Production Agreements (CPA), Chile.

In 2010, the Chilean National Committees of Clean Production carried a national evaluation to quantify carbon emissions from sectors that have previously agreed to be under the CPA. The assessment compared carbon emission scenarios before and after the agreement. Results showed that the 16 sectors evaluated had reduced their emissions with 4 million tonnes of carbon. Based on the results, the Chilean government launch a carbon emission monitoring system in 2013, covering all the sectors under CPA. The monitoring system aims to inform the contribution of the Chilean productive sector to international targets of sustainable production, and will help to achieve the goals set by Aichi Biodiversity Target 4.

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TARGET 5: HABITAT LOSS HALVED OR REDUCED

By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation are significantly reduced.

"Habitat loss, including degradation and fragmentation, is the most important cause of biodiversity loss globally. Natural habitats in most parts of the world continue to decline in extent and integrity, although there has been significant progress to reduce this trend in some regions and habitats. Reducing the rate of habitat loss, and eventually halting it, is essential to protect biodiversity and to maintain the ecosystem services vital to human wellbeing." (CBD 2016c)

Habitat change is the primary cause of biodiversity loss globally, and in the LAC region habitat alteration and transformation is identified as the greatest risk to biodiversity, as habitat fragmentation, reduction and loss is causing a biodiversity crisis (UNEP 2010). The fifth national reports to the CBD for the region focus on forests and marine habitats, with very little information about other ecosystems. The national reports present a variable picture of progress, with a reduction in the rate of deforestation reported by Argentina, Brazil, Colombia, Cuba, Ecuador and Mexico, while Costa Rica, Nicaragua and Panama report that forests are recovering, at least in some areas (CBD 2015). However, other countries in the region have no available or scattered information. There has been considerable work investigating past and present patterns of forest loss in the lowlands and Andean portions of other countries (Etter et al. 2006). Moreover, dry tropical rainforest loss has been observed throughout the region (Leadley et al. 2014). Loss has also been seen in the Mediterranean forest in central Chile, with a national report showing an average annual decline of 0.5 per cent per year between 2001 and 2013 (Ministerio del Medio Ambiente, Chile 2014).

FAO's 2014 report on the 'State of the World's Forest' identifies Latin America and the Caribbean, as well as Europe, as the regions with most forest cover (25 per cent each) (FAO 2014b). Forest cover in South America is estimated at 864,351,000 ha, 49 per cent of the land area. For Central America this figure is 19,499,000 ha, 38 per cent of the land area (FAO 2014), and forest cover in the LAC region as a whole constitutes around 45 per cent of land area. Analysis of remotely sensed data by Hansen et al. (2013) indicates that six per cent of forest cover was lost in Latin America and the Caribbean between 2001 and 2013 (Figure 5.2). Annual rates of forest loss fluctuated over the period, with the highest annual loss recorded as 61,000 km² in 2004 (0.55 per cent of 2000 forest cover), and the lowest annual loss was 40,000 km² in 2013 (0.37 per cent of 2000 forest cover). These forest losses are in line with trends in forest extent reported by the FAO Global Forest Resources Assessment, which indicates forest cover loss of nine per cent between 1990 and 2015 in the LAC region (FAO 2015c).

International bodies such as the United Nations Framework Convention on Climate Change (UNFCCC) and the CBD have recognized the importance of the multiple services and functions provided by forests, and have initiated efforts to address the impacts of, and to reduce, forest loss and degradation (Miles et al. 2013). Many countries in the LAC region are working to develop policies to help address the drivers of deforestation, including the conversion of land for agriculture and development (Miles et al. 2013).

In preparation for REDD+ implementation, many countries have developed, or are developing, national REDD+ strategies or action plans, which describe how emissions will be reduced, and/or how forest carbon stocks will be enhanced, conserved or sustainably managed. LAC countries with significant areas of forest cover that are preparing to participate in REDD+, through a variety of national and international mechanisms include; Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay and Peru (Sanhuenza and Antonissen 2014). As well as REDD+, actions taken across the region in support of Target 5, include monitoring programmes and implementation of conservation strategies.

At the national scale, progress towards reducing habitat loss can be seen most clearly in Brazil and Colombia. The IPCC Fifth Assessment Report noted a 36 per cent reduction in the rate of deforestation in the Brazilian Amazon between 2005 and 2009 (Magrin et al. 2015). However, while the Amazon in Brazil remains mostly contiguous, the Brazilian Atlantic Forest has been dramatically fragmented and is now largely made up of forest patches under 1,000 ha. Reducing fragment areas and increasing the distance between them generally reduces the abundance of biodiversity and the capacity for carbon storage in all forest types (Haddad et al. 2015). Fragmentation caused by logging and vegetation clearance is also causing severe environmental damage in Chile's temperate forests (Echevarría et al. 2007). Studies suggest that if fragmentation process continues at the current rate, the ability of the remaining forest to maintain their original levels of biodiversity and support ecological process will be significantly reduced (Newton 2007).

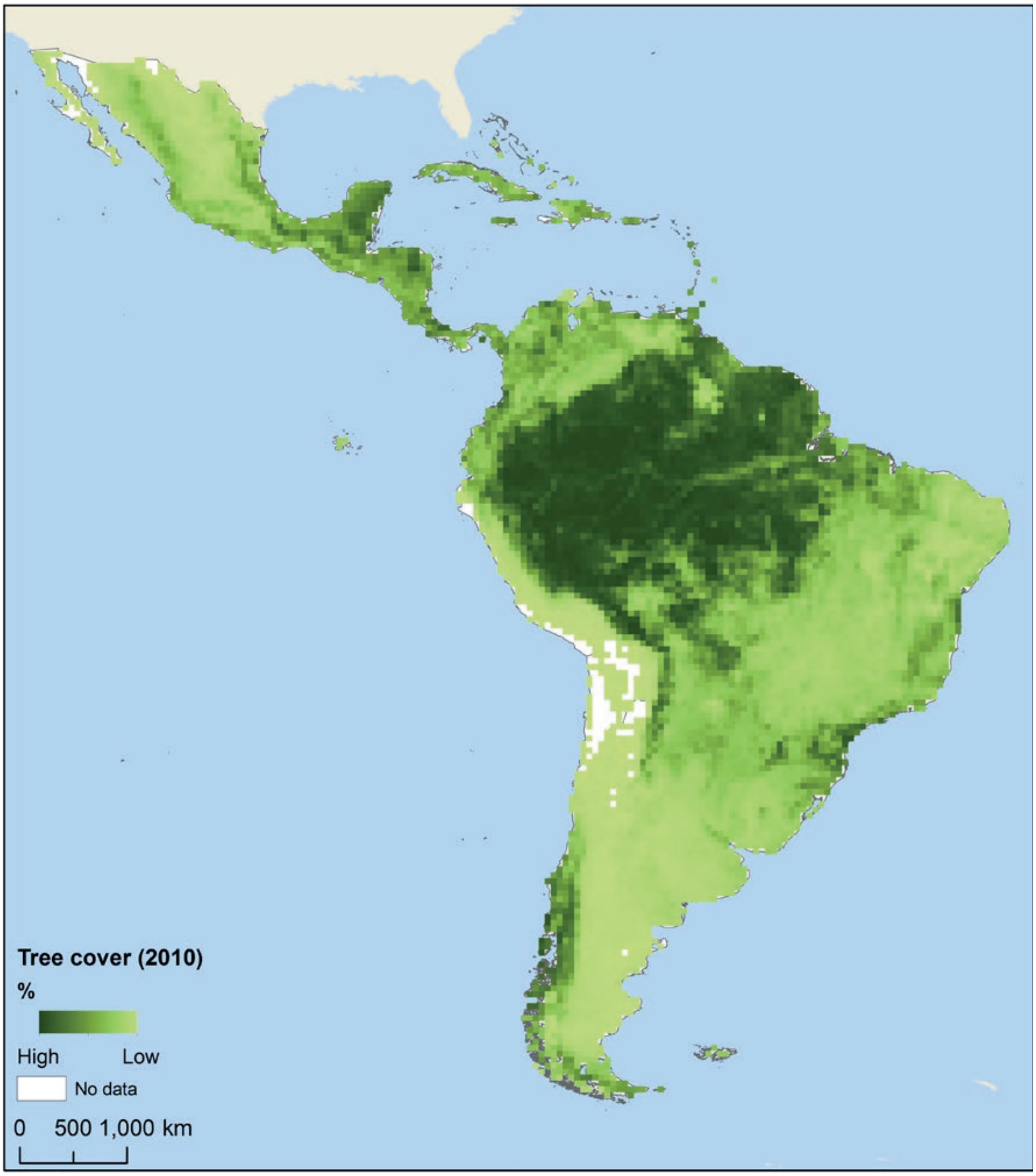


Figure 5.1: Tree cover density in the Latin America and Caribbean region (map produced by UNEP-WCMC using data from Hansen et al. 2013).

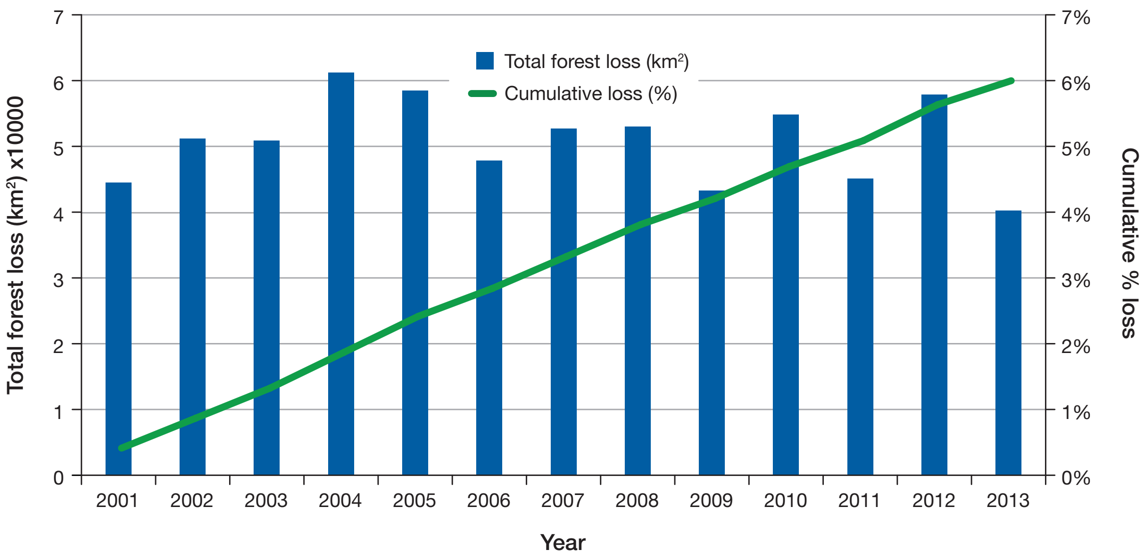


Figure 5.2: Changes in at least 10% tree cover density in the Latin America and the Caribbean region (1990-2013) compared to 2000 tree cover, blue bars represent annual forest loss and the grey line represents cumulative loss. Data are from global Landsat imagery at 30m spatial resolution. Version 1.1 was used which includes a new 2013 loss layer and updated 2011 and 2012 layers. A threshold of greater than 10% tree cover was used to remove uncertainty in forest definition around areas with sparse tree cover. Trees are all vegetation taller than 5m in height. Forest loss is a stand-replacement disturbance or a change from forest to non-forest state (source: Hansen et al. 2013).

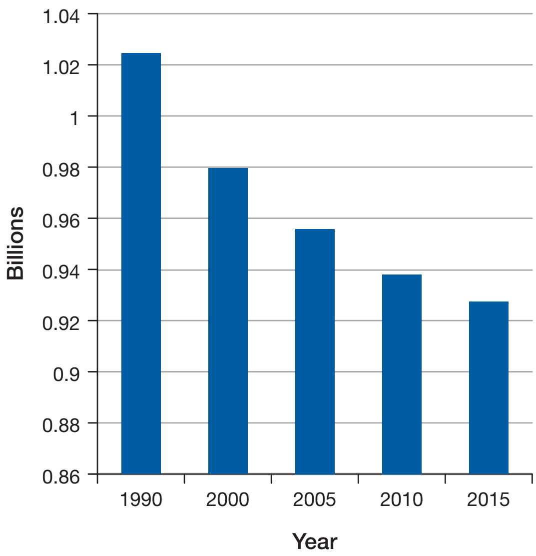


Figure 5.3: Total forest area in Latin America and the Caribbean (1990-2015) (source: FAO 2015c).

Around 12 per cent (22,000km²) of the world's mangrove forests are also found in the Caribbean (Spalding et al. 2010). Mangrove forest extends from Baja California in Mexico to the north of Peru on the Pacific coast, and from the Gulf of Mexico to Brazil's southern state of Rio Grande do Sul, in the Atlantic (CONABIO 2009). Giri et al. (2011) used Global Land Survey (GLS) data to map distribution and extent of global mangroves validated using and GIS[2] data and published literature, and report that the remaining area of mangroves worldwide is lower than previously reported by the FAO. The study reports that South America account for approximately 11 per cent of world mangrove extent, with the largest mangrove areas in Brazil and Mexico; 962,683 ha and 741,917 ha respectively.

[2] *Geographic Information Services (GIS) software*

Trends in mangrove forest cover in the LAC region are hard to assess accurately. Various studies and datasets use different metrics and sources to provide estimations of mangrove area and change in mangrove forest cover. The FAO Global Forest Resources Assessment data shows that mangrove extent increased in Latin America and the Caribbean between 2000 and 2015 (Figure 5.4) (FAO 2015c). These data are based on a combination of information provided from in-country reports and remote sensing data, and as with many datasets based on country reporting, there associated error in estimations should be considered. A study by Valiela et al. (2001) using country data from LAC countries which had multilayer records available found evidence of increase in mangrove are due to restoration initiatives in some countries, such a Belize, Cuba and Jamaica. Spalding et al. (1997) reported a 257 km^2 increase in area due to mangrove plantations, which match positive trends reported by FAO (2015c). These results are at variance with older studies that found losses of mangrove cover. For example, Polidoro et al. (2010) found that rates of mangrove area loss in the Caribbean sub-region were the second highest in the world, with around 24 per cent of mangrove area lost over 25 years.

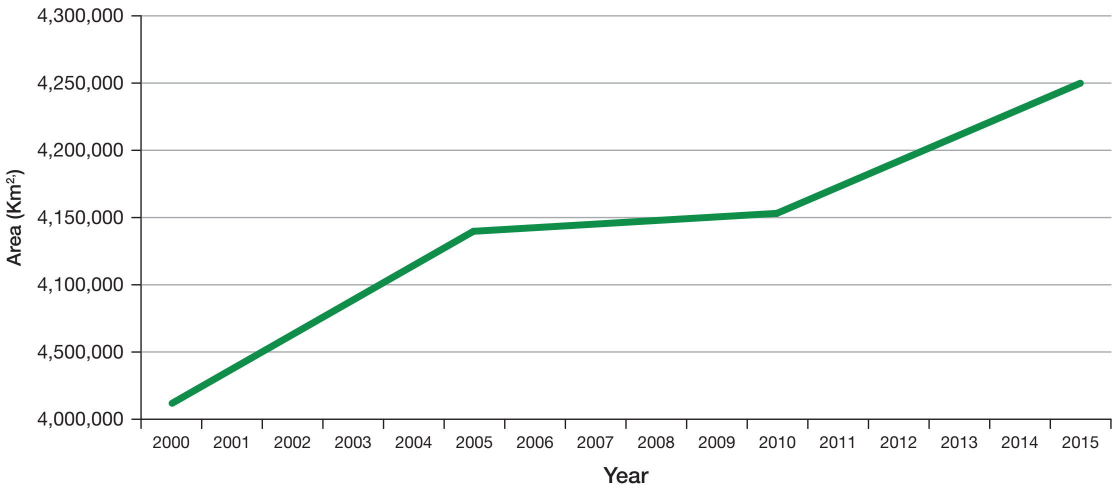


Figure 5.4: Total mangrove area in in Latin America and the Caribbean according to the FAO State of the World's Forests report (2000-2015) (source: FAO 2015c) (note: Barbados and Nicaragua are missing data for 2000 - as they have the same mangrove area for every subsequent year the same amount was entered for 2000).

The LAC region also hosts extensive areas of woodland savannahs, which are highly biodiverse. The Cerrado Region in Brazil has the largest extent of woodland savannah in South America, and is the most biodiverse savannah in the world. Rapid expansion of agriculture in the region has made it the largest producer of beef and important cash crops (World Bank 2015). Analysis of land cover by Beuchle et al. (2015) found that the net annual vegetation cover loss in the Cerrado was 0.44 per cent in the 2000s, a reduction from 0.79 per cent in the 1990s. In Colombia, high rates of habitat transformation and land use change can be seen in the savannahs of the Orinoco region and in the Llanos Orientales region (Romero-Ruiz et al. 2011; Etter et al. 2011). Between 1987 and 2007, 14 per cent of the Llanos Orientales study area underwent land use or land cover change, with greater loss of flooded savannah habitat linked to the expansion of palm oil plantations, growing from 31 km^2 in 1987 to 162 km^2 in 2007 (Romero-Ruiz et al. 2011).

Large and important wetlands are also found in the region. The Wetlands Extent Index uses a methodology, which combines over 1,000 existing datasets to assess broad global and regional trends in wetland cover (Dixon et al. 2016). Globally, the index declined by 31 per cent between 1970 and 2008. This study uses the Neotropical region (broadly equivalent to LAC) for analysis, but an accurate trend for this region could not be created as there was insufficient data (Dixon et al. 2016, Mosquera et al. 2015).

In conclusion, this region still contains huge areas of natural habitats, but many of these are shrinking due to human pressures, such as conversion for agricultural and urban development. Innovative policies around forests in the region have helped slow the rates of forest loss, particularly in the Amazon basin and in the region's mangrove forests. Other habitats, especially the savannah woodlands, are – however – being rapidly lost. In general, a lack of consistent and accurate data sources make it difficult to assess progress towards Target 5 confidently.

Box 5.1: Loss of Mangroves in Antigua and Barbuda.

Mangrove extent in Antigua dropped sharply in the decade to 2000, as a result of anthropogenic pressure on the coastline, particularly from development linked to the tourism sector. Since 2000, substantial efforts have been made to restore mangroves, resulting from increased awareness of their importance in supporting the local fishing industry, as well as understanding of other intrinsic values of mangroves. However, these attempts have been hindered by the island's exposure to frequent hurricanes and storms, which have been compounding the losses. The fifth national report to the CBD reports that mangrove cover increased between 2000 and 2004, and again between 2005 and 2010, but that a sharp loss between 2004 and 2005 resulted in 2010 levels being only slightly higher than cover in 2000. Every year between 2006 and 2012 saw at least one hurricane or tropical storm affect the island (Environmental Division, Government of Antigua and Barbuda 2014).

Box 5.2: Grenada's Forests.

Forests in Grenada are dominated by secondary forest, with only pockets of climax forest. A combination of anthropogenic pressures and natural disasters threaten the existing forest cover, including clearances for agriculture and development of the tourism sector housing, infrastructure and other commercial activities. Hurricanes, forest fires and invasive alien species are all threats to the forests and the biodiversity they contain. In 2004, hurricane Ivan had a severe impact on forest communities in Grenada. Weak public education and inadequate legislation, enforcement and monitoring have resulted in unsustainable extraction of species from the forests.

A substantial proportion of Grenada's population depend on its forests for their livelihoods, and despite these pressures, forests in Grenada are currently in a recovery phase. Replanting of mangrove forests in particular has achieved over 50 per cent restoration of mangrove ecosystems (Government of Grenada 2014).

Box 5.3: Modelling Land Use Change in Brazil.

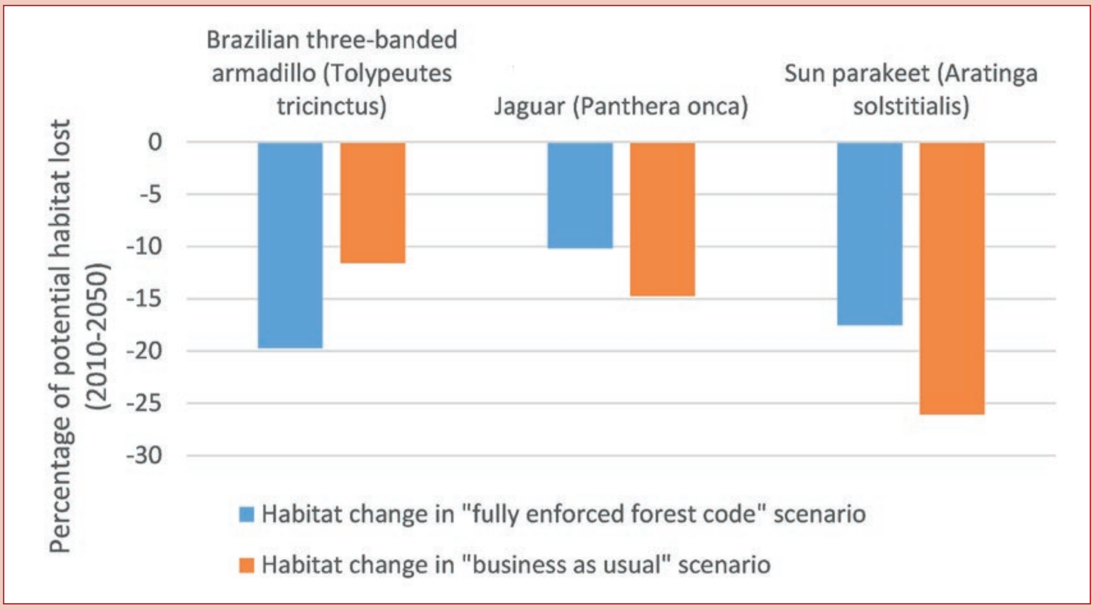
Brazil is committed to reducing its emissions from deforestation and to conserving its rich biodiversity. The policy options for reducing deforestation include the recently-revised Forest Code and various approaches to its implementation. Through the REDD-PAC project, an economic land use model GLOBIOM-Brazil has been used to model implementation of its different provisions, which differ among biomes, for different levels of enforcement. The results give projections of land use change over 2010-2050, which have been used to assess potential biodiversity impacts.

Focusing on areas identified by the Ministry of the Environment as “extremely important” for biodiversity (MMA 2007) in a scenario of full enforcement of the Forest Code, the analysis showed that:

- Relatively little conversion is projected for the remaining natural areas in the highly protected Amazonia and Mata Atlantica, suggesting positive biodiversity outcomes in these biomes.
- The Caatinga, Cerrado and Pantanal biomes face greater potential land use change pressure. 17 per cent of the area identified as “extremely important” for biodiversity in the Caatinga may face conversion.

Projected land use change under different scenarios can also be used to assess potential impacts on threatened species and compatibility of these scenarios with achieving Aichi Biodiversity Target 12 on reducing extinction of threatened species. Such analysis could also inform assessments of species threat status.

Projected impacts on the habitats of threatened species differ depending on whether or not there is full enforcement of the Forest Code. Some species, mainly in Caatinga and Cerrado, are projected to lose a large proportion of their potential habitat. The model projects a larger loss under full enforcement of the Forest Code for some species, because of displacement of land-use change pressures from Amazonia to other biomes.



Habitat loss projected for three of Brazil’s threatened species under different scenarios

Three banded armadillo

Jaguar

Sun parakeet

Box 5.4: Measuring Change in Marine Systems in the Caribbean.

The Coral Reef Watch programme of the National Oceanic and Atmospheric Administration (NOAA) uses satellite monitoring to provide near-real-time data on reef environmental conditions at 5 km or 50 km resolution, including temperature and acidification. Monitoring these conditions enables identification of sites where bleaching is likely to occur, allowing bleaching response plans to be put in place promptly (NOAA 2016). A similar tool to predict the risk of coral disease is under development (Mumby et al. 2014).

CONABIO has in place a Satellite-Based Ocean Monitoring System to provide information at a 1 km resolution for the analysis of patterns in critical oceanographic processes, such as marine productivity, harmful algal blooms, and thermal stress in coral reefs in the Gulf of Mexico, northeastern Pacific Ocean, and western Caribbean Sea (Cerdeira-Estrada and López-Saldaña 2011).

Climate change data for the Caribbean are also provided by The Caribbean Community Climate Change Centre[3] at 50km resolution. The website includes a climate modelling tool which can be used to show predicted changes in temperature, precipitation, humidity and wind speed across the region to 2100 (Mumby et al. 2014).

Box 5.5: Monitoring Forest Change in the Great Chaco Region.

(source: Caballero et al. 2014)

Forest cover change monitoring in the Gran Chaco region in South America was undertaken using visual interpretation of Landsat satellite images, taken at monthly intervals throughout 2013. The Gran Chaco Americano is a region of forest habitat with exceptional biological diversity and unique ecological process. It covers an area of 1,066,000 km2 in four LAC countries; most of the region is in Argentina, followed by Bolivia, Paraguay and in smaller proportion, Brazil (TNC 2005).

Changes in land use were detected in 502,308 ha in 2013, the equivalent to a deforestation rate of 1,376 ha per day. Paraguay had the highest proportion of land use change recorded with 236,869 ha, followed by Argentina with 222,475 ha, and then Bolivia with 42,963 ha. According to the spatial distribution and trend of deforestation identified at the provincial, departmental, and municipal level, the Boqueron and Alto Paraguay departments had the highest rates of deforestation recorded around the Gran Chaco region. In Argentina, deforestation is concentrated in the provinces of Santiago del Estero, Salta and Chaco; whereas in Bolivia the province with the largest area of change was Santa Cruz. With a loss of over half a million ha of forests in 2013, the land-use change in the Gran Chaco region is of great concern, and is primarily driven by the international demand for food, particularly meat production in Paraguay and soybean in Argentina.

[3] *www.caribbeanclimate.bz/*

TARGET 6: SUSTAINABLE MANAGEMENT OF AQUATIC LIVING RESOURCES

By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

> "Overexploitation is a severe pressure on marine ecosystems globally and has led to the loss of biodiversity and ecosystem structure. Harvests of global marine capture fisheries have been reduced from the unsustainable levels of a decade and more ago. However, overfishing still occurs in many areas, and fisheries could contribute more to the global economy and food security with more universal commitment to sustainable management policies. Target 6 should be regarded as a step towards ensuring that all marine resources are harvested sustainably." (CBD 2016c)

The sustainable management of natural resources, especially in marine and freshwater habitats, is critical for maintaining biodiversity but also for the provision of food to an expanding human population. People in the LAC region are heavily dependent on local marine and freshwater resources for food, and there are also important export industries around many marine fisheries.

Latin America and the Caribbean accounts for approximately 24 per cent of the global fisheries catch (Pérez-Ramírez et al. 2015). Peru is the second largest fisheries producer in the world, after China. No other fish species has yielded catches as large as the Peruvian anchoveta (Anchovy), but changing approaches to combat overfishing, together with shifting weather patterns, have resulted in great fluctuations in yearly catches. Argentina, Chile and Mexico also rank in the top twenty fisheries producers globally (Asthana 2015).

These issues, together with increasing demand for fish and government incentives, are also contributing more widely to the unsustainability of the fishing industry in Latin America and the Caribbean (FAO, 2011). Particular challenges are found in the deep water fisheries located in the southern end of the region, where the fish are very slow to mature, but also in the more productive fisheries of the cold water upwelling along the coast of western South America. Coral reef fisheries in the Caribbean are also challenged by overfishing at the artisanal level and the reefs themselves are also threatened by climate change and land-based pollution, including nutrient run-offs. Around two thirds of Caribbean coral reefs are under threat from coastal urbanisation, sedimentation, pollution from toxic substances, water acidification and overfishing (UNEP 2010).

None of the countries in Latin America and the Caribbean has reported in their fifth national reports to the CBD that aquatic stocks are sustainably managed, and only Guatemala specifically reports that overfishing has declined, although this may be a result of declining stocks and changing weather conditions rather than a response to policy or regulation. Actions taken around the region include establishing legislation and management plans, establishment of marine protected areas (MPAs), and the training of fishermen in sustainable fishing practices. Most actions have been implemented recently and for this reason, there is no evidence yet of positive impacts on fish populations (CBD 2015).

Only four per cent (around 10 fisheries) of fisheries in Latin America and the Caribbean are certified by the Marine Stewardship Council (MSC), and catch levels for MSC certified fisheries declined by one third between 2012 and 2015 (Figure 6.1). The ten MSC certified fisheries in the region have made twelve improvements in their environmental impact, the health of their target fish stocks and fisheries management practices, and have agreed to make a further 83 by 2020 (MSC 2016) (Figure 6.2). However, unstable governance and limited management information often hinders fisheries management (Pérez-Ramírez et al. 2015).

A study lead by the Humboldt Institute concluded that continental fisheries have reduced their catch by 60 per cent in recent decades. An inefficient and unsustainable management of these fisheries will most likely lead to their collapse, affecting communities who rely on the fishing industry, particularly in Colombia, Brazil and Peru. In general, continental fisheries are suffering great pressures, and the importance and impact of traditional fishing methods is being overlooked by policy and decision makers when designing sustainable use strategies for these fisheries (Lasso et al. 2011).

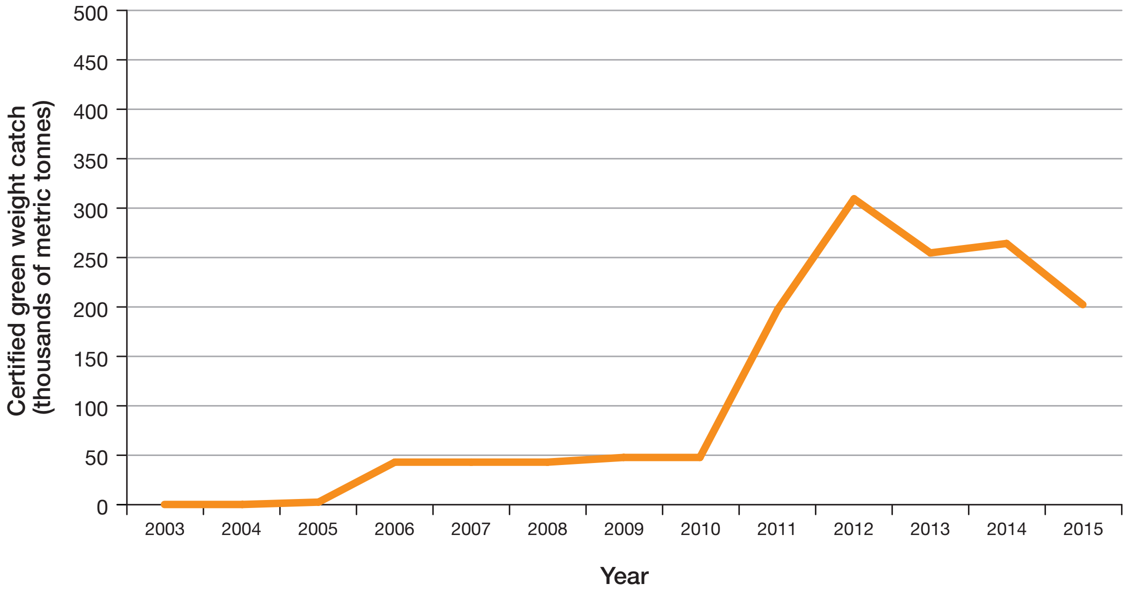


Figure 6.1: Total MSC certified catch in Latin America and the Caribbean, 2003-2015 (source: MSC 2016). All MSC fisheries assessments are carried out by accredited 3rd party certifiers, and therefore all data provided here have been generated by these companies. The MSC does monitor and correct data where possible, but cannot guarantee that the data has been validated against the most recent reports available on msc.org. Catch data collected prior to 2012 have in some cases been estimated or extrapolated based on past fisheries assessment reports in order to fill in data gaps.

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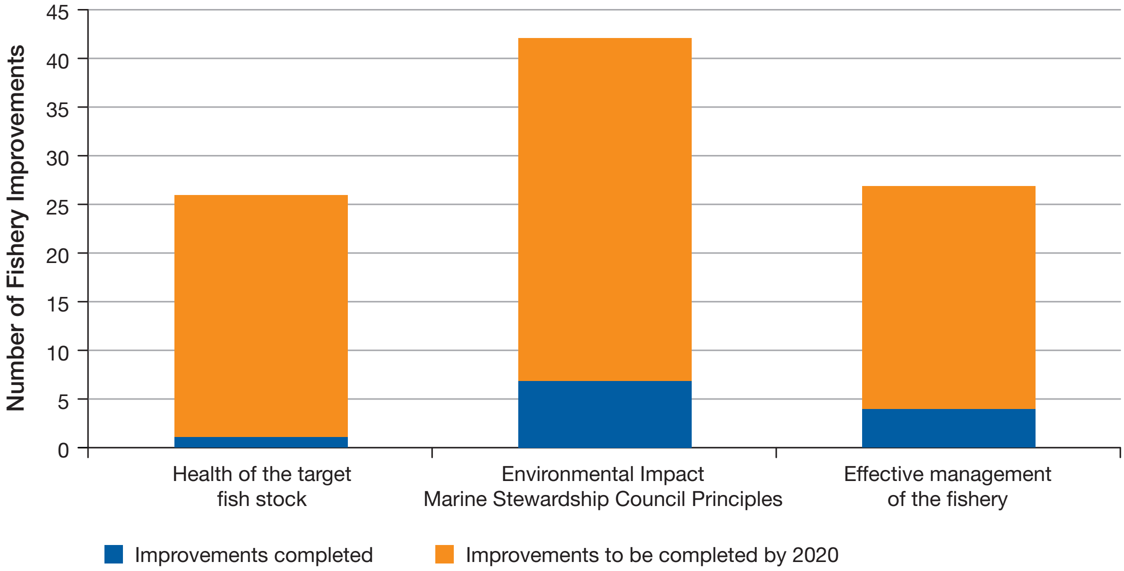

Figure 6.2: Number of fishery improvements completed and to be completed by MSC fisheries in Latin America and the Caribbean by 2020 (source: MSC 2016). There are 10 fisheries certified in Latin America and the Caribbean (as of end 2015). This includes 3 based in Argentina, 2 in Chile, 3 in Mexico, 1 in Suriname and one in the Falkland Islands (Malvinas).

In conclusion, the region is not on track to meet Target 6 by 2020, and much more needs to be done. The downturn in certification of marine fisheries in the region in recent years is of particular concern, as is the continued overfishing and illegal fishing of some of the regions fish stocks.

Box 6.1: The Patagonian Toothfish.

The Patagonian Toothfish (*Dissostichus eleginoides*) occurs in the Economic Exclusive Zones (EEZs) of Chile and Argentina as well as several sub-Antarctic islands. It grows up to 2 metres and lives for 50 years, which, combined with a relatively late sexual maturity and low fecundity, mean it is particularly vulnerable to overfishing (Lack and Sant 2001). Historically, legal catch volumes have followed a similar pattern in both Chile and Argentina, with a rapid expansion (peaking in 1992 in Chile and 1995 in Argentina) followed by nearly as rapid a decline (FAO 2004b).

Illegal, unreported and unregulated (IUU) fishing is a substantial pressure on toothfish populations; estimates of IUU for 1999/2000 range from 8.4 thousand tonnes to 33.9 thousand tonnes, compared to a reported legal catch of 25.2 thousand tonnes (Lack and Sant 2001). In response, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) established an International Catch Documentation Scheme (CDS) to monitor trade by requiring its members to document all toothfish catch (FAO 2004b). Argentina, Brazil, Chile and Uruguay are all members (CCAMLR, 2016). Catch quotas for fisheries, limits on the number of vessels working in exploratory fisheries and vessel monitoring systems (VMS) for all vessels with a licence to catch toothfish are among other conservation tools employed (Lank and Sant 2001).

More recently, although IUU remains a concern for the toothfish, estimated volumes are substantially lower, with estimates for IUU in 2007 ranging between 3.6 thousand tonnes and 5.7 thousand tonnes, approximately 16 per cent of the total toothfish trade (Lack 2008).

TARGET 7. SUSTAINABLE AGRICULTURE, AQUACULTURE AND FORESTRY

By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.

"The growing demand for food, fibre and fuel will lead to increasing losses of biodiversity and ecosystem services if issues related to sustainable management are not addressed. On the other hand, sustainable management not only contributes to biodiversity conservation but also can deliver benefits to production systems in terms of services such as soil fertility, erosion control, enhanced pollination and reduced pest outbreaks, as well as contributing to the well-being and sustainable livelihoods of nearby communities engaged in the management of local natural resources." (CBD 2016c)

Agriculture, aquaculture and forestry are all significant threats to biodiversity across Latin America and the Caribbean, often driven by demand for exports. The fifth national reports to the CBD mention a variety of projects designed to increase sustainable agriculture across the region, including 'Clean Production Agreements' in Chile (Box 7.1).

Impacts from sustainable agriculture initiatives are varied, with several countries, including Belize, Ecuador, and Peru reporting an increase in sustainable agriculture, while Costa Rica reports a decrease in organic agriculture. Less information is available about aquaculture, but Belize stands out as a leading country for shrimp farm certification, and Peru provides guidelines for sustainable aquaculture within its National Aquaculture Development Plan (CBD 2015). Intensive salmon farming in Southern Chile – the second biggest salmon producer in the World - still presents important environmental challenges. In 2007, Chile produced a total of 904,000 tonnes of salmon, mollusc and seaweed through aquaculture (Buschmann et al. 2009). This intense production has caused overcrowding of farms which have been forced to use record levels of antibiotic to treat diseases (e.g. Piscirickettsiosis), causing significant impacts to marine ecosystems.

Countries may choose to incorporate sustainable practices into their National Biodiversity Strategic Action Plans (NBSAPs). For example, one of the activities in Peru's NBSAP was to strengthen the sustainable management of forest resources and wild animals by the second half of 2015 through implementing national plans and prioritising community forest management (Epple et al. 2014). There are also other elements of sustainable forest management in the region – for example a move towards Long-Term Forest Licences (Belize) and forest certification (Uruguay) are among the many programmes in place to move towards sustainable forestry, but there is little information on their impact (Forest Department, Ministry of Forestry, Fisheries and Sustainable Development, Belize 2015).

7.1 Agriculture

Rising global demand for meat and dairy products has substantially increased agricultural activity in the region. Between 2001 and 2011, poultry production in Latin America and the Caribbean nearly doubled, and production of milk, beef and pork increased by over one third, far exceeding average global increases. In 2012, the region produced 28 per cent of the world's beef, and 23 per cent of the world's poultry. Continued rapid growth in production is forecasted over the next decade (FAO 2014). This agricultural expansion leads to environmental pressures as deforestation occurs in order to grow crops, such as soybeans, as feed for livestock (Herrero et al. 2009), and highlights the need for sustainable agricultural practices.

Irrigation in the LAC region has expanded annually by an average of 250,000 ha over the past 50 years. In 2015, 15 million ha were equipped for irrigation, and 12 million ha were actually irrigated. Most irrigation utilises surface water, but there is a strip of land approximately 500 km wide and 2,500 km long, in Brazil and northeast Argentina, which is mainly irrigated from groundwater. A comparison of the withdrawal volume of groundwater for agriculture, industry and domestic water supply to the availability of groundwater found that 26 of 77 river basins studied across the LAC region face severe water scarcity for at least one month each year, and three experience water scarcity all year round. In total, 76 per cent of groundwater withdrawals across the LAC region are related to crop production (Mekonnen et al. 2015).

Box 7.1: Clean Production Agreements in Chile.

The National Council for Clean Production (NCCP) sits under the Ministry of Economy for Chile. The main instrument used by the NCCP is the Clean Production Agreement (CPA), a voluntary agreement setting out actions to be implemented by a productive industry within a specified time period. CPAs are agreed and signed by industrial organisations representing the companies in a specific sector. Under the agreements, companies receive technical assistance and training to help implement the agreed actions, and a certification scheme is in place to recognise companies that operate as set out in the CPAs. Reduction of carbon emissions is a key goal of the NCCP.

A study of 16 of the 54 CPAs implemented and certified between 2002 and 2010 estimated that each CPA had reduced carbon dioxide emissions by an average of 31.6 kilotonnes per year. By 2012, 76 CPAs had been signed (UNFCCC 2012).

Box 7.2: Sustainable Production Systems and Biodiversity in Mexico.

(source: Martha Rosas Hernández)

The Sustainable Production Systems and Biodiversity Project in Mexico supports producer associations to introduce biodiversity-friendly production practices and enables them to gain or increase access to markets that reward biodiversity-friendly goods and services. The project is being implemented by the National Commission for the Knowledge and Use of Biodiversity (CONABIO), co-financed by the Global Environmental Facility and supervised by the World Bank.

Implemented in six states in southern Mexico, the project is working on applying biodiversity-friendly production practices across seven production systems: coffee, cocoa, honey, eco-tourism, wildlife, forestry and silvopastoral systems. The agro-ecological perspective to production, coupled with the market linkages of biodiversity-friendly production, make this approach unique and adaptable to similar settings in other countries.

With more than 50 per cent of the land in Mexico being used for agricultural production, the management of natural resources with landscape approaches inevitably integrates food production and income generation with conservation of environmental assets.

Box. 7.3: National Policy for Agroecology and Organic Production - PNAPO.

The Brazilian National Policy of Agroecology and Organic Production (PNAPO) (DECREE No. 7794, 08/20/ 2012) was established with the objective to integrate, coordinate and adapt policies and programs, promote agroecological transition and organic production, contribute towards sustainable development and improve the quality of life for people through sustainable use of natural resources and the supply and consumption of healthy foods. The National Plan for Organic Production (PLANAPO) was set up for the implementation of the PNAPO, and includes multiple guidelines for producers and their organization, certification, credit expansion, technical training, fostering the conservation, management and sustainable use of resources natural; democratization of the research agenda, recognizing and strengthening the role of young people and rural women in agroecology and organic production. Between January 2014 and January 2015, the number of farmers who opted for organic production grew from 6,719 to 10,194 (51.7 per cent). The Northeast region is where there are the most organic farmers. *http://www.agricultura.gov.br/comunicacao/noticias/2015/03/numero-de-produtores-organicos-cresce-51porcento-em-um-ano.*

7.2 Aquaculture

In 2012, 20 per cent of fish production in Latin America and the Caribbean was from aquaculture. Chile is the largest producer in the region, with annual production of 0.7 million tonnes, mainly industrial production of Atlantic salmon. The majority of aquaculture production in other countries in the region is generally small-scale. Globally, it is expected that aquaculture will expand substantially to meet increasing demand for fish that cannot be met from extractive fishing due to depletion of marine resources (FAO, 2014). The World Wide Fund for Nature (WWF) and the Dutch Sustainable Trade Initiative (IDH) established the Aquaculture Stewardship Council (ASC) in 2010. The ASC aims to be a global leader in certification and labelling for responsible farmed seafood (ASC 2016). In 2014, the WWF received a grant from Sea Pact, a coalition of seafood companies in the US, for its Chilean Aquaculture Improvement Project, which seeks to move the farmed salmon industry in Chile into ASC certification (Undercurrent News 2014).

In conclusion, aquaculture has been expanding in the region, especially in southern countries. Efforts are being made to improve the sustainability of aquaculture production, especially for the salmon fisheries of Chile and Argentina, and of shrimp farming in the tropical countries of Central America.

Box 7.4: Shrimp Farming Certification in Belize.

The shrimp farming industry in Belize has taken the lead in introducing certification under the Aquaculture Stewardship Council. Belize is the first country in the world to introduce certification, and expects 75 per cent of its 13 shrimp farms (which together employ over 1,000 people) to be certified (Forest Department, Ministry of Forestry, Fisheries and Sustainable Development, Belize 2014).

Box 7.5: Law for the Promotion and Development of Aquaculture, Peru.

The Law for the Promotion and Development of Aquaculture was introduced in Peru in 2001. Under the regulations, a National Plan for Aquaculture Development is required to be approved by the Ministry of Production. Concessions are granted for the development of aquaculture in public areas, and authorisations are granted both for the development of aquaculture on private property, and for research and restocking. Legislation requires that an Environmental Certificate of the Environmental Impact Study granted by the Ministry of Production is in place before species are moved or introduced, and before aquaculture operations are established (FAO 2016a).

7.3 Forestry

Between 2005 and 2010, over 3.9 million ha of forest cover was lost in the region each year. This represents 70 per cent of the global reduction in forest cover over that period (FAO, 2014). Total annual roundwood production has steadily increased over the last decade, and FAO data show that 504 million cubic metres of roundwood were produced in Latin America and the Caribbean in 2014 (FAO 2016b).

The need for sustainable management programmes and protected area enforcement for forest habitats is clear. One way of promoting sustainability within forestry is through the certification of timber. The FAO Global Forest Resources Assessments (FAO 2015c) contains detailed information on certification, including country reports with detailed assessments of deforestation and land cover, which allows the analysis of the sustainability of forest management techniques.

The Forest Stewardship Council (FSC) has been working in Latin America and the Caribbean since 1993, originally in Costa Rica, and shortly followed by Brazil in 1995. Both the area of certified sustainably managed forests, and the number of countries reporting certification, have increased steadily until a peak in 2010 and have remained reasonably stable since then. In July 2015, 12.8 million ha of land were under an FSC certification (Figure 7.1). Nearly half of the certified land in the region (6.1 million ha) in July 2015 was within Brazil (FSC, 2016). Latin America has the second largest share of FSC Forest Management (FM) certificates in the world, after Europe. The FM certification confirms that an area of forest is being managed in line with the FSC principles and criteria, as assessed by an FSC accredited certification body, and with the PEFC (Programme for the Endorsement of Forest Certification) Sustainability Benchmarks, as assessed by a notified certification body (PEFC 2016). These certifications are valid for five years (FSC 2106).

As well as FSC certification, the PEFC is another certification scheme used, often by small forest owners, across the region. The first countries to join the PEFC were Chile and Brazil in 2002, followed by Uruguay in 2006 and Argentina in 2010. Chile became the first country in the region to achieve PEFC endorsement in 2004, with Brazil following one year later. Uruguay and Argentina achieved PEFC endorsement in 2011 and 2014 respectively. As of June 2015, 4.7 million ha of land were under PEFC certification. Nearly half of this area is in Brazil, which has the largest percentage increase in PEFC certified forest area to date growing from 1.3 to 2.4 million ha. Chile has remained stable at 1.9 million ha. Uruguay added its first PEFC-certified area in June 2015 (360,000 ha), and Argentina declared its first PEFC-certified area in 2016.

In the LAC region, Mexico has the largest percentage increase in FSC Certificates (18 per cent). Panama and Chile have seen the highest growth in areas of forest certified under the FSC, with a growth of 139 per cent for Panama and 49 per cent for Chile between 2013 and 2015 (FSC 2015). The number of Chain of Custody (CoC) certifications, which trace wood from the forest through all stages of the production and distribution process, have grown steadily from 539 in 2010 to 1,450 in 2015 (FSC 2016), improving the sustainability of timber harvesting and marketing in the region.

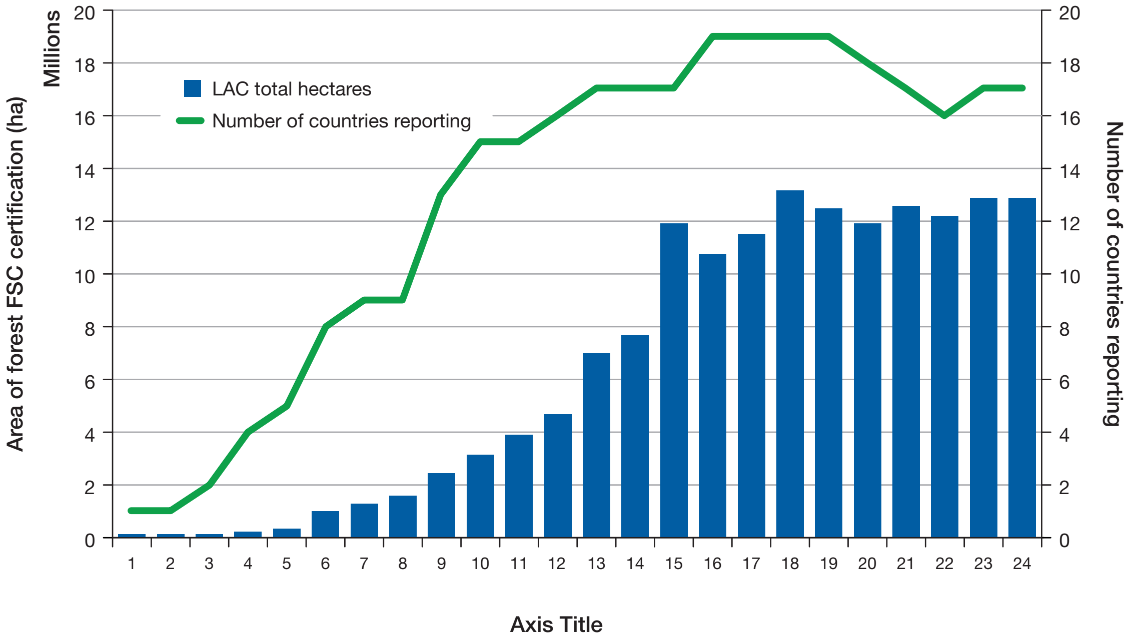

Figure 7.1: Area of forest with FSC certification, and the number of countries reporting sustainable forest management in Latin America and the Caribbean (1993-2015) (source: FSC 2016).

In conclusion, some progress is being made to achieve this target across the region. Efforts are in place to developed and maintain appropriate data bases and monitoring techniques to improve the sustainable management of agriculture, aquaculture and forestry. However, these efforts and the progress made seem insufficient to fully meet the target by 2020. There has also been some concerning stabilisation of the uptake of the certification standards in the region, and much of the production of materials remains uncertified. While PEFC certified area has grown by half a million ha from June 2015 to June 2016, there appears to be less of an interest in promoting sustainable forest management through forest certification than in other regions, such as Asia and the Pacific.

TARGET 8: POLLUTION REDUCED

By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.

"Nutrient loading, primarily of nitrogen and phosphorus, is a major and increasing cause of biodiversity loss and ecosystem dysfunction, especially in wetland, coastal and dryland areas. As nitrogen and phosphorus are often limiting nutrients in many ecosystems, when they are present in excessive quantities they can result in rapid plant growth which can alter ecosystem composition and function. Humans have already more than doubled the amount of "reactive nitrogen" in the biosphere, and business-as-usual trends would suggest a further increase of the same magnitude by 2050." (CBD 2016c)

Agriculture, urbanisation, and mining are significant sources of pollution in Latin America and the Caribbean. Nearly 80 per cent of the population of Latin America and the Caribbean live in cities, the highest proportion of any region in the world (UN Habitat, 2012). Urban areas are particularly susceptible to outdoor air pollution, and over 100 million people living in the region are exposed to air pollution levels that exceed World Health Organization (WHO) air quality guidelines (UNEP 2016a). In 2014, the XIX Forum of Ministers of Environment of Latin America and the Caribbean adopted a Regional Action Plan on Air Pollution, with specific objectives including establishment of national standards, monitoring and evaluation programmes and national action plans for air quality (Clean Air Institute 2014). The quality of fresh water, in both rural and urban areas, is a key issue across Latin America and the Caribbean. Infrastructure is available to treat just 35 per cent of waste water, and in practice only 20 per cent is treated effectively (Mejia 2014). Cities across the region, including Buenos Aires (Argentina), Sao Paulo (Brazil), Bogota (Colombia), Mexico City (Mexico), and Lima (Peru), have been planning substantial development of wastewater treatment, but such investments have typically been delayed for many years due to institutional and policy framework challenges (Mejia 2014).

Pollution resulting from nutrient run-off from crops fields and farming activities is also a serious concern in the LAC region, including its downstream effects on marine and coastal areas. Around 18 million ha of land across the region are irrigated for agriculture each year, and in 2008, production and consumption of food and energy resulted in an average reactive nitrogen loss of around 36 kg of nitrogen per inhabitant per year. This is around 7.5 kg per person per year higher than the global average, with the difference being mostly attributable to food production (Figure 8.1). Use of nitrogen and phosphorus in agriculture varies, with different levels of nutrient loading across the region. No areas have a nitrogen or phosphorous load greater than 250,000 kg per hectare, however higher nitrogen loading (1,000–250,000 kg per hectare) is seen in Mexico, Cuba and southern Brazil, and phosphorous loading occurrences are also seen in southern Brazil (Figure 8.2). Other negative effects caused by agricultural intensification include pollution through release of pesticides, herbicides and organic waste into the environment (UNEP 2016a), and salinization resulting from irrigation in Argentina, northeast Brazil, Cuba, Mexico and Peru (Mejia 2014).

It has been estimated that 96.7 billion m^3 of water is affected by nitrogen-related pollution annually in the LAC region; 46 per cent as a result of crop production, 17 per cent by industrial production and 37 per cent resulting from domestic water supply (Mekkonen et al. 2015). Only 7 per cent of the total volume of water polluted is estimated to be a result of production for exports. Maize, sugarcane and wheat together account for 52 per cent of all fresh water pollution from crop production in the LAC region (Mekkonen et al. 2015).

Unfortunately, there is limited information reported in the fifth national reports to the CBD on actions taken to address Target 8. Just two countries in the region (Argentina and Dominica) report any improvement in pollution levels and only eight countries report any direct actions to tackle pollution (CBD 2015).

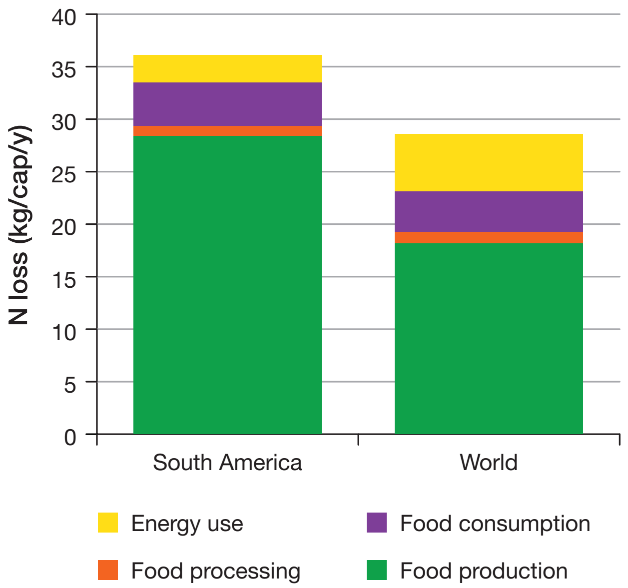

Figure 8.1: Average loss of reactive nitrogen per inhabitant in 2008 (source: International Nitrogen Initiative 2014a)

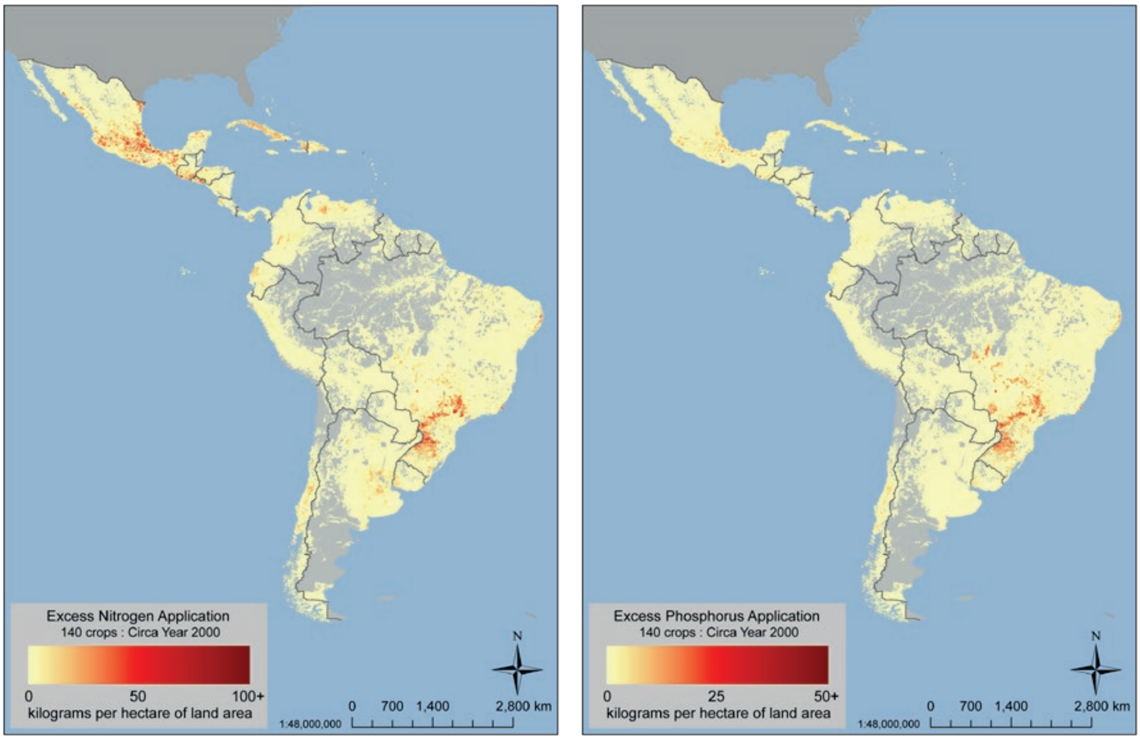

Figure 8.2. Nitrogen (a) and phosphorus (b) excess application in Latin America and the Caribbean. Data are based on administrative-level and crop-specific fertilizer application rates modelled at 5' spatial resolution (~10 km) using crop area and yield data as inputs. Given uncertainties in the model estimates at the grid cell scale, interpretation based on broader administrative units is advised (West et al. 2014) (source: Global Landscapes Initiative, Institute on the Environment, University of Minnesota. Data available at EarthStat.org).

Mining activities in many locations across Latin America and the Caribbean result in the release of pollutants to the environment, such as mercury from gold mines and 'red mud' resulting from bauxite extraction (UNEP 2016a). It has been estimated that over 13 billion cubic metres of water containing dissolved toxins are released into fresh water ecosystems each year from mining and metallurgy operations (Bebbington and Williams 2008). Similarly, the oil and gas industry is also a major source of water pollution.

Pollution in the Caribbean sub-region continues to be a problem, especially in marine and freshwater ecosystems, however there is limited available data on how pollution affects coastal water quality in the Caribbean. Available studies show that, in areas of coastal development and unregulated agriculture, water transparency generally declines steeply. For example, this has been demonstrated at Carrie Boy Cay in Belize and La Parguera in Puerto Rico. Coastal pollution has been linked to coral disease, but limited research has been carried out on this subject (Jackson et al. 2014). Díaz and Rosenberg (2008) identify 15 hypoxic 'dead zone' sites in Latin America and the Caribbean, where ocean biodiversity cannot survive due to low levels of oxygen in seawater (NOAA 2016). Most of these are associated with urban areas, including Buenos Aires in Argentina, Recife, Rio de Janeiro and Sao Paulo in Brazil, Cancun in Mexico, Lima in Peru and Montevideo in Uruguay (UNEP 2016a). The high maritime traffic in the semi-enclosed Caribbean Sea also increases the threat of pollution, from oil spills and ship waste water, and Singh et al. (2015) found that around 83 per cent of the Caribbean Sea could be impacted by oil spills derived from shipping if the current situation and lack of management continues.

In conclusion, pollution remains one of the region's most visible environmental problems, and more work is needed, as LAC is so far not on track to meet Target 8 by 2020. Pollution is particularly serious in some of the major cities in the region, and in the rivers and marine and coastal areas downstream of them. However, contamination levels remain lower across much of the areas in the LAC region, especially in some of the extensive remote forest and wetland habitats.

Box 8.1: Pollutant Release and Transfer Registries (PRTRs).

PRTRs are databases used to record and share information on both the release of chemicals and other pollutants into the air, water or soil, and the transfer of pollutants off-site for disposal by businesses and industry. They can be used by governments to monitor trends in the release and transfer of pollutants in order to take steps to reduce potentially damaging releases. Chile, Honduras and Mexico have all implemented national PRTRs (UNECE 2016).

TARGET 9: INVASIVE ALIEN SPECIES PREVENTED AND CONTROLLED

By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.

"Invasive alien species are one of the main direct drivers of biodiversity loss at the global level. In some ecosystems, such as many island ecosystems, invasive alien species are the leading cause of biodiversity decline. Invasive alien species primarily affect biodiversity by preying on native species or competing with them for resources. In addition to their environmental impacts, invasive alien species can pose a threat to food security, human health and economic development. Increasing levels of travel, trade, and tourism have facilitated the movement of species beyond natural bio-geographical barriers by creating new pathways for their introduction. As globalization continues to rise, the occurrence of invasive alien species is likely to increase unless additional measures are taken." (CBD 2016c)

Invasive Alien Species (IAS) are a serious and increasing problem globally, with species being moved around the world through global trade, especially in the marine realm (Bax et al. 2003). Island systems are particularly vulnerable to invasive species of plants and animals, sometimes resulting in considerable numbers of local extinctions (Butchart et al. 2006).

A review of the fifth national reports shows that ten countries within Latin America and the Caribbean have programmes in place to control or eradicate specific invasive alien species, for example the marine lionfish in Belize and Saint Vincent and the Grenadines, which is also known to be a problem in Antigua and Barbuda (Gómez Lozano et al. 2013). Another five countries are undertaking identification and assessment activities to identify IAS problems. Argentina, Brazil, Cuba, Dominican Republic, and Ecuador have each implemented a national strategy on invasive alien species, indicating a more comprehensive approach (CBD 2015).

In 2006, Brazil finished its first national report on invasive alien species. About 500 species were identified, recoding effects from invasive species on wild animals and plants, species of socio-economic importance and on marine and freshwater habitats. A national strategy was designed following this report by the Ministry of the Environment, however it suffers from continuity and a strategic implementation plan (MMA 2006).

There is insufficient and scattered data regarding marine alien species in the Caribbean, with the exception of the green mussel (*Perna viridis*) and the red lionfish (*Pterois volitans*). Researchers are aware of 45 alien species, but as a result of poor taxonomic knowledge in the region it is often difficult to determine whether species are introduced alien species, or native, but not previously recorded (Miloslavich et al. 2010).

Eradications of invasive alien species from islands are an important contribution towards meeting Aichi Biodiversity Target 9. So far, 175 successful island eradications of 20 different vertebrate species have been carried out in 15 countries in Latin America and the Caribbean (Figure 9.1). Of these, 28 per cent were carried out in Mexico by the "Grupo the Ecología y Conservación de Islas" (a Civil Society Organization in collaboration with different governmental institutions; Samaniego et al. 2009; Aguirre-Muñoz et al, 2011). A further 39 eradications (22 per cent) were carried out in the Galapagos archipelago (Ecuador), a well-known center of biodiversity and evolution (Island Conservation, University of California at Santa Cruz, IUCN SSC Invasive Species Specialist Group, University of Auckland and Landcare Research New Zealand, 2014). A recent highlight was the rat eradication in Cayo Centro, part of the Banco Chinchorro area in the Mexican Caribbean.

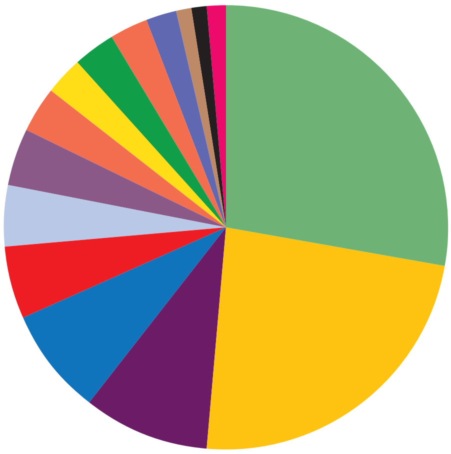

Figure 9.1: Per centage of successful invasive vertebrate species eradications from Mexico (MX), Ecuador (EC), United States Virgin Islands (VI), Antigua and Barbuda (AG) , Saint Lucia (LC), Puerto Rico (PR), Turks and Caicos Islands (TC), Chile (CL), Bermuda (BM), Brazil (BR), Martinique (MQ), Bahamas (BS), Saba, Sint Eusatius and Bonnaire (BQ), Guadeloupe (GP) and the British Virgin Islands (VG) (n = 175) (source Database of Islands and Invasive Species Eradications, June 2014 (Island Conservation, University of California at Santa Cruz, IUCN SSC Invasive Species Specialist Group, University of Auckland and Landcare Research New Zealand, 2014)).

In conclusion, Invasive Alien Species are a significant challenge in parts of the region – especially in the islands and some of the near shore marine areas. There are also examples of introductions of invasive northern hemisphere mammals and plants into southern South America. Active programs to control and eradicate these species are in place and some successes have been achieved. However, there remains much to do and progress towards the target is probably insufficient to fully address its needs by 2020.

Box 9.1: Early Warning System and Rapid Response for Alien and Invasive Species in Cuba.

Cuba has developed an Early Warning System and Rapid Response for Alien and Invasive Species, which is now being implemented for 13 plant and 14 animal species. It is an important mechanism for both early detection of exotic species, and for the detection of any unusual behaviour seen in both alien and native species. Over 30 national institutions are involved in this initiative and progress has been high since 2011 (República de Cuba 2014).

Box 9.2: Mitigating the Threats of IAS in the Insular Caribbean (Dominican Republic).

The major achievements of the project "Mitigating the Threats of IAS in the Insular Caribbean" include (Ministerio de Medio Ambiente y Recursos Naturales, República Dominicana 2014):

- Creation of the National Committee on IAS
- Preparation of the National IAS Strategy (Ministerio de Medio Ambiente y Recursos Naturales, República Dominicana 2012)
- Publication of a Critical Situation Analysis of IAS in the Dominican Republic
- Preparation and publication of a booklet with basic guidelines for the management of invasive species, aimed at students in secondary education
- An education and awareness campaign was conducted nationwide, including the creation of a documentary about invasive species. This campaign was complemented by talks aimed at secondary school students in five pilot provinces
- Baseline studies conducted in Alto Velo, to identify the presence of invasive plants as well as mammals
- Implementation of the pilot project "Eradication of mammal invaders" in Cabritos, which resulted in the removal of a total of 133 donkeys, 196 cats and 2 cattle (Caribbean Invasive Alien Species Network 2011).

Box 9.3: Identifying Invasive Alien Species in Mexico and Implementing Measures.
(source: Ana Isabel González, Georgia Born-Schmidt and Patricia Koleff)

Mexico developed its National Strategy on Invasive Alien Species (NSIAS) during 2008-2010. This document is in line with other strategies on biodiversity (at both national and state levels), considering the importance of safeguarding Mexico´s natural capital and preserving its extraordinary biological diversity (CNM 2009).

Work on the implementation of the NSIAS has been ongoing since 2010, with the collaboration of numerous institutions and experts. Examples include changes in the General Law of Wildlife, which now includes invasive alien species (IAS) that should be regulated. CONABIO coordinated the risk evaluation of over 450 taxa belonging to most biological groups, to provide the Ministry of Environment with a comprehensive list of the worst IAS that are already present in the country, those that are of major concern considering pathways and some feral species that pose a threat to areas of high biodiversity value. The National Invasive Species Information System (NISIS) continues to be an important reference regarding decision making on IAS in Mexico, and has been widely used by decision makers. The system currently holds information on almost 2000 species, including risk assessment data, specimen and observation records, distribution maps and species information sheets; to improve the monitoring and early detection of IAS the NISIS is also successfully associated with other national efforts such as the Degradation Monitoring Systems, which are based on the National Forest Monitoring System and the citizen science portal (NaturaLista), as well as with international partners such as the Invasive Species Compendium from CABI, the Global Invasive Species Database and the GIASIPartnership. The GEF financed project "*Enhancing National Capacities to Manage Invasive Alien Species (IAS) by Implementing the National Strategy on IAS*" has been running since 2014 and aims to strengthen the strategic actions that are being developed to ensure that, by 2020, Mexico will achieve the results set in the NSIAS as well as Aichi´s Biodiversity Target 9. There are currently 15 partners in this project, including federal and state governments, productive sectors, universities and NGO´s and it is being implemented with support from UNEP and coordinated by CONABIO and CONANP.

Box 9.4: Pinzón and Plaza Sur Islands, Galápagos.

Rats introduced to Pinzón Island preyed on the eggs and hatchlings of the island-endemic Pinzón Giant Tortoise (Chelonoidis nigra duncanensis) for 150 years, preventing them from reproducing and leaving an aging population to gradually die off. In the 1960s, conservation efforts were implemented by harvesting eggs, incubating them and raising the hatchlings in captivity until they were big enough to survive the rats in the wild. To implement a more permanent solution, an eradication operation was carried out by a partnership of conservation organisations in 2012 to remove all invasive rodents from the island. Extensive monitoring in 2015 confirmed that the eradication was successful, allowing the Pinzón Giant Tortoise to once again reproduce successfully in the wild.

On the small nearby island of Plaza Sur, invasive house mice were eating the root systems of a sister species of the Opuntia cactus (Opuntia galapageia), found only in the Galápagos Islands. Not only was this causing the cacti to fall over and stopping them from regenerating, but the fruit of the cactus is the favoured food of the Galápagos Land Iguana (Conolophus subcristatus) and so the mice were also depleting the iguana's food source. A successful eradication operation was also carried out on Plaza Sur in 2012 (Island Conservation et al. 2016).

TARGET 10: ECOSYSTEMS VULNERABLE TO CLIMATE CHANGE

By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

"Urgently reducing anthropogenic pressures on those ecosystems affected by climate change or ocean acidification will give them greater opportunity to adapt. Where multiple drivers are combining to weaken ecosystems, aggressive action to reduce those pressures most amenable to rapid intervention should be prioritized. Many of these drivers can be addressed more easily than climate change or ocean acidification." (CBD 2016c)

This target focuses on coral reefs and their status under climate change as well as other climate vulnerable ecosystems – such as high mountain habitats, Andean forests and mountain wetlands.

Globally Target 10 was not reached by its 2015 deadline. The fifth national reports to the CBD suggest a similar situation for Latin America and the Caribbean. A slight recovery of corals was reported in Costa Rica, and Belize reported an increase in coral cover together with a decrease in coral health. The overall picture, however, is that marine ecosystems vulnerable to climate change and ocean acidification continue to face significant pressures. Actions implemented across the region to address these pressures include MPAs, trawling bans, and managed access areas (CBD 2015).

Coral reefs harbour the most biodiversity of any marine ecosystem and constitute important links in maintaining healthy fisheries (Miranda et al. 2003). Within the LAC region, the Caribbean and Indo-Western Pacific sub-regions in particular supports important tropical coral reef communities (Reef Base 2014; Mumby et al 2014). Analyses of the threats to the coral reefs in the LAC region based on Reef Base (2014) data show that many of the reefs have been affected by bleaching events in the period 1998-2006 (Figure 10.1). The oceans of the region are also subject to satellite measured thermal stress (Figure 10.1). In the eastern Pacific, coral reefs face a variety of threats, including sedimentation, overgrowth of algae and algal blooms, worsened by high levels of nutrients resulting from agricultural and urban pollution, and increasingly from growing levels of plastics reaching coastal and marine areas. In the Atlantic and the Caribbean Sea, declines in coral reefs area linked to overfishing and diseases, both of corals themselves and of other marine biodiversity such as the long-spined sea urchins (*Diadema antillarum*) that graze on algae, making space for corals. Other threats include pollution and damage from hurricanes. Over 75 per cent of Caribbean reefs are considered to be under threat, and over 30 per cent are categorised as highly, or very highly, threatened. Almost all reefs, which are considered to have a low threat status, are distant from large landmasses (Burke et al. 2011) (Figure 10.2).

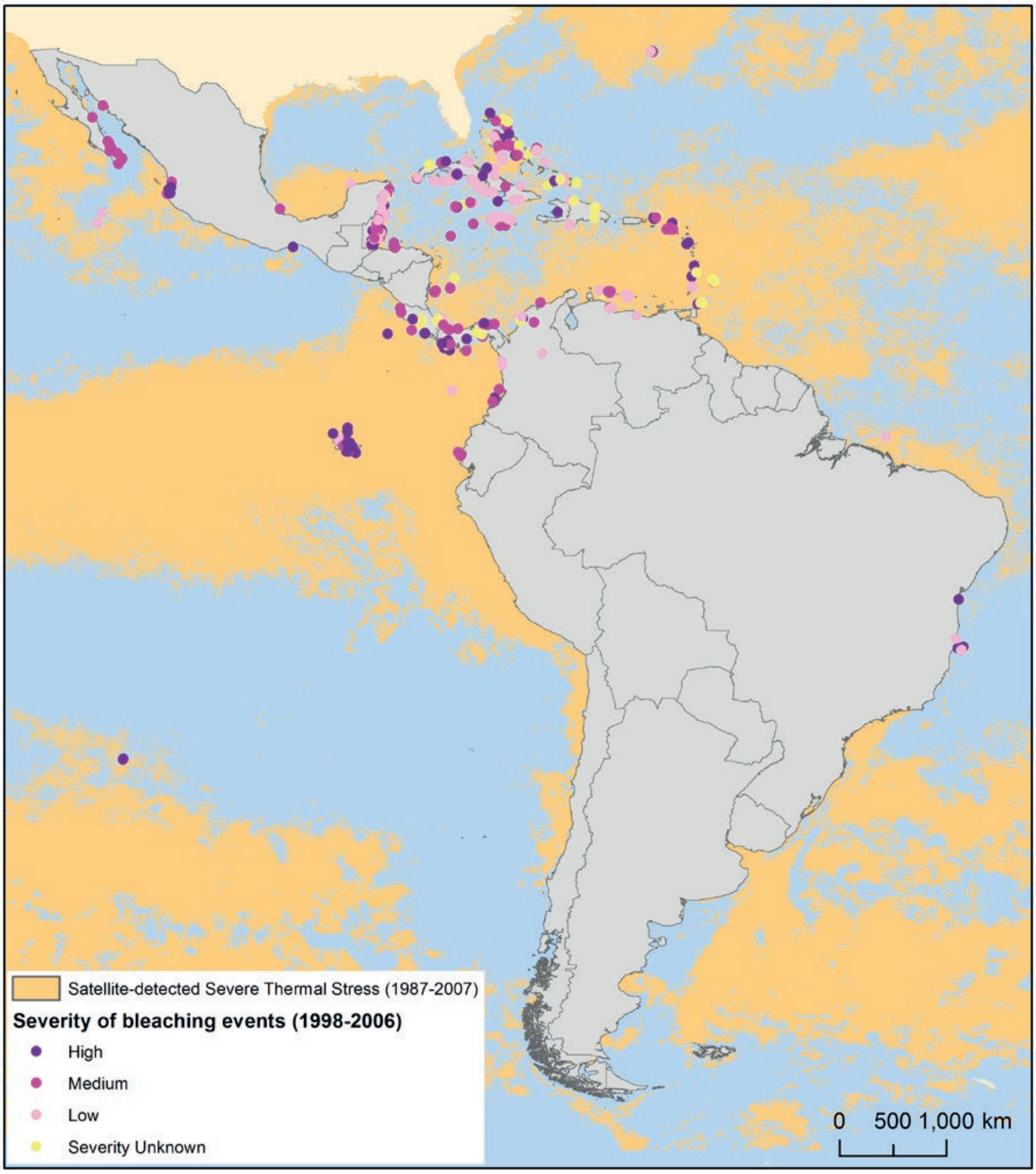

Figure 10.1: Severity of coral bleaching in Latin America and the Caribbean coral reefs and areas of high thermal stress in the region's oceans (Reef Base 2014).

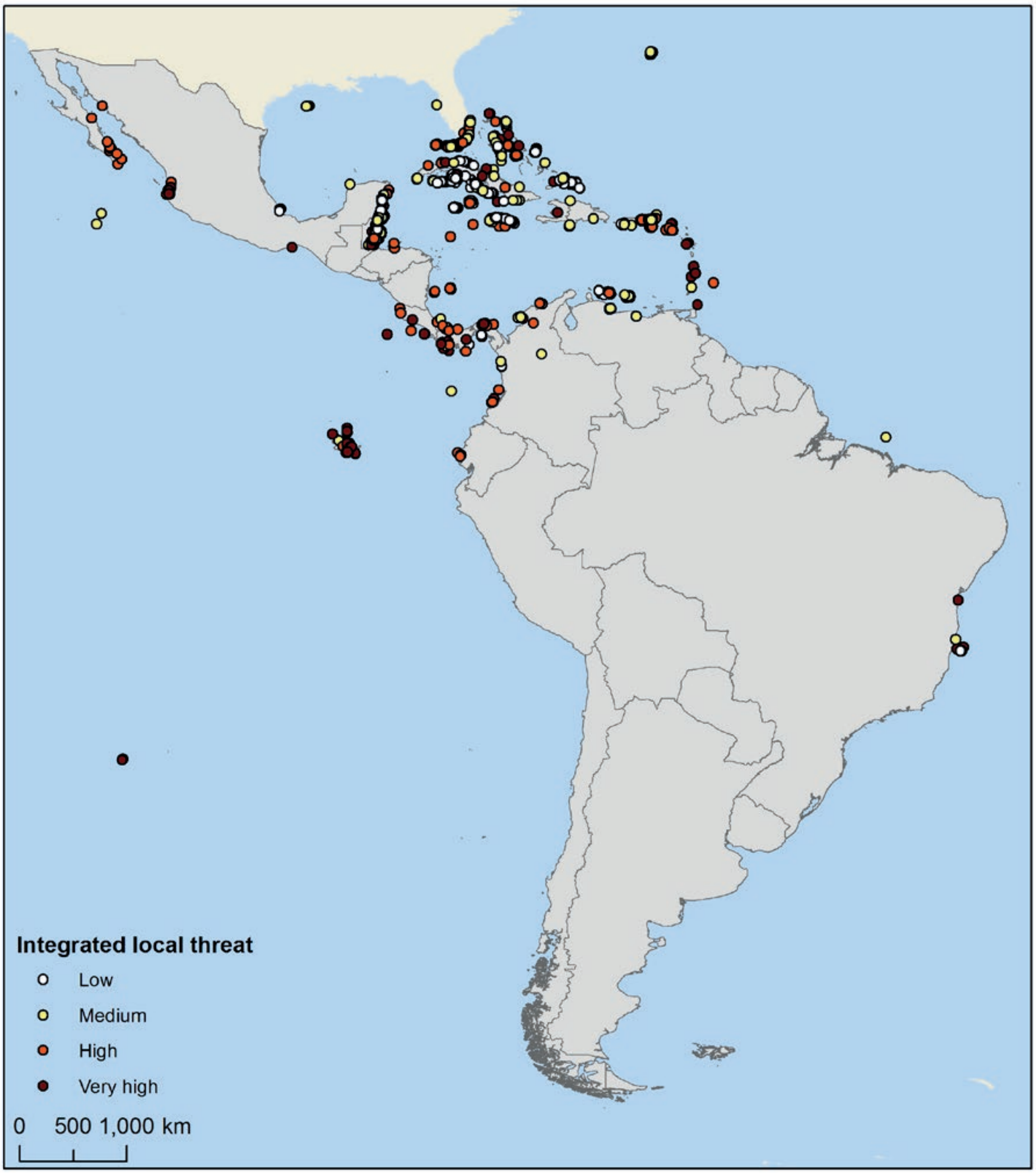

Figure 10.2: Coral reefs classified by integrated local threats. Reef locations are based on 500 meter resolution gridded data reflecting shallow, tropical coral reefs of the world. Organizations contributing to the data and development of the map include the Institute for Marine Remote Sensing, University of South Florida (IMaRS/USF), Institut de Recherche pour le Développement (IRD), UNEP-WCMC, The World Fish Center, and WRI. The composite data set was compiled from multiple sources, incorporating products from the Millennium Coral Reef Mapping Project prepared by IMaRS/USF and IRD (map produced by UNEP-WCMC using data from Reef Base 2014).

Anthropogenic pressures also pose a serious threat to marine and coastal ecosystems. Driven by international market demand for reef resources, overfishing and unsustainable fishing practices are both threats to coral reefs (Mumby et al 2014). Bleaching is most severe around the Caribbean islands and Central American coastline (Figure 10.1). Reef systems are highly sensitive to human disturbance, and sedimentation from upstream land-uses and pollution are among the greatest threats to coral reefs (International Coral Reef Initiative 2016). Mining activities also cause increased sedimentation and can severely harm reef ecosystems, especially in cases where wastes are dumped directly in rivers and oceans, which can cause heavy metal pollution (Guzmán and Garcia 2002). In addition, warming of the oceans due to climate change will likely continue to cause coral bleaching and further damage the coral reefs of the area, making these ecosystems some of the most endangered globally within the next decade.

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Box 10.1: Water Security in the Plurinational State of Bolivia.

Climate change is leading to serious water security concerns in the Plurinational State of Bolivia. Due to limited rainfall, cities at high altitudes in the arid Andes rely on water sources such as glaciers and lakes. This is especially the case in winter, as 90 per cent of rainfall occurs in the wet summer season. Almost half the ice mass of glaciers in the Bolivian Andes has been lost over the last 50 years, and projections suggest that many lower altitude glaciers in the region may disappear altogether over the next 10 to 20 years. Investment in infrastructure, water management policies and changes in agricultural practices will be required to enable the Plurinational State of Bolivia to adapt to these changes in the supply of water (Rangecroft et al. 2015).

Another set of climate vulnerable ecosystems in the LAC region are some of the high mountain habitats of the Andes. Significant global warming may threaten some of these habitats, along with the extremely high diversity of endemic species they support. Between 1939 and 2006, temperatures in the tropical Andes have increased by about 0.7 degrees Celsius, and in that time glaciers have been severely diminished. For example, glaciers in Venezuela have lost 95 per cent of their surface area since 1850. In 2010, glacier area in Colombia was 45 km^2, with an estimated 3 km^2 being lost every year. Projections suggest that the largest future temperature increases will occur at high altitudes, where the glaciers are located (Vuille 2013).

In conclusion, progress towards Target 10 is challenging, and is currently insufficient to achieve all requirements by 2020. Particular challenges are around the reduction of other factors that are stressing coral reefs and hence making them more vulnerable to climate change impacts. Vulnerable systems in the high Andes are also facing pressures in addition to climate change that makes managing the impacts of climate change more challenging.

TARGET 11: PROTECTED AREAS

By 2020, at least seventeen per cent of terrestrial and inland water, and ten per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

"Well-governed and effectively managed protected areas are a proven method for safeguarding both habitats and populations of species and for delivering important ecosystem services. Particular emphasis is needed to protect critical ecosystems such as tropical coral reefs, sea-grass beds, deep water cold coral reefs, seamounts, tropical forests, peat lands, freshwater ecosystems and coastal wetlands. Additionally, there is a need for increased attention to the representativeness, connectivity and management effectiveness of protected areas." (CBD 2016c)

Protected areas are widely regarded as one of the most successful strategies for conserving nature (Geldmann et al. 2013). Target 11 includes several different elements, which need to be met in order for the target to be reached in full; these relate to coverage, effectiveness, equitability, representativity and connectivity.

The fifth national reports to the CBD suggest that nine countries in the region are on track to meet or exceed the coverage element of Target 11 by 2020, however there is less information provided on effectiveness and equitability. Limited information about connectivity is provided although some relevant actions are being taken including the establishment of biological corridors. Some countries highlight the selection of protected areas based on representativeness of ecosystems (CBD 2015).

Protected area designation for terrestrial areas (which includes inland water) covered 23 per cent of the region by 2010, exceeding the 17 per cent global target (Figure 11.1; Figure 11.2). Individually, 17 countries in the region had already met the 17 per cent target by 2014. Together those 17 countries make up 71 per cent of the total land area of Latin America and the Caribbean. Three countries in the region have over a third of their total land area designated as a protected area: Venezuela (53.9 per cent), Nicaragua (37.1 per cent), and Belize (36.7 per cent) (UNEP-WCMC 2014).

Countries in the LAC region, which are engaging in REDD+, are making greater efforts to promote activities, which protect carbon stocks and the multiple functions of forests (Miles et al. 2013). Mapping protected areas can help prioritise areas for specific REDD+ actions, and may also help identify important considerations for REDD+ safeguards, such as in the equitable management of protected areas. Areas suitable for REDD+ implementation often overlap with areas of high biodiversity importance, carbon storage and a wealth of ecosystem services. Countries including Brazil, Ecuador, Paraguay (Walcott et al. 2015) and Panama (Kapos et al. 2015) have used mapping of protected areas to identify areas for potential REDD+ activities.

The Amazon basin plays an important role in conservation and there are ongoing conservation initiatives such as the 'Integration of Amazon Protected Areas' (IAPA) – Amazon Vision project, implemented by FAO, WWF, IUCN and UNEP, that aims to create a network around the protected areas systems located in the Amazon region, covering more than 170 million ha; one-fifth of Brazil's Amazon is protected through around 300 Conservation Units (SNUC). Colombia and Ecuador are also leading in terms of forest protection, with 70 and 80 per cent of the natural rainforest estimated to be under protection in Colombia and Ecuador, respectively (Ringhofer et al. 2013). Chile has almost 20 per cent of its area assigned to protected areas, making the country, currently above the conservation target set by Aichi Biodiversity Target 11 (Tognelli et al. 2007).

There has been less progress in the designation of marine protected areas, and the region is not close to meeting the target of coverage of at least 10 per cent of marine and coastal areas (Figure 11.1). For territorial seas (0 to 12 nautical miles) 13.8 per cent was protected by 2014, with Ecuador notably protecting 76 per cent of its territorial seas. However, only 2.1 per cent of EEZs (12 to 200 nautical miles) was protected by 2014. Taking territorial seas and Economic Exclusion Zones together, the region has protected 3.4 per cent of the total area, and only two countries have met the 10 per cent target: Ecuador (13 per cent) and Nicaragua (10 per cent) (UNEP-WCMC 2014). In addition, the Dominican Republic has protected over 10 per cent of their EEZ area and are part of the Caribbean Biological Corridor, along with Haiti and Cuba, that provides a framework for cooperation among the countries of the insular Caribbean for protecting and reducing the loss of biodiversity, by rehabilitating the environment, developing livelihood alternatives -particularly in Haiti-, and alleviating poverty as a mean to reduce the pressure on biological resources.

Reflecting the importance of Caribbean marine ecosystems, the Caribbean Challenge Initiative (CCI)'s goal to "effectively conserve and manage at least 20 per cent of the marine and coastal environment by 2020" is substantially more ambitious than Target 11 (CCI 2016). Knowles et al. (2015) calculated that across the whole of the insular Caribbean, around 7 per cent of the EEZ area is protected. However, when only sovereign states are considered that figure drops to approximately 3.25 per cent closer to the level of protection found across Latin America and the Caribbean as a whole.

There is no readily compiled information on trends in protected area effectiveness, although some baselines are found in Coad et al. (2015). Similarly, there are no trends in equitability of the protected areas in the region over time, and baseline information is also hard to find relating to the LAC region. Representativity of the protected areas network in the LAC region has been calculated as a baseline by Butchart et al. (2015) and connectivity at the continental scale by Santini et al. (2015), who calculated the per centage of reachable area within protected area networks around the world for different dispersal abilities. The study found that South America has one of the highest scores for amount (per centage) of reachable areas for species dispersal within protected areas (0.86–2.25 per cent).

Although connectivity has not been assessed for the LAC region specifically, there are some efforts to measure it in specific biomes. Brazil's Atlantic Forests is an example of the importance of inter-protected area connectivity, as these forest habitats are severely fragmented and deforested, causing forest bird species to extend their ranges to cover small fragmented forest patches (Santini et al. 2015). Thus, the creation of conservation corridors between larger patches of forests and the establishment of networks of small protected forest areas is key to maintain species abundance (Uezu and Metzger 2011). Using a case study from the Brazilian Atlantic forest, Tambosi et al. (2014) assessed the effectiveness of ecological restoration actions towards biodiversity conservation, taking into account different constraints. They proposed a multiscale framework based on landscape attributes of the habitat extinction and connectivity to infer landscape resilience. Results show that areas with high restoration effectiveness represent only 10 per cent of the region, identifying around 15 million ha of land that could be the focus of restoration actions.

The coverage of endangered and endemic species by protected areas varies throughout the LAC region. In Chile, over 13 per cent of all species are not covered by any protected area, and 73 per cent of vertebrate species ranges are not currently under protection (Tognelli et al. 2007).

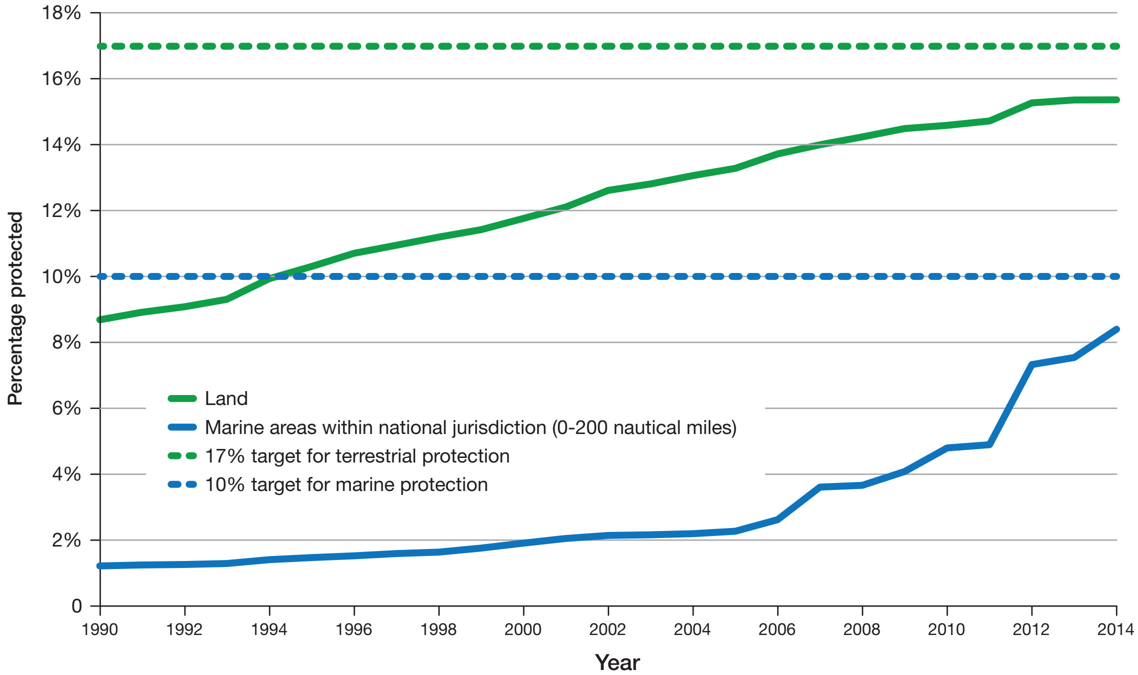

Figure 11.1: Global protected area trends and targets, 1990-2014 (source: UNEP-WCMC 2014).

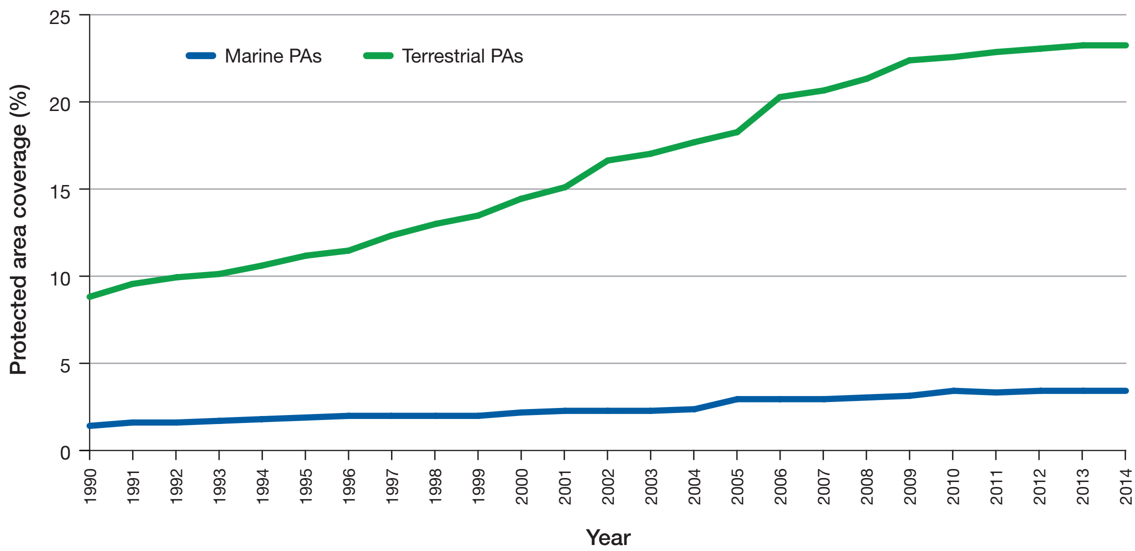

Figure 11.2: Trends in terrestrial and marine protected areas coverage over time in the Latin America and Caribbean region (1990-2014) (source: UNEP-WCMC 2014).

Key Biodiversity Areas (KBAs) are sited which contribute significantly to the global persistence of biodiversity, and KBA sites can be identified through assessments against standard criteria which consider the levels of threatened biodiversity based on Red Lists, amongst other biodiversity-related criteria (IUCN 2014a). Brooks et al. (2016) assessed the trend in coverage of KBAs, specifically of Important Bird Areas (IBAs) and Alliance for Zero Extinction (AZE) sites[4], by protected area in all UNEP regions, including Latin America and the Caribbean (Figure 11.3; Figure 11.4).

[4] http://www.zeroextinction.org/

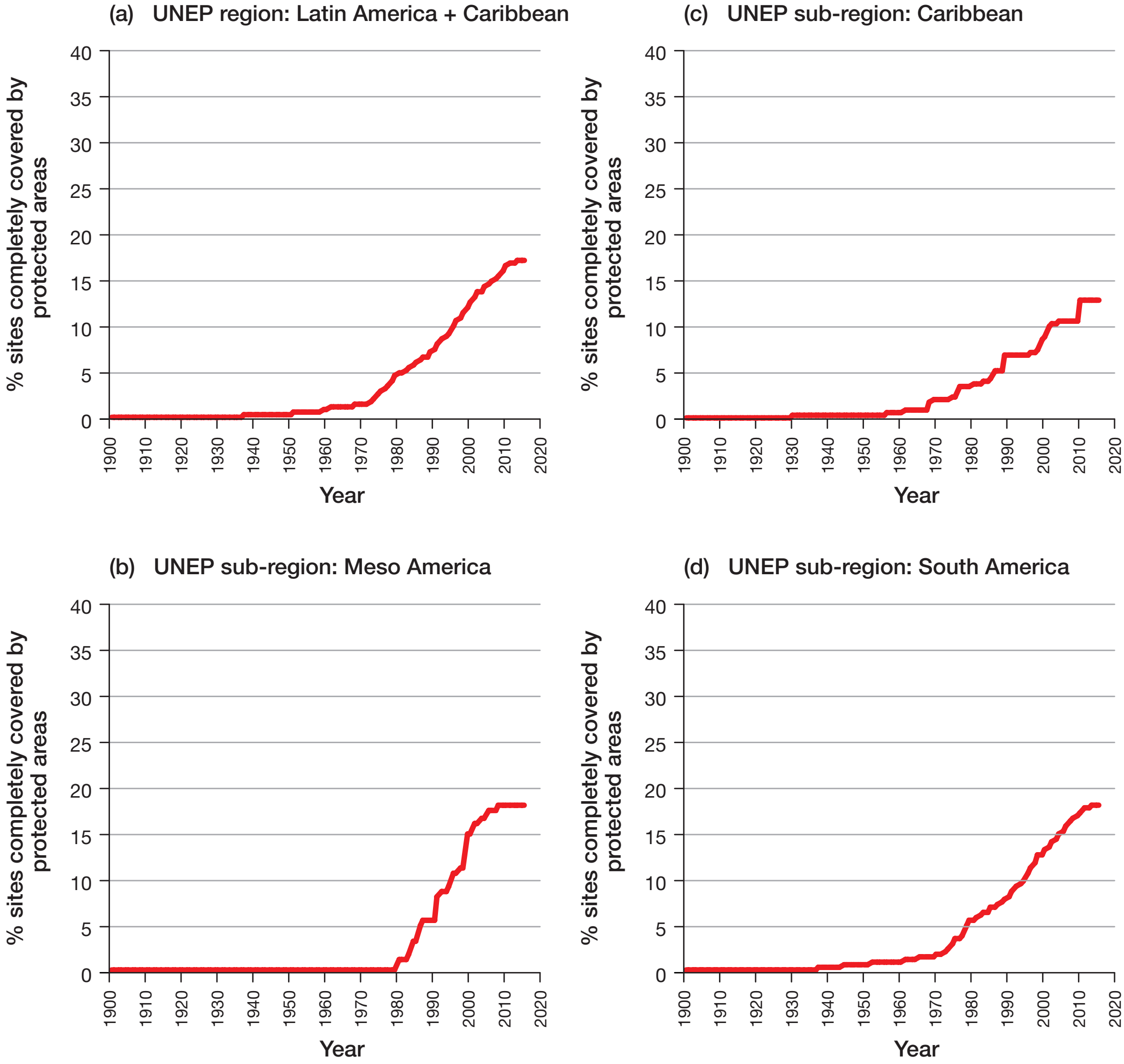

Figure 11.3: Growth in proportion of IBAs fully covered by protected areas for the LAC region (a) and sub-regions; Meso America (b), Caribbean (c) and South America (d) (source: Brooks et al. 2016).

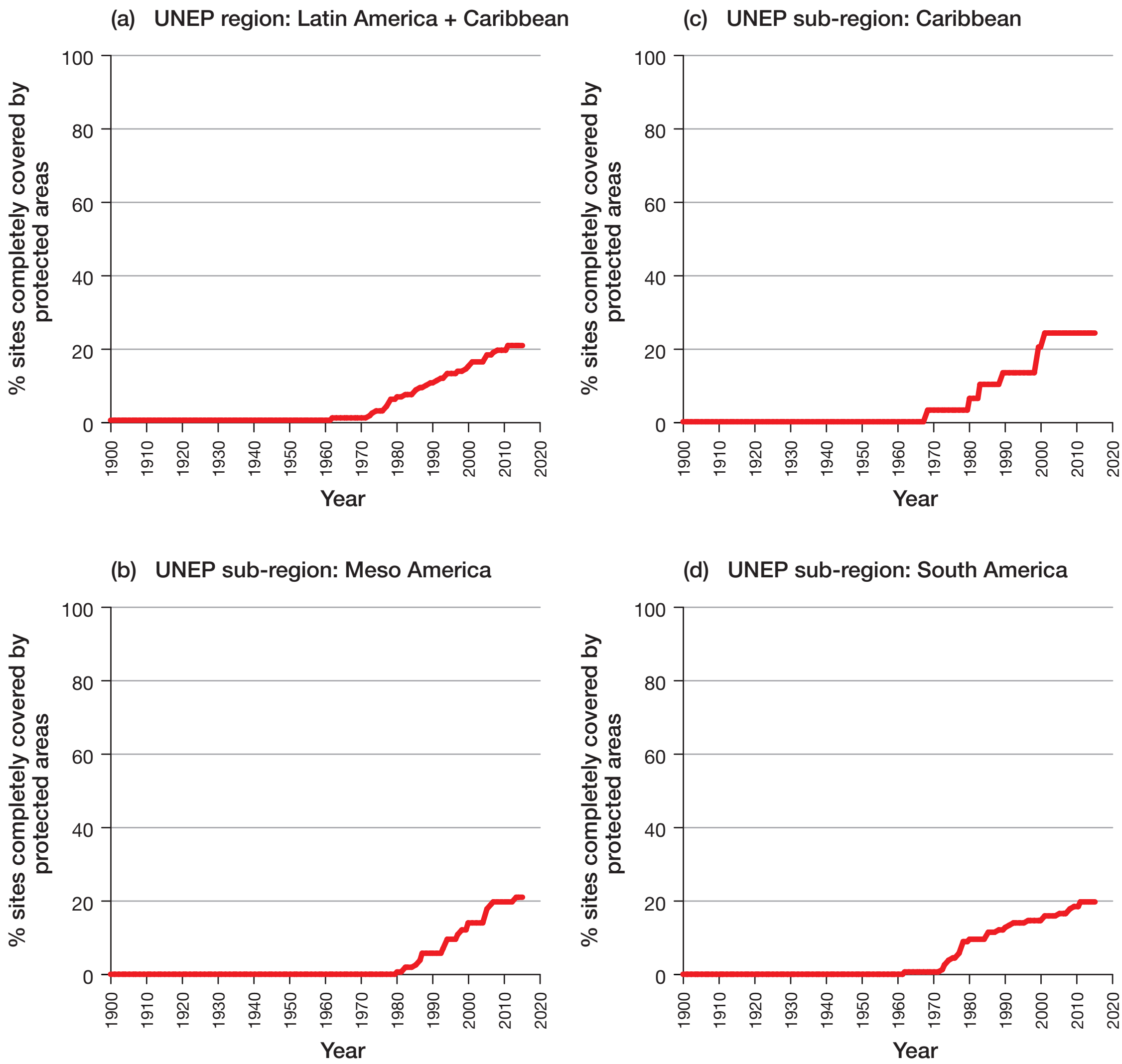

Figure 11.4: Growth in proportion of AZE sites fully covered by protected areas for the LAC region (a) and sub-regions; Meso America (b), Caribbean (c) and South America (d) (Brooks et al. 2016).

In conclusion, although the coverage element of the target has been or will be achieved by 2020, other elements of the target are less well studied and progress is less clear. More work is required to better understand and put in place systems to track changes in management effectiveness, equitability, connectivity and representativity over the next years until 2020.

The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations

Figure 11.5: Map of the protected area network in the Latin America and Caribbean region (IUCN and UNEP-WCMC 2015). This map is derived from the February 2016 version of the World Database on Protected Areas. Some sites, particularly community and privately managed reserves may be missing because they have not been submitted to UNEP-WCMC by the relevant focal points in the region.

Box 11.1: Guiding Conservation Efforts in Mexico.

(source: Tania Urquiza Haas and Patricia Koleff)

In face of global environmental change, an important first step to achieve Aichi Biodiversity Target 11 is the identification of ecologically representative and biodiversity relevant areas to strategically guide conservation efforts. This is of particular importance in megadiverse countries, like Mexico, where biodiversity is heterogeneously distributed and there is significant environmental degradation. In 2005, following commitments to the CBD Program of Work on Protected Areas, Mexico started an ambitious analysis under the coordination of The National Commission for Knowledge and Use of Biodiversity and the National Commission of Natural Protected Areas in which more than 260 stakeholders from academia, government and nongovernmental organizations participated. This analysis demonstrated the importance of having a National Biodiversity Information System to provide open access and reliable data to conduct systematic conservation planning. Further, it demonstrated the need for updated information on environmental degradation to avoid the identification of unsuitable conservation areas. In a timeframe of five years, the country concluded a comprehensive analysis to identify priority areas in the marine, freshwater and terrestrial realms and the identification of conservation gaps in the protected area network (CONABIO et al. 2007a, CONABIO et al. 2007b; Koleff et al. 2009; CONABIO and CONANP 2010). During the process, important institutional capacities were gained to carry through systematic analyses with large amounts of data at different spatial scales and to model the human impact on biodiversity using spatial information on environmental drivers (Kolb 2009). The results of these analyses provides updated insights into conservation needs for Mexico to fulfil Aichi Biodiversity Target 11 and guides the expansion of protected areas, as well as the promotion of other conservation measures, such as sustainable forestry, sustainable use of wildlife, ecological restoration, payment for ecological services, and ecological planning of the territory.

Box 11.2: Integrating Ecosystem Services and Biodiversity into Spatial Conservation Planning for the Benefit of Local and Traditional Communities.

Spatial conservation planning can be a powerful tool for choosing the best, or most cost-effective areas for conservation of biodiversity, such as formal protected areas e.g. parks or reserves and other effective area-based conservation measures (OECMs) - e.g. some community conservation areas. Most spatial conservation planning exercises, including those in South America and the Caribbean, have focused on the biological aspects of target areas such as forest cover, species distribution and existing protected areas. With the improvement in computational power, however, more data layers have become readily available and can be added to these spatial conservation planning tools such as Zonation, Marxan and C-Plan.

UNEP-WCMC has been exploring the integration of both potential and realised ecosystem services data into spatial conservation planning tools. By utilising the Co$ting Nature model UNEP-WCMC has been able to integrate data layers which incorporate water provision, carbon derived services and hazard mitigation to more traditional data layers such as species and habitats in spatial conservation planning work (Mulligan 2015; Mulligan et al. 2010). This work utilised the Zonation tool and focussed on the Chocó region in Colombia. The work has been carried out with the support of the Rainforest Trust, which wants to improve the science underpinning its decision making for the establishment of new conservation areas, including protected areas and connectivity conservation areas. The work aims to delineate complementary areas that not only have high biodiversity conservation value but also a high provision of potential and realised ecosystem services, thereby identifying areas, which have the potential to benefit indigenous and traditional communities whilst simultaneously strengthening biodiversity conservation.

Box 11.2 continued

The model below represents how Zonation integrates all these data layers and generates a complementarity-based balanced ranking of the landscape, e.g. how to incorporate as much of the three environmental data layers, around the two focal area datasets whilst accounting for the human threats layer. The model outputs show the best areas for conservation and how much is gained in terms of biodiversity and ecosystem services by increasing these conservation areas. In this example, the graph shows that a small increase in the area already protected (circa 11 per cent of total target area) can enhance dramatically the conservation of species and ecosystem services if the right areas are chosen. This model can help decision makers across multiple sectors make sound scientific decisions that will both conserve biodiversity as well as help maintain the economic, social and cultural health of local and neighbouring communities, and support the tracking and achievement of important commitments such as the UN's Aichi Biodiversity Targets and Sustainable Development Goals (SDGs).

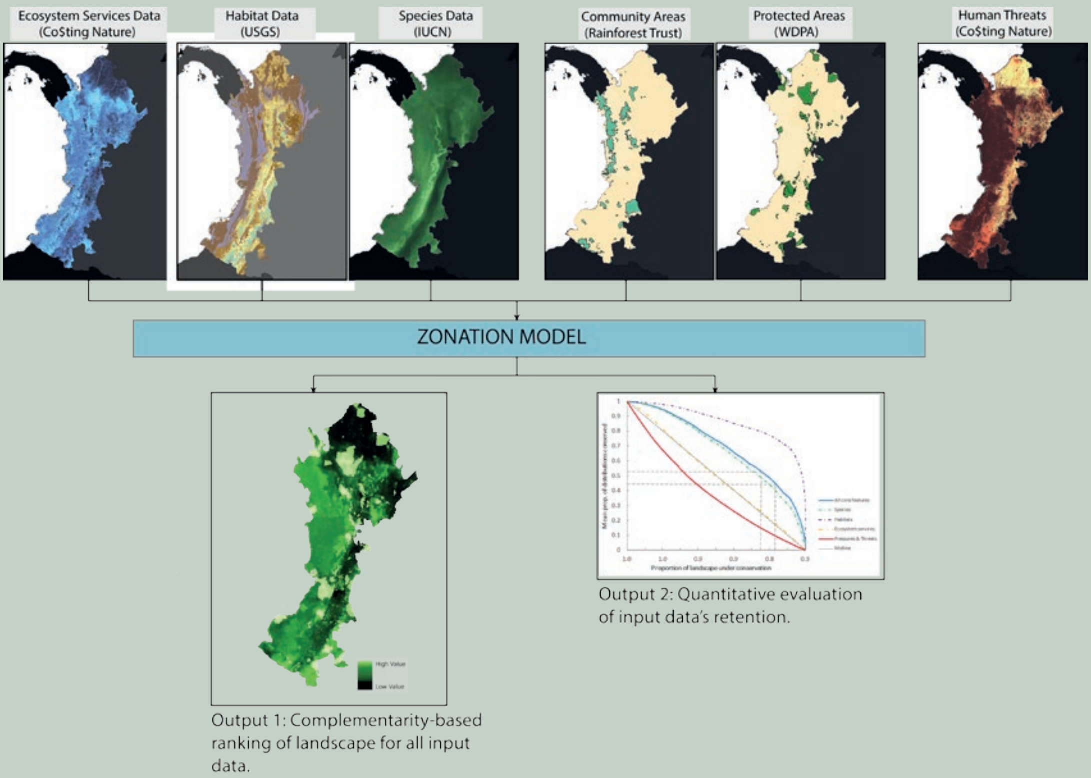

Figure 11.6: The Zonation model effectively balances where to prioritise for conservation (via the environmental layers) and where to avoid (via the human threats cost layer) using the community and protected areas as the starting point for any further expansion. Data layers have been simplified (aggregated) for graphical purposes.

Box 11.3: Community Based Monitoring of Fog Capture in Loma Alta, Ecuador.

In 1995, several villagers from the community of Loma Alta, situated in the Loma Alta watershed, were trained by People Allied for Nature (PAN) and EarthWatch to monitor the quantity of water captured by local trees and plants. After a year of monitoring, they reached a conservative estimate that forest clearances resulted in a loss of about 190 thousand litres of water per hectare per year that would have otherwise become available for use. Water supply is a key issue in the area as agriculture is water-limited, and so water lost to deforestation represents a substantial economic loss to Loma Alta.

The results of the monitoring were communicated locally through leaflets, talks in schools, and circulation of a video featuring the villagers who had taken part in the monitoring. The information generated a strong response throughout the community and six community meetings were held to discuss a resulting proposal to establish a forest ecological reserve in order to protect water resources. In August 1996, an area of about 1,000 ha was officially declared a reserve.

This rapid response was possible because the community of Loma Alta have had established tenure of their land since the *Law of the Comunas* in 1937. There is no private ownership of the land, but the *Comuna* had granted land use rights to individuals. Strong governance enabled discussion with those individuals with existing right over the course of the community meetings until a consensus was established that the reserve should be established. Since then, the reserve has tripled in size to 3,000 ha, and deforestation within the reserve has been effectively eradicated (Becker et al. 2005; Balmford, 2012).

TARGET 12: REDUCING RISK OF EXTINCTION

By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

"Though some extinctions are the result of natural processes, human actions have greatly increased the extinction rate in recent times. Reducing the threat of human-induced extinction requires action to address the direct and indirect drivers of change (see the Aichi Biodiversity Targets under Goals A and B of the *Strategic Plan for Biodiversity 2011-2020*) and can be long-term processes. Yet imminent extinctions of known threatened species can in many cases be prevented by protecting important habitats (such as Alliance for Zero Extinction sites) or by addressing the specific direct causes of the decline of these species (such as overexploitation, invasive alien species, pollution and disease)." (CBD 2016c)

Species extinction is one of the major environmental challenges facing the LAC region. Species endemism in the LAC region is high; a recent study by Brooks et al. (2016) shows that the LAC region contains the highest proportion of threatened species (critically endangered, endangered and/or vulnerable) when compared with all other regions on Earth (Figure 12.1), providing an indication of the scale of the challenge to prevent extinctions in the coming decades. Particularly high endemism is found in the Andean and Atlantic forests (CEPF 2015; CEPF 2016), and the Caribbean islands, as many species are confined to single islands or small patches of forest along the Andean mountain chain or in the Amazon basin.

Global trends indicate that little progress is being made toward preventing the extinction of known threatened species and that progress is moving away from improving the conservation status of those species most in decline (SCBD 2014). Within the LAC region, the fifth national reports to the CBD demonstrate that management plans have been implemented across the region for specific species, and the establishment of protected areas are expected to contribute to reaching Aichi Biodiversity Target 12. Success stories highlighted include the humpbacked whale in Brazil, whose status is being reconsidered from 'threatened' to 'almost threatened' and the critically endangered Ridgway's Hawk (*Buteo ridgwayi)*, which is starting to recover in Dominican Republic. However, despite these success stories, only Cuba and Mexico mention that they will meet the target by 2020, whereas the majority of countries in the region that provide information on Target 12 acknowledge that threat levels are increasing for many species, in line with global trends (CBD 2015).

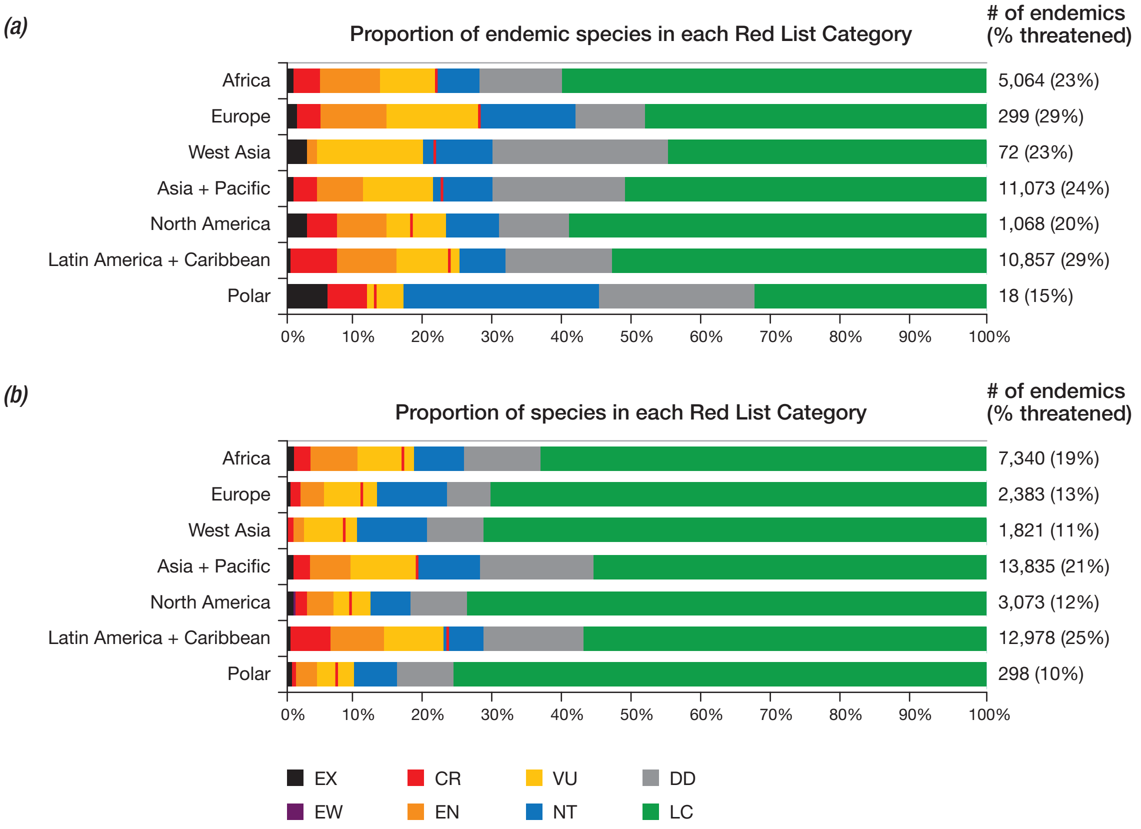

Figure 12.1: (a) Proportions of endemic species, by Red List Category, in comprehensively assessed groups on The IUCN Red List of Threatened Species and (b) proportion of all species, by Red List Category, in comprehensively assessed groups on The IUCN Red List of Threatened Species (Version 2015-2) occurring in each UNEP region. The vertical red lines show the best estimate for the proportion of extant species, which are considered threatened (CR, EN and VU). The number to the right of the bar represent the total number of species assessed, and the best estimate of the percentage threatened is written in brackets. The numbers to the right of each bar represent the total number of species assessed and in parentheses the best estimate of the percentage threatened. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, DD = Data Deficient, LC = Least Concern (source: Brooks et al. 2016).

Estimates of the intactness of local ecological assemblages in terms of species richness in the LAC region, using the PREDICTS model (Newbold et al. 2015), show that the Amazon rainforest is projected to retain most of its original species richness, whereas other areas outside the main forest block are projected to have lost considerable amounts of their original species richness (Figure 12.4). Nonetheless, this region retains a much more intact flora and fauna than some other regions (Newbold et al. 2015).

A species richness map for mammals, amphibians and birds based on ranges of occurrence for species from the Red list of threatened Species (IUCN 2014b) shows the Amazon basin in particular has high species richness levels (Figure 12.3). Mean range-size rarity in the LAC region was also analysed using the Red List data, and serves as a measure of endemism, which is higher in areas of the Andes mountains where species' ranges are smaller (Figure 12.2).

The boundaries shown on this map do not imply official endorsement or recognition by the United Nations

Figure 12.2: Patterns of range size rarity (a measure of richness in endemic species) based on known distributions for all birds, mammals and amphibians in the LAC region at 0.5 degree resolution (source: IUCN 2014b).

The boundaries shown on this map do not imply official endorsement or recognition by the United Nations

Figure 12.3: Species richness at 0.5 degree resolution based on known distributions for all birds, mammals and amphibians in the LAC region (source: IUCN 2014b).

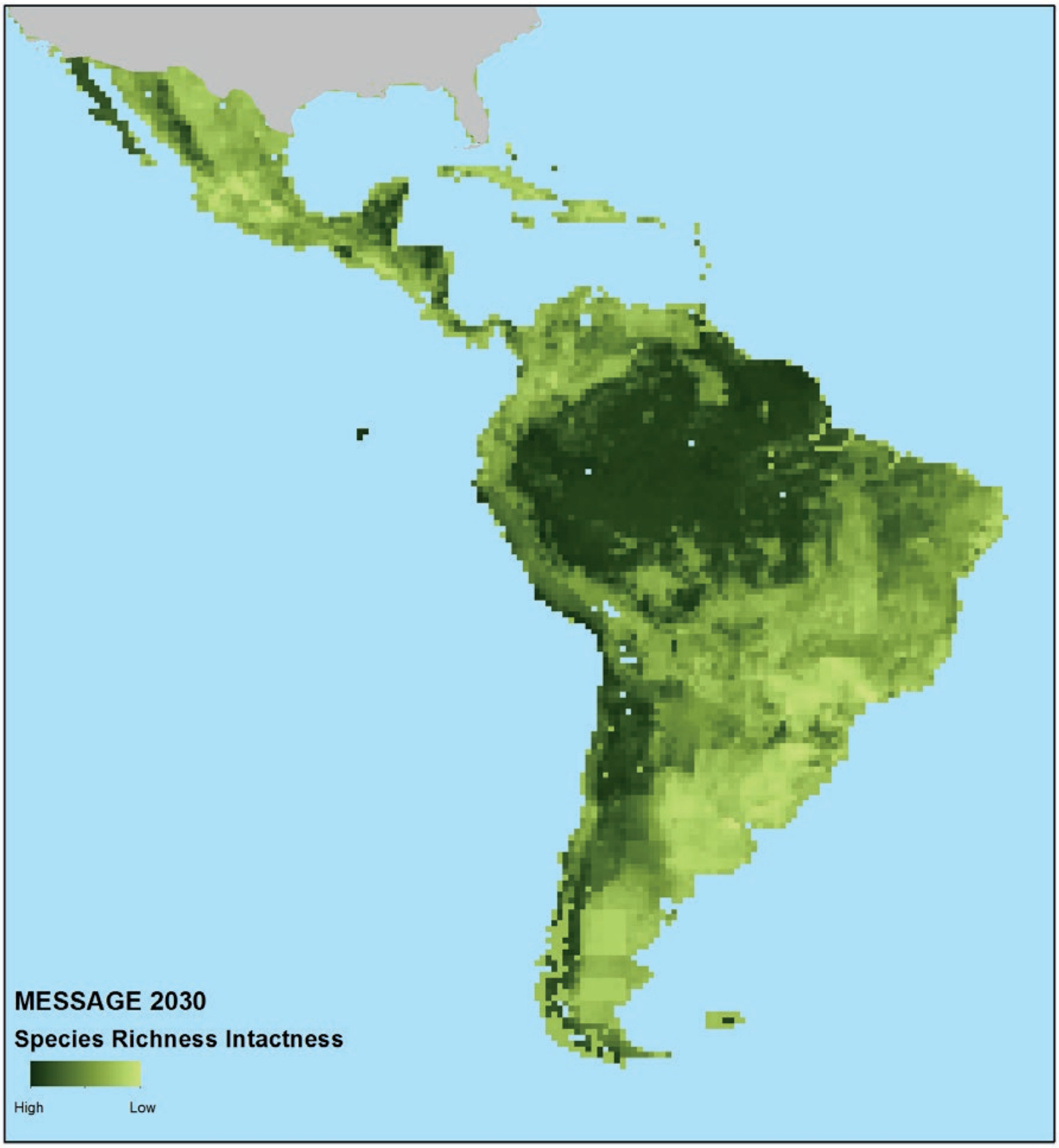

Figure 12.4: Intactness of the species richness assemblage in the LAC region as measured using the PREDICTS database and modelling framework (source: Newbold et al. 2015).

The IUCN Red List Index (RLI) for bird species, compiled by BirdLife International, shows that, on average, bird species of Latin America and the Caribbean have higher RLI values (i.e. a lower extinction risk), than bird species globally. Between 2008 and 2012, however, the RLI for bird species within the LAC region showed an increasing risk of extinction (Figure 12.5). This downward trend is concerning and shows that the rate at which species are moving towards extinction is accelerating. Considerable action is thus needed to safeguard the unique biodiversity of this region.

The Living Planet Index (LPI) (WWF 2014), a weighted measure of changes in species populations, shows a steep decline in the population sizes of vertebrates in the Neotropical realm (broadly equivalent to the LAC region) between 1970 and 2010, although this has stabilised since around 2010 (Figure 12.6). Overall, this region has recorded the highest rate of decline on Earth: on average, population sizes decreased by 83 per cent over this time period. This analysis is based on data from 86 species of marine and freshwater fish, 61 species of amphibians, 25 species of reptiles, 310 species of birds and 66 species of mammals.

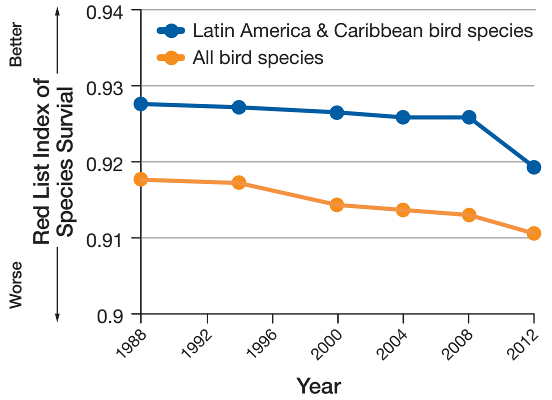

Figure 12.5: IUCN Red List Index of species survival (1988-2012). A Red List Index value of 1.0 means that all species are categorized as 'Least Concern', and hence none are expected to go extinct in the near future. A value of zero indicates that all species have gone extinct (source: BirdLife International 2016b).

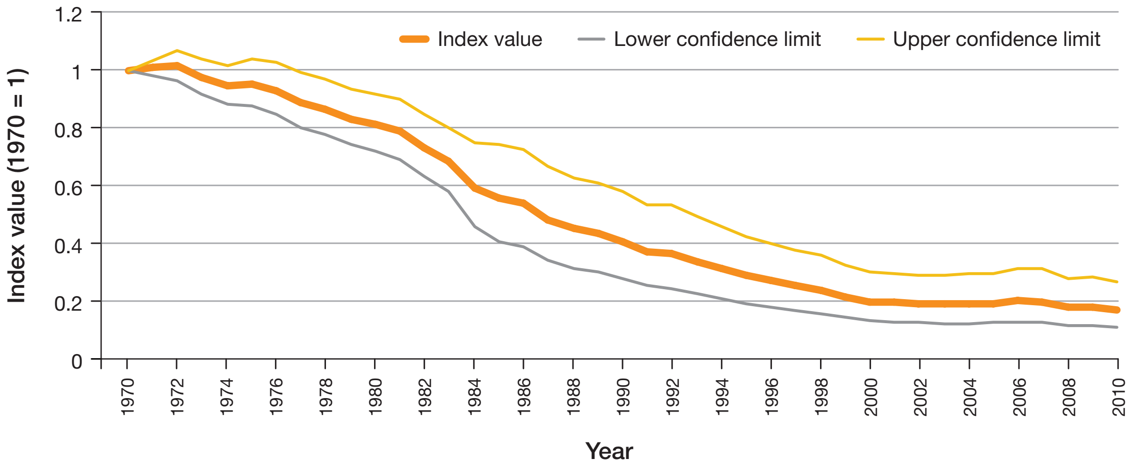

Figure 12.6: Neotropical Living Planet Index 1970-2010. Dashed lines indicate confidence limits (source: McRae et al. 2014).

In conclusion, the LAC region contains exceptional biodiversity and in the main forest region, this diversity remains largely intact, with losses elsewhere – particularly in the more developed agricultural and pasture regions, and on the islands of the Caribbean. Preventing extinction and managing populations of heavily threatened species – especially on the offshore islands – will likely remain the focus in this region. The target is not likely to be met in the LAC region, but many countries are making serious efforts to stem biodiversity loss.

TARGET 13: SAFEGUARDING GENETIC DIVERSITY

By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.

"The genetic diversity of cultivated plants and farmed or domesticated animals and of wild relatives is in decline, as is the genetic diversity of other socio-economically and culturally valuable species. The genetic diversity that remains needs to be maintained and strategies need to be developed and implemented to minimize the current erosion of genetic diversity, particularly as it offers options for increasing the resilience of agricultural systems and for adaptation to changing conditions (including the escalating impacts of climate change)." (CBD 2016c)

The genetic diversity of domestic crops and animals is high in this region. Most major food crops grown and consumed by the majority of the world's population originate in the tropics and subtropics of Asia, Africa and Latin America (FAO 2004a). Famous examples of genetically diverse and important crops originating from the LAC region include potatoes and tomatoes in the Andes and maize in South and Central America (FAO 2004a; Hijmans et al. 2000). Efforts by the countries of the region to maintain their diversity are extensive, with dedicated centres in place to maintain diversity of some key crop types – such as the International Potato Center[5] with regional offices in Quito (Ecuador) and Lima (Peru).

Domesticated animals, for example cattle, sheep and goats brought to the region contain a relatively low diversity of breeds. Currently, the LAC region contains 27 per cent of the world's cattle population, 15 per cent of the world's chicken population, 7 per cent of the world's sheep population and 9 per cent of the world's pig population, with the highest numbers in Brazil and Mexico (FAO 2015g).

Data on domestic animal population sizes from the Domestic Animal Diversity Information System (DAD-IS) enable calculation of extinction risk, based on population sizes described by the FAO (2007). Using this approach, 58 per cent of transboundary breeds in Latin America and the Caribbean are not considered at risk, broadly in line with transboundary breeds globally. However, there is very little information about the risk status of local breeds in Latin America and the Caribbean, and the region has been identified as having one of the highest proportions of breeds with an unknown risk status, making it difficult to assess the challenges and conservation needs for species and breeds (Leadley et al. 2014). For example, population sizes are unknown for 92 per cent of the 581 local breeds reported in the region, compared to 64 per cent globally (Figure 13.1) (DAD-IS 2016).

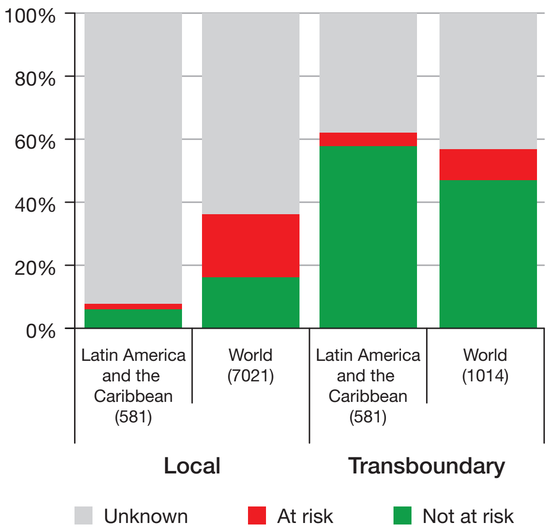

Figure 13.1: Per centage of breeds at risk of extinction in Latin America and the Caribbean, and globally, for both local and transboundary breeds. The absolute numbers for each category are included in brackets (source: DAD-IS 2016).

Country reports to FAO's Second Report on the State of the World's Animal Genetic Resources (2015) show that some countries in the region have a relatively high proportion of breeds maintained under conservation programmes (Figure 13.2), and high scores are more frequent in Latin America (and southern Asia) than in other developing regions.

[5] http://cipotato.org/

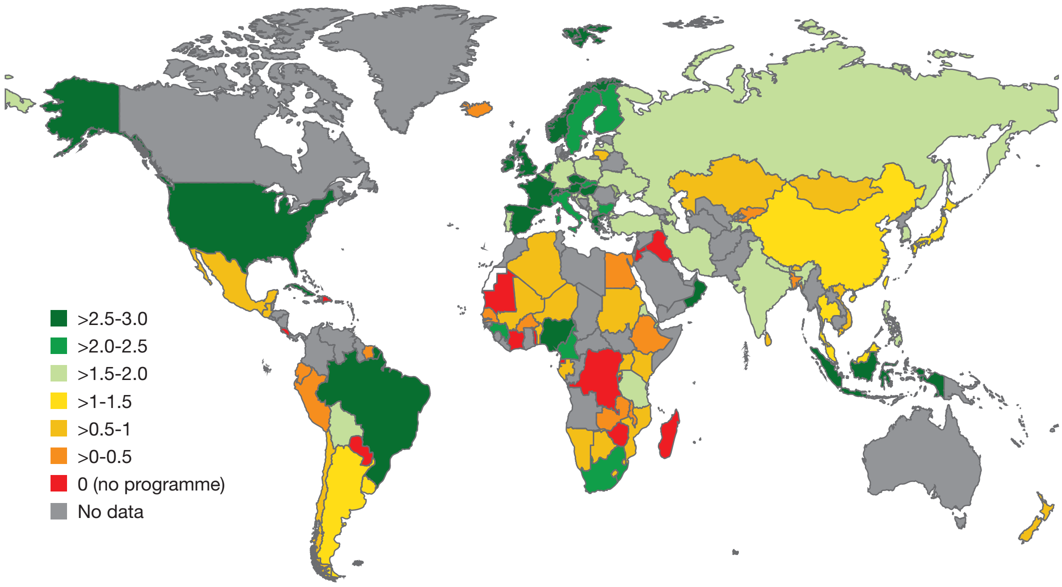

Figure 13.2. Coverage of in situ conservation programmes for five big livestock species. Coverage indicates the reported extent to which country's breeds are covered by conservation programmes, scored as none (0), low (1), medium (2) or high (3) for each of the big five species (cattle, sheep, pigs, chickens and goats). Beef, dairy and multipurpose cattle were treated separately (source: FAO 2015g).

The LAC region's progress towards Target 13 differs across countries. Some notable developments include the implementation of selection schemes for improving goat meat and milk production in a small selection of imported and locally adapted breeds in Brazil (FAO 2015g). In the past decade, efforts to manage genetic diversity in the LAC region have increased. In 2002, the Andean Community of Nations (CAN) put in place a number of instruments relevant to the management of animal genetic resources through Decision 523, which approved the Regional Biodiversity Strategy for the Countries of the Tropical Andes (FAO 2015e). However, this strategy did not include any provisions specifically addressing animal genetic resources management, but it included a "line of action" on the conservation and sustainable use of native and locally adapted agrobiodiversity.

The fifth national reports from Latin America and the Caribbean region outline a large number of actions undertaken by countries to safeguard the genetic diversity of plants, including the establishment of seed and gene banks (Argentina, Bolivia, Brazil, Chile, Dominican Republic, El Salvador, Guatemala, Nicaragua, Panamá, Uruguay, with plans to establish a gene bank in Suriname) and herbariums (SCBD 2015). The status of these gene banks varies across the region, and some are private initiatives with no central coordination. However, very little information is provided in the fifth national reports to the CBD about the preservation of genetic diversity of animals (CBD 2015).

Box 13.1: Impact of Legislation on Preservation of Genetic Diversity in Brazil.

Regarding rural producers, Embrapa Genetic Resources and Biotechnology carried out an assessment of how existing legislation is impacting on the conservation of local products, given that it has been observed that the implementation of public policies has been leading to a decrease in the seed/species exchange networks among rural producers, which creates a risk of loss of land race varieties of cultivated and raised species, reduction of gene flow, and reduction of the generation of new varieties.

In conclusion, safeguarding genetic diversity has important implications for food security in the region (León-Lobos et al. 2012). The LAC region is an important centre of crop diversity for some of the main food crops globally. The conservation of this diversity is important in the region and there have been significant efforts to maintain diversity with dedicated centers for some of the main crops established in the region. The diversity of domestic animals is lower and the main global breeds are fairly newcomers to the region. Overall, the region is making progress towards the target but is unclear whether it will fully achieve the target by 2020.

TARGET 14: ECOSYSTEM SERVICES

By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

> "All terrestrial, freshwater and marine ecosystems provide multiple ecosystem services. Some ecosystems are particularly important in that they provide services that directly contribute to human wellbeing by providing services and goods to fulfil daily needs. Actions taken to protect and restore such ecosystems will have benefits for biodiversity as well as human wellbeing." (CBD 2016c)

An ecosystem is a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit (Art. 2 of the Convention on Biological Diversity). Ecosystem services are the benefits that people obtain from ecosystems (MA 2005). Four types of ecosystem services have been defined; provisioning (e.g. food, water and fibre); regulating (e.g. climate and flood regulation); cultural (e.g. aesthetic, recreation and spiritual); and supporting (e.g. nutrient cycling and soil formation).

The GBO-4 analysis suggested that globally we are moving away from the target, especially with regard to provisioning services being over-used to support economies and human livelihoods (SCBD 2014). Continued degradation of habitats that provide important ecosystem services suggests that service provision from natural habitats is declining, but there is little data on this at regional scales. Global analyses, although with limited data, suggest that we are moving away from the target in terms of taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

Actions reported in the fifth national reports to CBD in relation to Target 14 tend to be a series of specific projects contributing to the protection of ecosystems, particularly forests. Argentina, Belize, Brazil, Cuba, Ecuador, El Salvador and Peru all report actions which take into the needs of women, or indigenous and local communities, including PES schemes and managed access programmes. Action plans have not generally been put in place to systematically address this target, and the region is not on track to meet the target by 2020. Colombia in particular reports that many ecosystems have already crossed irreversible thresholds making them impossible to restore, such as the eutrophication of wetlands (CBD 2015).

There is a strong link between Aichi Biodiversity Target 14 and a number of the Cancun safeguards for REDD+, which were agreed in 2010 (UNFCCC 2014). These include: safeguards d) which promotes the full and effective participation of relevant stakeholders, particularly indigenous people and local communities and e) which supports the protection and conservation of natural forests and their ecosystem services (UNFCCC 2016). Community consultations may help to identify essential services that can be incorporated into REDD+ planning and the design of REDD+ actions to secure their provision.

Although there are limited data available to measure progress towards Target 14, it is possible to examine trends in some of the benefits derived from ecosystem services in the region, and on how access to those services is distributed across the population.

Food

The per centage of land dedicated to agriculture across Latin America and the Caribbean has increased steadily since 1961 (FAO, 2015a) (Figure 14.1). FAO data also show that access to food has improved within the region. In 1990-1992 (three year average) five countries (Bolivia, Dominican Republic, Haiti, Nicaragua, and Peru) had a dietary energy supply adequacy of less than 100 per cent of the energy requirement of their population, but by 2014-2016, Haiti is the only country in the region reported to have an overall food energy deficit (FAO, 2015b). Despite a surplus of food available in the majority of countries, it is estimated that 13 per cent of the population of Latin America and the Caribbean will be undernourished between 2014 and 2016, based on a three year average (FAO, 2015c). Progress is being made as this is a reduction from 25 per cent between 1990 and 1992 (FAO, 2015c), but more needs to be done to ensure the poor and vulnerable have access to sufficient food security (Figure 14.2).

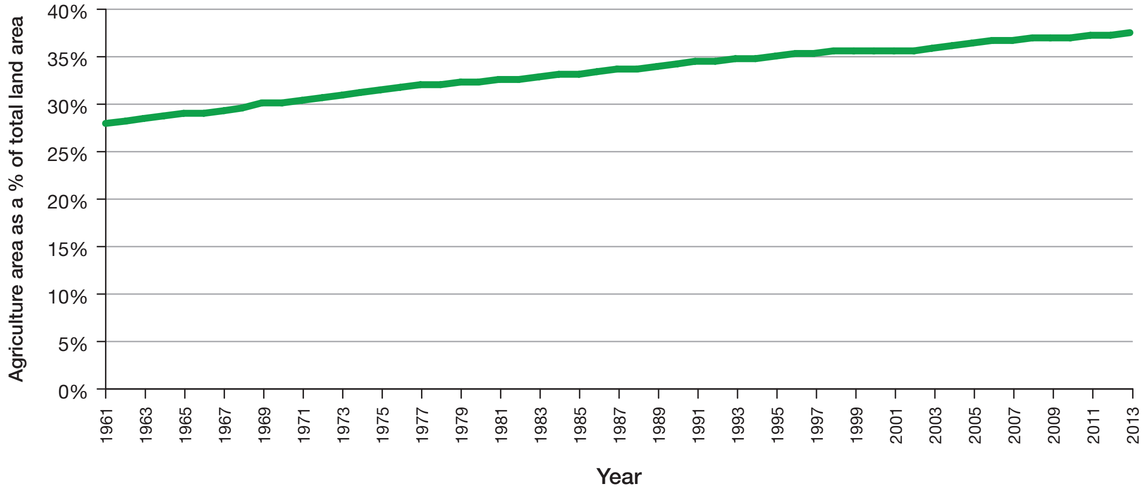

Figure 14.1: Trends in agriculture area as a % of total land area in Latin America and the Caribbean between 1961 and 2013 (source: FAO, 2015a).

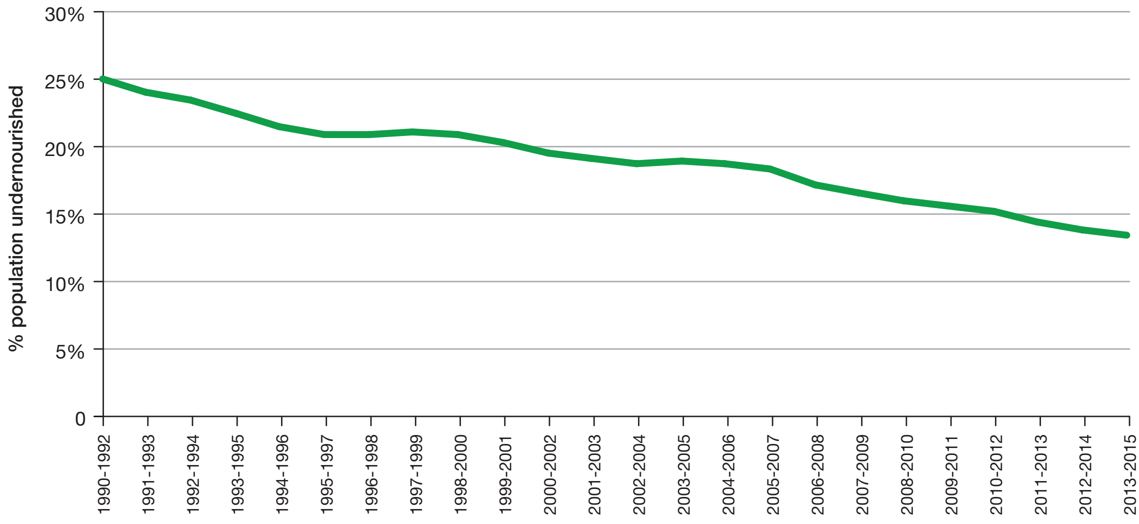

Figure 14.2: Trends in the proportion of the population of Latin America and the Caribbean estimated to be undernourished, shown as three year averages from 1990-1992 to 2013-2015 (source: FAO, 2015c).

Water

Around 34 per cent of the world's renewable water resources are in Latin America and the Caribbean, although this is not distributed evenly across the region (Mekonnen et al. 2015). A country with annual renewable water resources of under 1,000 m³ per capita is considered to be under water stress (Falkenmark & Lindh, 1976; UN-Water, 2011) and in 2014, six Caribbean countries fell into that category (Antigua and Barbuda, Barbados, Haiti, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines). Barbados has the least water per capita of any country in the region, at 280 m³ per person per year (FAO, 2015d).

Access to improved water sources (defined as "one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter" (JMPWSS, 2015a) has increased across the region from 67 per cent (1990) to 83 per cent (2014) (JMPWSS, 2015b). Despite this improvement in access to clean water, a steadily increasing population in Latin America and the Caribbean is putting increasing pressure on overall freshwater resources (FAO, 2015d) (Figure 14.3).

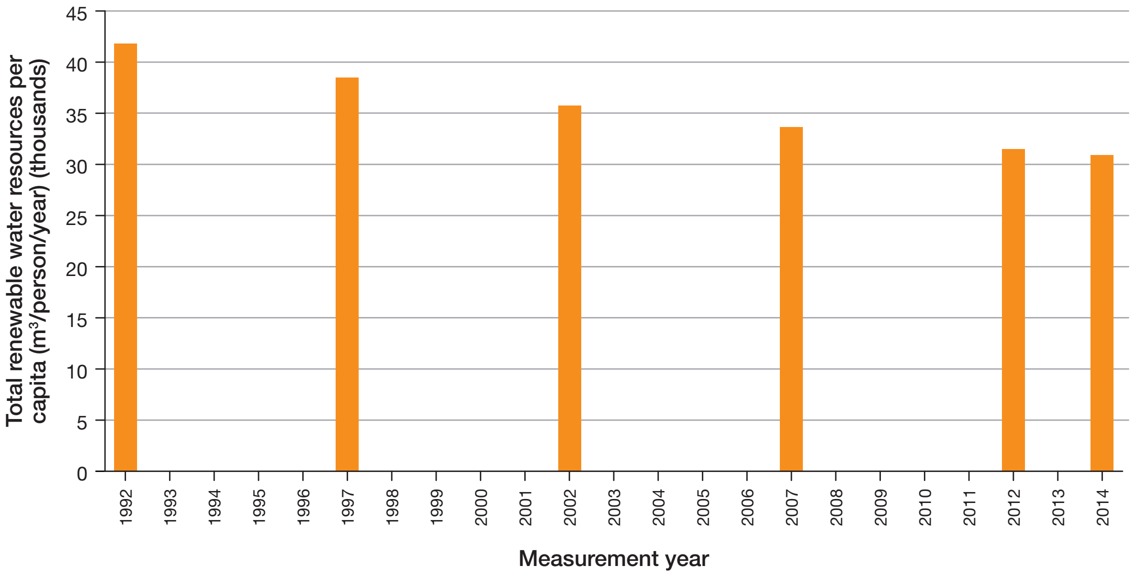

Figure 14.3: Trends in total renewable water resources per capita, measured at different intervals between 1992 and 2014, in Latin America and the Caribbean (source: FAO, 2015d).

Air quality

Yale University's Environmental Performance Index shows that the proportion of the region's population exposed to fine particulate matter ($PM_{2.5}$) over the WHO recommended levels of 10µg/m³ (WHO, 2005) has remained fairly stable since 2000. In 2012, over 10 per cent of the population was exposed to higher than recommended levels in four countries: Bolivia (12 per cent), Mexico (50 per cent) Paraguay (33 per cent) and Peru (12 per cent) (Figure 14.4). More needs to be done to improve air quality, particularly in these countries. The proportion of the population exposed in other countries in the region averaged between zero and nine per cent over the same period (Yale University, 2012).

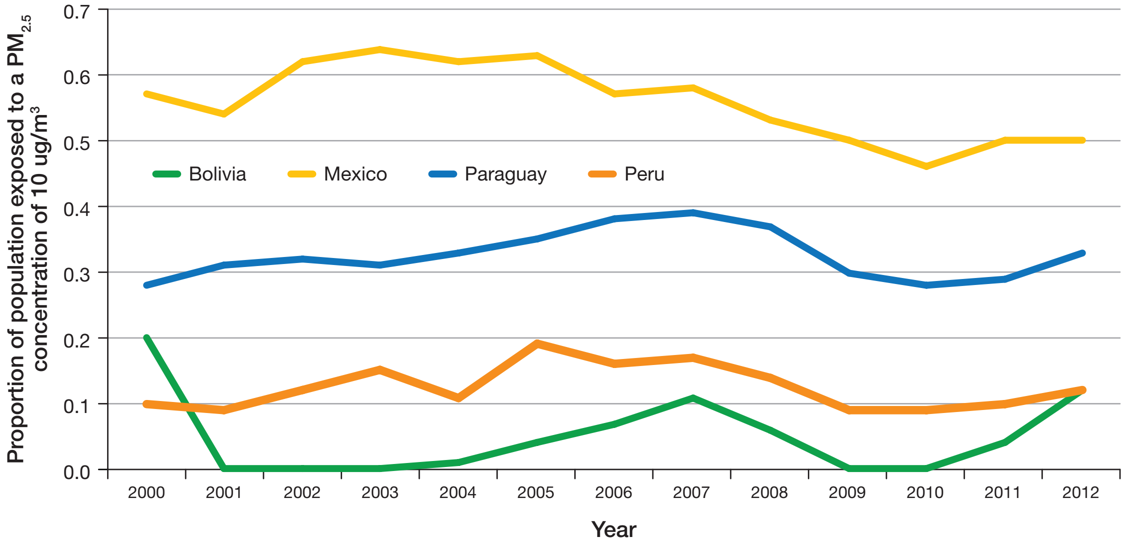

Figure 14.4: Trends in the proportion of the national population exposed to a $PM_{2.5}$ concentration of 10µg/m³, from 2000 to 2012, for all countries in Latin America and the Caribbean with a proportion of over 10% in 2012 (source: Yale University 2015).

Ocean

The Ocean Health Index combines multiple datasets to calculate annual index scores for ten goals, plus an overall index score, which cover the range of ecosystem services that humans derive from the ocean (Figure 14.5). In 2015, Latin America and the Caribbean scored slightly lower than the global average in all but three of the elements of the index (*Carbon Storage*, *Livelihoods and Economics*, and *Sense of Place*). Latin America and the Caribbean scores particularly low in absolute terms, and compared to global averages, in *Natural Products* and *Tourism and Recreation*. Ocean Health Index scores for Latin America and the Caribbean have not changed significantly between 2012 and 2015 (Ocean Health Index, 2016). However, some of the underlying datasets have not been updated since 2012, which may be masking regional changes (Halpern et al. 2015).

In conclusion, there are considerable broad scale data on changes in ecosystem services in the region. Natural resources are being converted gradually through ecosystem service provision and resulting in a lower stock of natural resources across the region. Although there are efforts to enhance sustainability of use of ecosystem services in the region, it is likely that the countries are mainly moving away from this target and that additional actions are needed to keep this target on track.

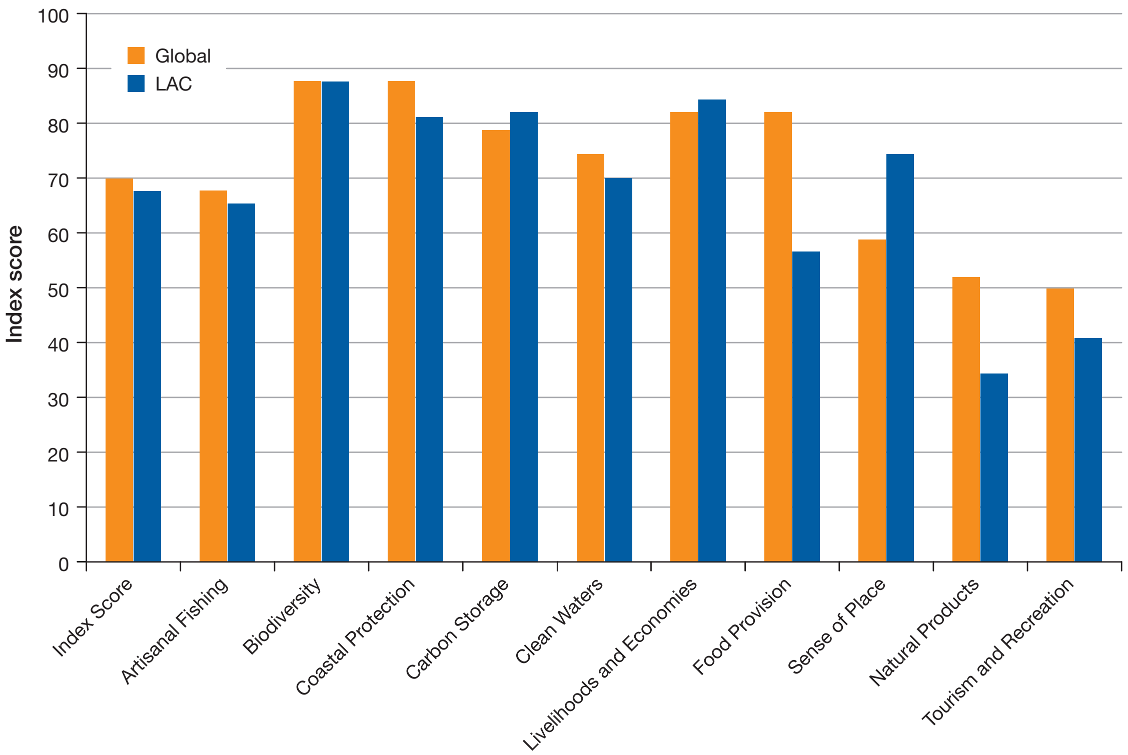

Figure 14.5: 2015 Ocean Health Index scores by goal, comparing Exclusive Economic Zone (EEZ) area weighted average scores for Latin America and the Caribbean with global scores (source: Ocean Health Index 2016).

Box 14.1: Impacts of Dams.

The increasing dam development in the Amazon basin is feared to have severe effects on the region's biodiversity.

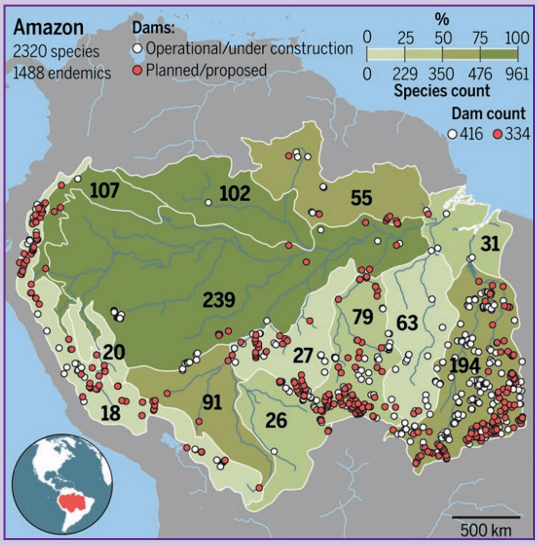

Figure 14.6. Fish diversity and dam locations in the Amazon basin. Numbers indicate where species occur only within a specific ecoregion (white boundaries) (source: Winemiller et al. 2015).

Current and planned dams in the Amazon Basin (Figure 14.6) are likely to have long-term cascading effects on biodiversity and ecosystem services, which are rarely analysed and considered fully during dam planning (Winemiller et al. 2015). For example, the Belo Monte dam project (Amazon Watch, 2016) is expected to set a new record for biodiversity loss due to high endemism amongst species in the construction site.

Sustainable management of infrastructure development is key in order for communities in affected areas to continue receiving benefits from the ecosystem services and goods provided. Actions must be taken in order to protect these habitats and their services, and to ensure that the costs of lost biodiversity, genetic resources, cultural values and water and soil quality do not outweigh the potential benefits from infrastructure development and energy supply to local communities.

Box 14.2: Brazilian Biological Resources Centers Network - Br-BRCN.

Ecosystems provide many different services, some of which are provided through the presence of microorganisms that contribute to the health of natural habitats, but also to industry, agriculture and health. Within this context, there is an important initiative in Brazil at the Federal Government level which entails the structuring of the Brazilian Biological Resource Center Network (Br-BRCN), composed of collections of protozoa, fungi, bacteria and virus, as well as replicable parts of these from Fiocruz (Oswaldo Cruz Foundation), Embrapa (Brazilian Agricultural Research Corporation), Unicamp (University of Campinas) and other universities, with the support of CRIA (Reference Center on Environmental Information), Inmetro (National Council of Metrology, Standardization and Industrial Quality), INPI (National Institute of Industrial Property) and SBM (Brazilian Society of Microbiology). The Brazilian BRCN will provide certified and authenticated biological material, specialized services and associated information in accordance with all the national and international regulations and legislations related to these biological materials and activities conducted by the BRCs. The Network aims to offer new opportunities to maintain the productive capacity of ecosystems and promote sustainable development. This infrastructure will be responsible for preserving an important part of Brazil's biodiversity.

TARGET 15: ECOSYSTEM RESTORATION AND RESILIENCE

By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least fifteen per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

"Deforestation, wetland drainage and other types of habitat change and degradation lead to the emission of carbon dioxide, methane and other greenhouse gases. The reversal of these processes, through ecosystem restoration, represents an immense opportunity for both biodiversity restoration and carbon sequestration. In fact, in many countries degraded landscapes represent a huge wasted resource. Restored landscapes and seascapes can improve resilience including adaptive capacity of ecosystems and societies, and can contribute to climate change adaptation and generate additional benefits for people, in particular indigenous and local communities as well as the rural poor. The conservation, restoration and sustainable management of forests, soils (especially peatlands), freshwater and coastal wetlands and other ecosystems are proven to be cost-effective, safe and immediately-available means to sequester carbon dioxide and prevent the loss of other greenhouse gases." (CBD 2016e)

Ecosystem resilience is a term that describes the capacity of ecosystems to absorb and adapt to disturbances while preserving their ecological functions and without moving to a new state governed by different processes and controls (Carpenter et al. 2001). Restoration of degraded ecosystems can enhance ecosystem resilience, improve the adaptive capacity of ecosystems, contribute to climate change adaptation and mitigation, and generate additional benefits for local people.

Despite its many benefits to ecosystems and biodiversity of restoration and enhancing resilience, there is a lack of indicators to assess the progress towards Target 15 (Chenery et al. 2015; GEO BON, 2015), due in part to the difficulties with defining restoration itself. The area of restoration projects in the Global Restoration Network Database is the only potential global indicator, but even this has low alignment to the target (Chenery et al. 2015).

The Group on Earth Observations Biodiversity Observation Network's (GEO BON) is working on a 'global ecosystem restoration index' that integrates elements of the restoration process, including structural and functional aspects, to assess improvements or declines against a baseline (GEO BON, 2015). This index builds upon recent advances in remote sensing (using the MODIS sensor) and ecosystem mapping to combine the assessment of three main elements of restoration: change in ecosystem productivity; change in ecosystem energy balance; and changes in land cover. The index has near-global coverage at 1 km^2 spatial resolution, but the data are not yet available for general use.

The fifth national reports to the CBD show that restoration of forests and mangroves is taking place across Latin America and the Caribbean, but progress is slow compared to the extent of ecosystem degradation. In Cuba, forest cover has increased since 2000 through management efforts, despite no reforestation or forest restoration taking place. Many countries in the region also report a reduction in deforestation rates, such as Brazil (for detail see text under Target 5). However, deforestation is currently expected to increase in many other countries (CBD 2015).

National statements have been made by several countries to the UNFCCC, indicating their intent to carry out reforestation through a variety of initiatives. These include: Intended Nationally Determined Contributions (INDCs) prepared for the UN Framework Convention on Climate Change (UNFCCC) 21^{st} Conference of the Parties (COP21) in Paris in December 2015 (see Box 15.2).

Activities carried out under commitments to REDD+ will also work toward increasing the resilience of forest carbon stocks to climate change and improve the ability of forest ecosystems to adapt to climate change (Miles et al. 2013). In Peru, elements of the country's NBSAP for 2014-2018 and their participatory approach to the implementation of Nationally Appropriate Mitigation Actions (NAMAs) for 3 main economic activities associated with deforestation and forest degradation have the potential to contribute to enhancing carbon stocks and mitigating climate change (Epple et al. 2014).

The largest such statements made by each country amount to 33.5 million ha, 4 per cent of the region's 2015 forest area, or 43 per cent of the reduction in forest area in the region between 1990 and 2015 (Murcia & Guariguata 2014; Miles & Sonwa, 2015; Murcia et al. 2015) (Figure 15.1). Thus if these intentions are enacted, significant progress will be made towards Target 15. As an example of forest recovery in the region, and according to FAO data (FAO 2015), forest cover has increased between 1990 and 2015 in six countries in Latin America and the Caribbean: Chile (16 per cent) Costa Rica (7 per cent) Cuba (55 per cent), Dominican Republic (79 per cent), Saint Vincent and the Grenadines (8 per cent), and Uruguay (131 per cent). This is against an overall 9 per cent total reduction of forest area across the region over the same period (FAO 2015e).

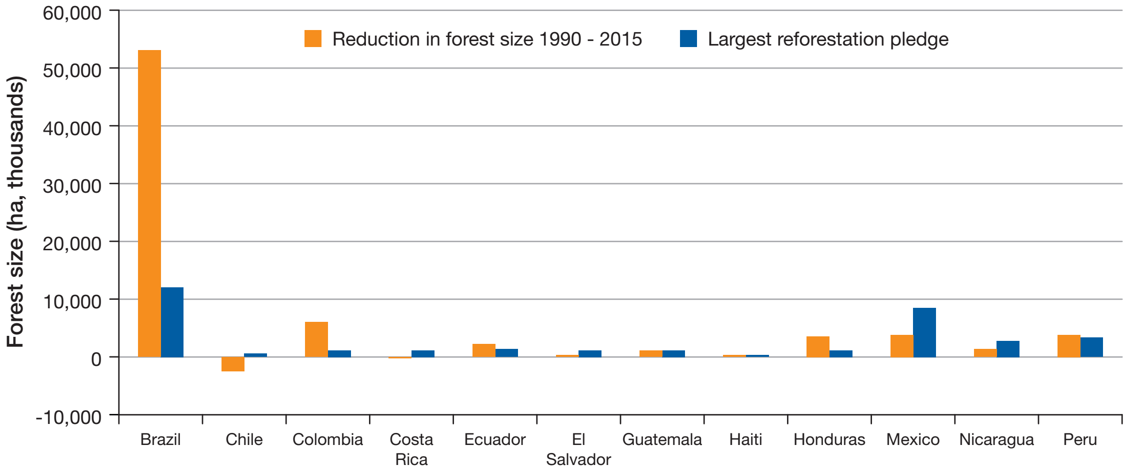

Figure 15.1: Reduction in forest size from 1990 to 2015 compared to the largest reforestation statement made, for all countries in Latin America and the Caribbean that have made a reforestation statement through an Intended Nationally Determined Contribution (INDC), the Bonn Challenge or Initiative 20x20 (source: Miles & Sonwa, 2015).

Reforestation cover is only one aspect of forest restoration. As well as the issues of replacing primary forest with new forest, Aide et al. (2012) found wide variation in deforestation and reforestation rates in the ten major biomes of Latin America and the Caribbean. Moist forest, dry forest and savannah/scrubland accounted for more than 80 per cent of deforestation in the region between 2001 and 2010, whereas over 40 per cent of reforestation over the same period took place in the desert/xeric shrub biome.

In conclusion, despite poor data and a lack of indicators to track the achievement of this target, there are a number of dramatic commitments at the global and regional level that, if implemented, would make a significant impact on the restoration of forests around the world, including within the LAC region.

Box 15.1: National Forestry Evaluation, Ecuador.

The National Forestry Evaluation in Ecuador, with technical input provided by the FAO, was initiated in 2006 to compile biophysical, environmental and socio-economic information about forests. Information about different classes of vegetation are captured so that changes in biomass and land use can be capture for different vegetation types. One impact of this approach has been to allow Ecuador to include trees outside of forests in its land cover measures. The outputs from the programme will inform decision making and policy development (The REDD Desk 2016b). Calculation of carbon stocks stratified across different ecosystems has been another output of the programme (Ministerio del Ambiente, Ecuador 2015).

Box 15.2: Initiative 20x20.

Initiative 20x20 was formally launched at the UNFCCC COP-20 in Lima, with the goal of bringing 20 million ha of degraded land across Latin America and the Caribbean into restoration projects by 2020. Initiative 20x20 will support the Bonn Challenge, a global commitment to restore 150 million ha of land by 2020. USD 730 million of private investment has been provided for ten countries, three states and one regional programme, which together have committed to begin restoring 27.7 million ha by 2020 (WRI 2016).

Box 15.3: Social Forest Program in Argentina.

The Social Forest Programme (Programa Social de Bosques, ProSoBo) aims to preserve and restore the sustainable use of native forests and their biodiversity, by enabling local people to utilise their environment to earn a livelihood and improve their standard of living. The programme provides technical and financial support, mostly to inhabitants of forests, including rural communities and farming organisations, indigenous peoples, and small farmers (Secretaria de Ambiente y Desarrollo Sustentable, Republica Argentina 2015).

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TARGET 16: ACCESS TO AND SHARING BENEFITS FROM GENETIC RESOURCES

By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.

"The fair and equitable sharing of the benefits arising out of the utilization of genetic resources is one of the three objectives of the Convention on Biological Diversity. The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) to the Convention on Biological Diversity was adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting in Nagoya, Japan." (CBD 2016e)

The *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS)* entered into force in October 2014. In order to fulfil its aim of fair and equitable sharing of the benefits of the utilisation of genetic resources, the Protocol provides a comprehensive framework aimed at ensuring that genetic resources and associated traditional knowledge are only accessed with free prior and informed consent of the country of origin providing those resources, the involvement of indigenous peoples and local communities, and under mutually agreed terms. The Protocol aims to provide users, producers of genetic resources and holders of traditional knowledge in all countries with greater legal certainty, clarity and transparency (South Centre, 2015). In brief, it advances in the implementation of the third objective of the CBD by enhancing the contribution of biodiversity to sustainable development and human well-being (CBD 2014b).

Progress towards the achievement of Aichi Biodiversity Target 16 is analysed in relation to two aspects. Firstly, with respect to those countries in the region that have ratified the Protocol, therefore bring it into force at the national level. Secondly, elements linked to the operationalisation of the Protocol consistent with national legislation will also be considered.

To date, nine countries in Latin America and the Caribbean have acceded to or ratified the Nagoya Protocol, and a further eight countries are signatories but have not yet ratified (Table 16.1) (CBD 2016b). In addition, consultation processes that could lead towards its ratification are taking place in several countries at the domestic level. Recent research found that 19 countries in Latin American and the Caribbean had some form of access and benefit sharing measures either in place or in the process of being drafted (CBD 2014a; Medaglia et al. 2014).

At the time of submission of the fifth national reports to the CBD, four countries (Argentina, Costa Rica, Honduras and Nicaragua) had national legislation in place on the utilization of genetic resources in support of the Nagoya Protocol. A further five (Dominican Republic, Ecuador, Guatemala, Mexico, and Panama) were in the process of developing such legislation. Other countries in the region either provided no information in their fifth national reports, or were in the early stages of considering Target 16 (CBD 2015).

Table 16.1: Dates of signature and ratification or accession to the Nagoya Protocol for countries in the Latin America and the Caribbean region (source: CBD 2016b).

Country	Signed	Ratification/ Accession
Antigua and Barbuda	28/07/2011	N/A
Argentina	15/11/2011	N/A
Brazil	02/02/2011	N/A
Colombia	02/02/2011	N/A
Costa Rica	06/07/2011	N/A
Cuba	N/A	17/09/2015
Dominican Republic	20/09/2011	13/11/2014
Ecuador	01/04/2011	N/A
El Salvador	01/02/2012	N/A
Grenada	22/09/2011	N/A
Guatemala	11/05/2011	18/06/2014
Guyana	N/A	22/04/2014
Honduras	01/02/2012	12/08/2013
Mexico	24/02/2011	16/05/2012
Panama	03/05/2011	12/12/2012
Peru	04/05/2011	08/07/2014
Uruguay	19/07/2011	14/07/2014

In accordance with the information available in the fifth national reports, most of the countries that ratified the Protocol are currently in the process of either developing legal and institutional frameworks to create conditions for effective implementation, or adapting existing legal and institutional frameworks in order to make them compliant with the Protocol's provisions. Other countries in the region are in the early stages of considering this target. Several other countries that are not Parties to the Nagoya Protocol, such as Argentina, Bolivia, Brazil, Colombia, Costa Rica, and Ecuador, had national legislation on access to genetic resources in place before the Protocol entered into force (Medaglia et al. 2014).

Moreover, the Secretariat of the Caribbean Community and Common Market (CARICOM) has conducted several activities in the Caribbean in order to build capacities of its Member States in the implementation of the Nagoya Protocol. The *Access and Benefit Sharing Capacity Development Initiative (ABS Initiative)* is working with CARICOM to support the development of the necessary legal and policy frameworks for that sub-region (ABS Initiative 2016). At the regional level, there have been substantive developments in the implementation of ABS, particularly in the Andean Community. Several countries in the LAC region are in the process of developing and implementing ABS regimes, through Global Environment Facility (GEF) projects implemented by UNEP.

Box 16.1: Advancing the Nagoya Protocol in Countries of the Caribbean.

This three year Global Environment Facility (GEF) project being implemented by UNEP intends to make progress in defining variables to measure implementation of the Nagoya Protocol within the Caribbean region, and to integrate Access and benefit Sharing (ABS) mechanisms into policies and government plans.

The project focuses on awareness raising and capacity building in eight countries across the Caribbean (Antigua and Barbuda, Barbados, Grenada, Guyana, Jamaica, Saint Lucia, Saint Kitts and Nevis, and Trinidad and Tobago) and has four components:

1. Identifying regional commonalities and assets, and basic elements conducive to policy formulation.
2. Uptake of the Nagoya Protocol.
3. Implementation of the Nagoya Protocol and establishing an enabling environment for the basic provisions of the NP.
4. Regional Coordination, technical support and capacity development.

The project plan identifies issues hindering the implementation of ABS mechanisms including: gaps in understanding of how ABS can be incorporated into the existing legal framework; no coordinated regional Inventory of Common Genetic Resources and Traditional Knowledge in place; and the absence of a dedicated National ABS Focal Point for most of the countries involved (UNEP 2015a).

In conclusion, Latin America and the Caribbean has made substantial progress in relation to the achievement of Aichi Biodiversity Target 16, though it has not been possible to fully reach the target by its agreed deadline. However, the progress is continuing and it seems highly likely that all countries will attain the target before 2020. There is also encouraging efforts in many countries to translate the Nagoya protocol into relevant national and even sub-regional policy and supporting legislation.

TARGET 17: BIODIVERSITY STRATEGIES AND ACTION PLANS

By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.

"National Biodiversity Strategies and Action Plans (NBSAPs) are the key instrument for translating the Convention and decisions of the Conference of the Parties into national action. For this reason it will be essential that Parties have developed, adopted and commenced implementing as a policy instrument an updated NBSAP which is in line with the goals and targets set out in the *Strategic Plan* by 2015" (CBD 2016c).

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In accordance with article 6 of the Convention on Biological Diversity, Parties have to develop National Biodiversity Strategies and Action Plans (NBSAPs). The NBSAPs need to address the three objectives of the Convention, i.e. conservation of biodiversity, sustainable use of the components of biodiversity, and fair and equitable sharing of the benefits deriving from the utilization of genetic resources. Parties have also been requested to develop or update their NBSAPs in line with the *Strategic Plan for Biodiversity 2011-2020* and the 20 Aichi Biodiversity Targets (SCBD 2011).

At the time of submission of the fifth national reports to the CBD, five countries in Latin America and the Caribbean (Colombia, Cuba, Dominican Republic, Ecuador, and Guatemala) reported that their NBSAP had been adopted as a policy instrument, while Peru was in the process of approving it. Most other countries in the region reported that progress was being made towards development or approval of the NBSAP (CBD 2015).

Through international support, considerable efforts have been carried out to assist countries in Latin America and the Caribbean to revise and update their NBSAPs. Since 2011, five regional and sub-regional capacity-building workshops were held for countries in the region under the CBD, with a focus on the information needs and use of indicators in setting and monitoring national targets to support the process of updating NBSAPs (CBD 2016a).

As of January 2016, seven of the 33 Parties to the CBD in Latin America and the Caribbean had submitted a post-2010 NBSAP to the CDB which incorporated the *Strategic Plan for Biodiversity 2011-2020* (Table 17.1). Only Haiti is yet to submit an NBSAP to the CBD, and ten countries have revised their submitted NBSAPs at least once (CBD 2016a).

Table 17.1: Status of NBSAP development for Latin America and the Caribbean (as of January 2016) (source: SCBD 2016).

Parties	Parties with their first NBSAP under development	*Parties that have submitted a pre-2010 NBSAP to the CBD, and have not yet submitted a post-2010 NBSAP*	*Parties that have submitted a post-2010 NBSAP to the CBD*
Antigua and Barbuda			X
Argentina		X	
Bahamas		X	
Barbados		X	
Belize		X	
Bolivia (*Plurinational* State of)		X	
Brazil		X	
Chile		X	
Colombia			X
Costa Rica		X	
Cuba		X	
Dominica			X
Dominican Republic			X
Ecuador		X	
El Salvador		X	
Grenada		X	
Guatemala			X
Guyana		X	
Haiti	X		
Honduras		X	
Jamaica		X	
Mexico		X	
Nicaragua		X	
Panamá		X	
Paraguay		X	
Peru			X
Saint Kitts and Nevis		X	
Saint Lucia		X	
Saint Vincent and the Grenadines		X	
Suriname		X	
Trinidad and Tobago		X	
Uruguay		X	
Venezuela (Bolivarian Republic of)			X
Total	1	25	7

In conclusion, this region is somewhat behind other parts of the world in its development of updated NBSAP documents for submission to the CBD. However, there is progress on this task in many countries and almost all countries have pre-2010 documents that provide a basis for much of their national action to achieve the goals of the CBD. Given that a number of countries are known to be working hard on their NBSAPs, for example, Mexico has a detailed national plan and set of subnational biodiversity strategies under development, it is expected that this region will complete the NBSAP process and have them under implementation before 2020.

TARGET 18: TRADITIONAL KNOWLEDGE

By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.

> "There is a close and traditional dependence of many indigenous and local communities on biological resources. Traditional knowledge can contribute to both the conservation and sustainable use of biological diversity. Target 18 aims to ensure that traditional knowledge is respected and reflected in the implementation of the Convention, subject to national legislation and relevant international obligations, with the effective participation of indigenous and local communities." (CBD 2016c)

The GBO-4 has shown that the world is making insufficient progress toward Target 18 due to "limited support, recognition and capacity" (SCBD 2014, p.115). However, there was also the recognition that there is "growing interest in traditional cultures and involvement of local communities in the governance and management of protected areas and the growing recognition of the importance of community conserved areas". This suggests that global trends may not reflect realties in some regions.

The LAC region has a strong history of conservation and awareness of the importance of biological diversity by indigenous peoples and local communities. Large areas of the Amazon are under the management of indigenous groups – and this has been formally recognised in the laws of a number of countries. There are also indigenously managed areas further south in the continent (Ricketts et al. 2010).

Examples of actions indicating progress in Latin America and the Caribbean towards Target 18 mentioned in the fifth national reports to the CBD include; the consultation and involvement of indigenous people in specific conservation projects (Colombia, Costa Rica, El Salvador, Guatemala, and Guyana), the creation of inventories of traditional knowledge (Dominican Republic), putting in place incentive systems to encourage indigenous communities to maintain traditional knowledge in Peru, and Chile (Crowley 2015). Relevant legislation and policy instruments include the creation of the Council of Family, Peasant and Indigenous Agriculture in Argentina, the Law of Ancestral Medicine in Bolivia, and the National Commission for the Sustainable Development of Traditional Peoples and Communities (CBD 2006) in Brazil. Little information is provided on the impact of these measures, although Dominica reports that traditional knowledge continues to decline (CBD 2015).

Linguistic diversity is an important indicator of measuring trends in traditional knowledge, as traditional knowledge is mainly transmitted orally from generation to generation, and indigenous people, in part, identify themselves as 'indigenous' through the use of their language (Larsen et al. 2012). Twenty-four per cent of the languages recorded in the *UNESCO Atlas of the World's Languages in Danger* are spoken in Latin America and the Caribbean, a disproportionately high number compared to the population of the region. The Atlas records that 390 languages in the region are definitely, severely, or critically endangered, a further 217 languages are recorded as vulnerable, and 36 are reported to be extinct (UNESCO 2015). The Index of Linguistic Diversity suggests that there has been a steep decline of linguistic diversity in Latin America and the Caribbean since 1970 (Figure 18.1) (Loh & Harmon 2014).

In conclusion, achieving the intention of this target by 2020 will be a challenge, however, there are many examples of indigenous knowledge being used to further conservation in the region and parts of the region have some of the most vibrant and intact systems of local knowledge remaining on Earth. The diversity of languages in the LAC region, the best proxy of indigenous knowledge that can be tracked across the whole region, is in decline, and this decline seems to be accelerating in recent years. This suggests it will be hard to meet the target by 2020.

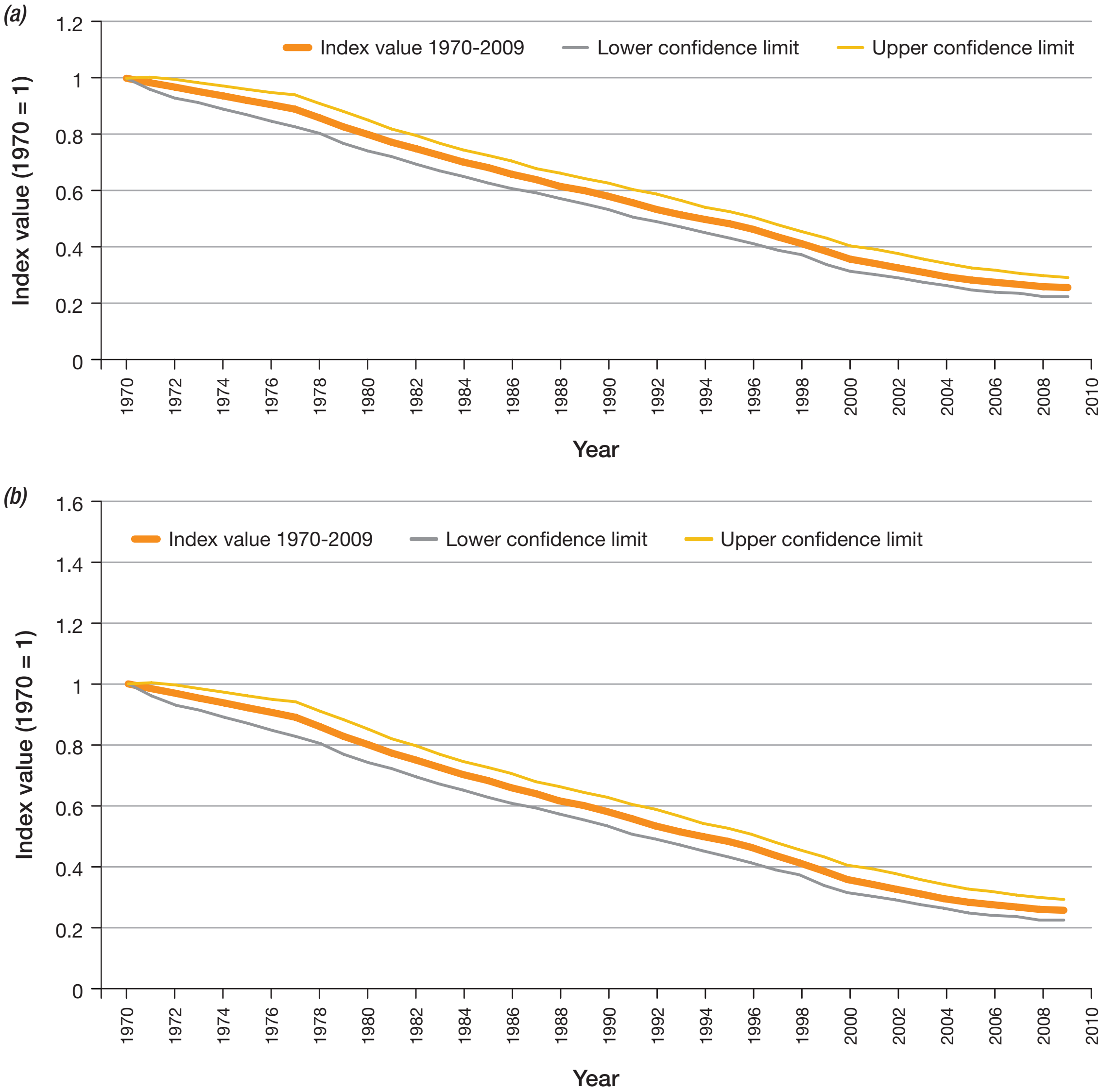


Figure 18.1: Neotropical (a) and Nearctic (b) Index of Linguistic Diversity 1970-2010 (source: Loh and Harmon 2014). While most of the LAC region is within the Neotropical realm, parts of Mexico fall within the Nearctic realm.

Box 18.1: Brazil's Indigenous Environmental and Territorial Management Project (GATI).

The main objective of Brazil's Indigenous Environmental and Territorial Management Project (GATI) is to strengthen "indigenous practices for the management, sustainable use and conservation of natural resources, as well as enhancing social inclusion of indigenous peoples" (Ministry of the Environment, Brazil 2015). The project has been implemented in 32 indigenous lands, selected to include all of the Brazilian forest biomes (Amazon, Atlantic Forest, Caatinga, Cerrado and Pantanal). Other criteria for the selection of land included a requirement for "significant biological diversity and vegetation cover", the existence of potential threats to biodiversity that could be mitigated by the project, and the existence of "outstanding indigenous initiatives" for environmental protection (Ministry of the Environment, Brazil 2015).

Since implementation of GATI in 2010, project activities have included: supporting small projects towards the sustainable management of native species; workshops on agroecology and agroforestry; ten information exchange events, including the participation of indigenous representatives in the United Nations Conference on Sustainable Development (Rio +20); and the establishment of the Indigenous Capacity Building Center (Ministry of the Environment, Brazil 2015).

Box 18.2: Protection Regime for the Collective Knowledge of Indigenous Peoples Derived from Biological Resources, Peru.

In 2002, Law No 27811 was introduced in Peru to establish a protection regime for traditional knowledge connected with biological resources. The objectives of the regime are:

a) To promote respect for and the protection, preservation, wider application and development of the collective knowledge of indigenous peoples;

b) To promote the fair and equitable distribution of the benefits derived from the use of that collective knowledge;

c) To promote the use of the knowledge for the benefit of the indigenous peoples and mankind in general;

d) To ensure that the use of the knowledge takes place with the prior informed consent of the indigenous peoples;

e) To promote the strengthening and development of the potential of the indigenous peoples and of the machinery traditionally used by them to share and distribute collectively generated benefits under the terms of this regime;

To avoid situations where patents are granted for inventions made or developed on the basis of collective knowledge of the indigenous peoples of Peru without any account being taken of that knowledge as prior art in the examination of the novelty and inventiveness of the said inventions" (The Peruvian Sate 2002).

The general principles of the law are that: prior informed consent is required from the representatives of indigenous peoples before traditional knowledge is accessed for scientific, commercial or industrial application; licences shall be used to ensure equitable distribution of benefits arising from commercial or industrial use of traditional knowledge; traditional knowledge shall be capture and preserved for the benefit of future generations (The Peruvian Sate 2002).

TARGET 19: SHARING INFORMATION AND KNOWLEDGE

By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.

"All countries need information to identify threats to biodiversity and to determine priorities for conservation and sustainable resource use. While nearly all parties report that they are taking actions related to monitoring and research, most also indicate that the absence or difficulty in accessing relevant information is an obstacle to the implementation of the goals of the Convention." (CBD 2016c)

Sharing information and knowledge plays a crucial role in assessing the status of biodiversity and identifying threats and responses to prevent its loss. Knowledge also helps countries undertake better conservation on the ground and play a larger role in international discussions related to conservation and sustainable use of natural resources. It thus greatly facilitate the achievement of all Aichi Biodiversity Targets.

The lack of consistent data and information collection relating to habitat loss is a problem in the LAC region. A recent review by Armenteras et al. (2016) on forest degradation in the LAC region identified the lack of information on forest degradation was an issue when trying to improve conservation and habitat protected in Bolivia and Nicaragua. However, in Paraguay deforestation and forest degradation has been estimated using aggregated data from three ecoregions, the Atlantic forest 'Alto Paraná', the humid Chaco region and the dry Chaco, using remote sensing techniques which allow a better assessment of the state of the countries forests, and thus better conservation planning.

The fifth national reports to the CBD demonstrate that nearly every country in Latin America and the Caribbean is increasing its knowledge base in relation to biodiversity, although it is acknowledged that gaps remain. For example, St Vincent and the Grenadines and Guyana specifically point to the lack of available information as a reason for a lack of progress towards the Aichi Biodiversity Targets as a whole (CBD 2015). Reported efforts to share and apply information are more limited and vary significantly across the region.

The Caribbean has a strong history of co-operation and knowledge sharing in marine research, starting with the establishment of the Association of Marine Laboratories of the Caribbean (AMLC) in 1957. More recently, the Census of Marine Life (Census) programme has been working in the Caribbean since an initial workshop in 2004, attended by ten Caribbean countries, to assess the state of marine biodiversity knowledge in the region. Since then, the Census has been involved in several projects to enhance understanding of marine ecosystems in the Caribbean, using the Ocean Biogeographic Information System[6] to provide wide access to the resulting data (Miloslavich et al., 2010).

Mexico's CONABIO institute is another example of efforts to strengthen capacity, serving as a bridge between academia, government ministries and society and offering information and knowledge to decision makers and acting as a National Focal Point for CITES, SBSTTA (Subsidiary Body on Scientific, Technical and Technological Advice) and IPBES. The availability of records in open access biodiversity data initiatives such as the Global Biodiversity Information Facility (GBIF) provides an indicator of progress towards the wide sharing of biodiversity information as part of Target 19. There has been a steady rise in the total number of species occurrence records in GBIF, on species collected or observed in Latin America and the Caribbean, from around 9 million in 2007 to over 38 million in 2015 (Figure 19.1). Three of the top 25 contributors to the total collection of records in GBIF (of which 23 are countries and two are organisations) are countries in Latin America: Costa Rica (ranked 18th with just over 3 million records), Mexico (ranked 19th), and Colombia (ranked 23rd). However only 5 per cent of records added to GBIF in 2014 related to biodiversity from the LAC region, and only 2 per cent were from a publishing institution based in the LAC region. Less than 10 per cent of GBIF records from the LAC region are about biodiversity from other regions, a lower per centage than seen in any other region (GBIF 2015).

[6] http://www.iobis.org/

Three of the first five projects funded under the GBIF capacity enhancement programme launched in 2014 were based in Latin America: the Biodiversity Information System of Colombia (SiB Colombia[7]); a project led by the Iberoamerican Programme for Science and Technology for Development (CYTED[8]) to increase capacity for "digitizing and publishing data from scientific literature, images and multimedia"; and mentoring led by CONABIO in Mexico, using the Plinian Core Standard[9] for species information to increase the quality of available data records. Six GBIF related events were held in Brazil, Colombia and Mexico in 2014, including the Brazilian Biodiversity Information System launch event (see Box 19.1) and the fourth GBIF Latin American Nodes meeting. In 2014, Mexico requested over 10,000 data downloads from GBIF, a download rate exceeded only by the United States (GBIF 2015).

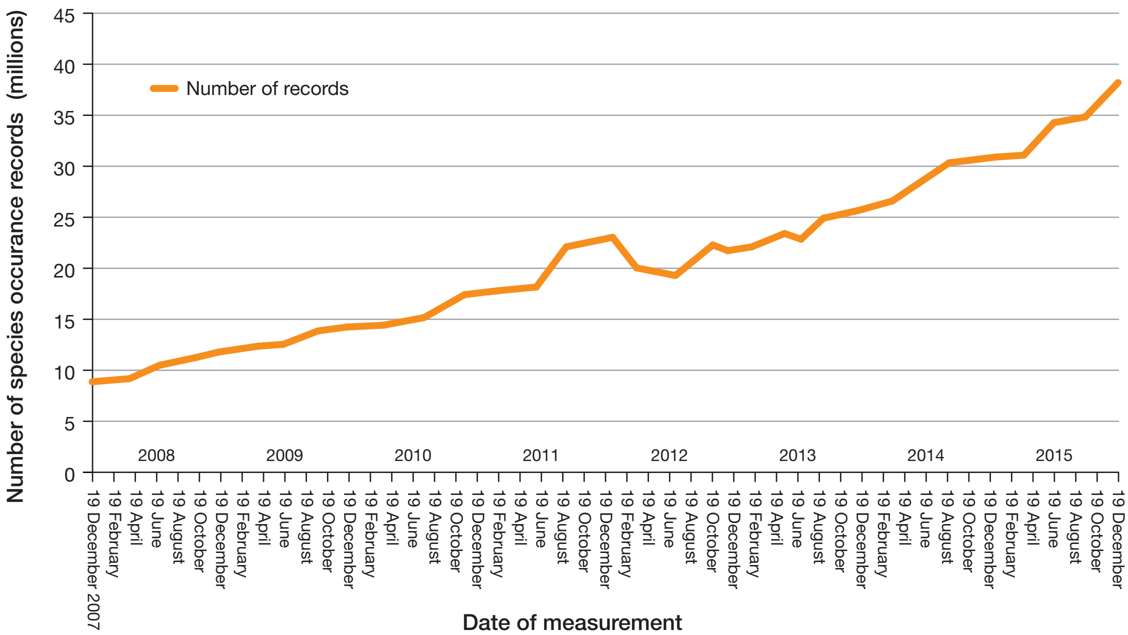


Figure 19.1: Growth in the number of species occurrence records, for species collected or observed in Latin America and the Caribbean, accessible through the Global Biodiversity Facility between 2007 and 2015 (source: GBIF 2016).

In conclusion, there has been considerable progress in recent years to make data on the biodiversity of the LAC region more widely available. This has been facilitated by global, regional and national data sharing and data availability platforms and projects, and by national initiatives for knowledge information exchange. Examples include the CaMPAM network and forum[10] designed to share information and lessons learned to inform decision-making around MPAs in the Caribbean region, and the Biodiversity and Protected Areas Management Programme (BIOPAMA)[11] which aims to address threats to biodiversity while reducing poverty, in many regions around the world, including the Caribbean. The region is now well placed to expand this work and increase the availability of relevant data for decision, although it still faces challenges in achieving sustainable financing for conservation. Given all these developments it seems that the region is on track to achieve or nearly achieve Target 19 by 2020.

[7] http://www.sibcolombia.net/web/sib/home
[8] http://www.cyted.org/
[9] Plinian Core v2.0 Concept Definitions
[10] http://campam.gcfi.org/campam.php
[11] http://www.biopama.org/

Box 19.1: Brazilian Biodiversity Information Systems.

The Brazilian Biodiversity Information System (SiBBr) is an initiative lead by Brazil's Ministry of Science, Technology and innovation to integrate information on biodiversity and ecosystems, with the objective of supporting scientific research and public policies. The SIBBR is already available online[12], and the first set of scientific data is currently being uploaded. The SiBBr is also the national focal point for the Global Biodiversity Information Facility (GBIF), which provides Brazil with access to technology to assist with implementation of SiBBr (Ministry of the Environment, Brazil 2015).

Another Brazilian initiative for recording biodiversity information is the Information System on Wildlife Health (Sistema de Informação em Saúde Silvestre, SISS-Geo)[13] lead by the Fundação Oswaldo Cruz (Oswaldo Cruz Foundation, known as Fiocruz) linked to the Brazil Ministry of Health. This foundation monitors wildlife and circulating pathogens occurring in natural habitats or on the borders between rural and urban environments, before they reach humans. The SISS-Geo is an online tool for recording animal observations using mobile communications devices through citizen science, with participants ranging from tourists, farmers, eco-tourism guides, birdwatchers, contractors and farmers. Based on recorded observations of animals and information on possible abnormalities (such as wounds or unusual behaviour) and characteristics of the environment in which the observations were made, the system generates alerts on incidents in wild fauna. These alerts are investigated by the technical units with the support of the Wildlife Health Laboratory Network and other specialists to confirm or rule out the pathogens potentially associated with the alert. This information is then made available to decision makers and society and provides the basis for developing prediction models, aiming to act before the diseases affect humans and other animals.

Box 19.2: Increasing Awareness of the Values of Biodiversity.

(source: Tania Urquiza Haas and Patricia Koleff)

To conserve and use biodiversity sustainably, decision makers need relevant and scientifically sound information to implement appropriate policy measures. Mexico´s ecosystem assessment (The Natural Capital of Mexico, CNM; CONABIO 2007a,b; 2010) connects science with policy-makers by providing a major synthesis of the knowledge on the components, structure, and functioning of the biodiversity, its conservation status and the threats and trajectories of anthropogenic impact, along with the policies, institutions, and instruments needed for its sustainable management. The assessment itself, and the process leading to it, have provided several important lessons that may be useful outside of Mexico, including:

1) multi-stakeholder participation of more than 700 scientists, government officers, and nongovernmental organization members participated with the support of the minister of environment will ensure that CNM will remain accepted and used for many year;

2) CNM provided and unprecedented work of data systematization, reflection, and analysis in order to provide solutions to complicated environmental problems and to highlight strategic priorities to encourage policies for the conservation and sustainable management of biodiversity; and

3) a strong scientific foundation for the development of the National Biodiversity Strategy and Action Plan. Whether this will serve to change the environmental degradation trends that Mexico continues to experience depends on the engagement of policy-makers and the support of society at large (Sarukhán et al. 2014).

One key element is to provide to society access to all information in a friendly format, through different media outlets (for example, Biodiversidad Mexicana[14]). Also, increasing the participation of people in Citizen Science programmes can help communities to increase the value of their natural capital (for example, aVerAves[15]) or to increase people's awareness of biodiversity (for example, Naturalista, CONABIO[16]).

[12] http://www.sibbr.gov.br/
[13] www.biodiversidade.ciss.fiocruz.br
[14] http://www.bioversidad.gob.mx/
[15] http://ebird.org/content/averaves/
[16] http://www,naturalista.mx/

Box 19.3: Colombia Biodiversity Information System (Sistema de Información sobre Biodiversidad de Colombia, SiB) (SiB 2016).

The Colombian Biodiversity Information System (SiB) is a country initiative designed to provide free access to information on Colombia's biodiversity, making it available to a wide variety of audiences. This initiative allows the online publication of biodiversity information which supports efficient and integrated biodiversity management.

Colombia's SiB initiative is led by the Directive Committee formed by the Ministry for Environment and Sustainable Development, five research institutes (IAvH, INVEMAR, SINCHI, IIAP and IDEAM) and Colombia's National University (UNAL). It's supported by the Technical Commission and working groups which, together, provide free online access to information through one single platform which includes metadata, reference documents and data files. The initiative is supported by GBIF. Information provided includes species population records, information on endangered species habitats and distributions, and species identification information.

The SiB actively encourages the distribution of information and knowledge related to biodiversity throughout Colombia, for example by organizing data sharing and quality assessment workshops with participants from other countries within the ALC region (e.g. Argentina, Brazil, Mexico) and outside the region too, such as Spain.

Box 19.4: Biodiversity Indicators Dashboard (NatureServe 2016).

The Biodiversity Indicators Dashboard is an online interactive dashboard developed by NatureServe and a team of expert international institutions to document, visualize and track biodiversity data in three regions of the world: the Topical Andes, the African Great Lakes, and the Mekong Basin. The dashboard monitor biodiversity trends and conservation performance in the Tropical Andes region, from 2001 to 2013, and can be used to help track progress towards conservation targets, support national and regional monitoring and reporting, inform policy and decision makers and catalyse investments in information infrastructure.

Regional scale analysis performed using the data collected by the dashboard include measuring pressure on biodiversity and rates of deforestation, state of species according to the IUCN Red List Index, conservation response measured though the network of KBAs, and benefit to human populations derived from freshwater provision (Han et al. 2014).

TARGET 20: MOBILISING RESOURCES FROM ALL SOURCES

By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

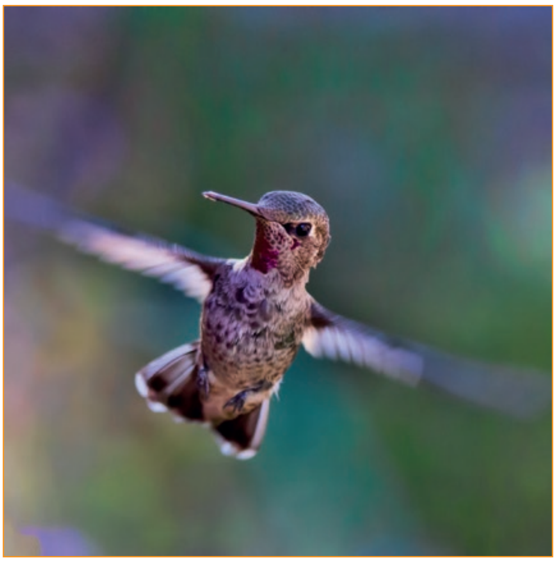
"Most countries indicated in their Fourth National Reports that limited capacity, both financial and human, was a major obstacle to the implementation of the Convention. The capacity that currently exists within countries needs to be safeguarded and increased from current levels, in line with the process laid out in the Strategy for Resource Mobilization, in order to enable countries to meet the challenges of implementing the Strategic Plan for Biodiversity 2011-2020. The fulfilment of Target 20 will have implications on the feasibility of achieving the other nineteen targets contained in the Strategic Plan." (CBD 2016c)

Financial, technical and human resources are required to implement and achieve the 20 Aichi Biodiversity Targets. This last target provides a means to track the commitment of both the countries in the region and the global agencies that support these countries in achieving the targets.

The fifth national reports to the CBD indicate that the Global Environmental Facility (GEF) is an important source of international funds for Latin America and the Caribbean, with Belize, Bolivia, Brazil, Cuba, Dominican Republic, Ecuador, Guatemala, Guyana, Mexico, and Nicaragua, among others benefiting from GEF funded projects. In most countries across the region investment in biodiversity has increased, but a significant funding gap remains. Dedicated funds are being created throughout the region, but only Ecuador and El Salvador report having a national strategy for resource mobilization in place, with another under development in Brazil (CBD 2015).

One of the constraints for effective conservation in the region is the resources available when competing with other governmental priorities. There has been significant funding provided by nations in the region as well as the international community – and this has had a measurable impact. However, there is still a need to increase the available resources using both traditional and new approaches to mainstream and include conservation planning into decision-making.

In addition, information from AidData (Tierney et al. 2011) was used to analyse the trends in the Latin America and Caribbean region on global funds committed towards environmental policy, laws, regulations and economic instruments. This data serves as a proxy for the commitment to mobilizing financial resources for the effective implementation of the *Strategic plan for Biodiversity 2011-2020*, as outlined in Target 20. Figure 20.1 shows how investment in the LAC region in environmental policy related projects has been irregular in the past decade, with a peak in 2004 of USD 0.8 billion, although an increase in committed funds was seen after 2008, the high being USD 3.7 billion in 2009. While AidData reflects the funding provided by environmental donors, it does not reflect the total investments in environmental policies and specifically the *Strategic Plan for Biodiversity 2011-2020* by national Governments or international bodies.



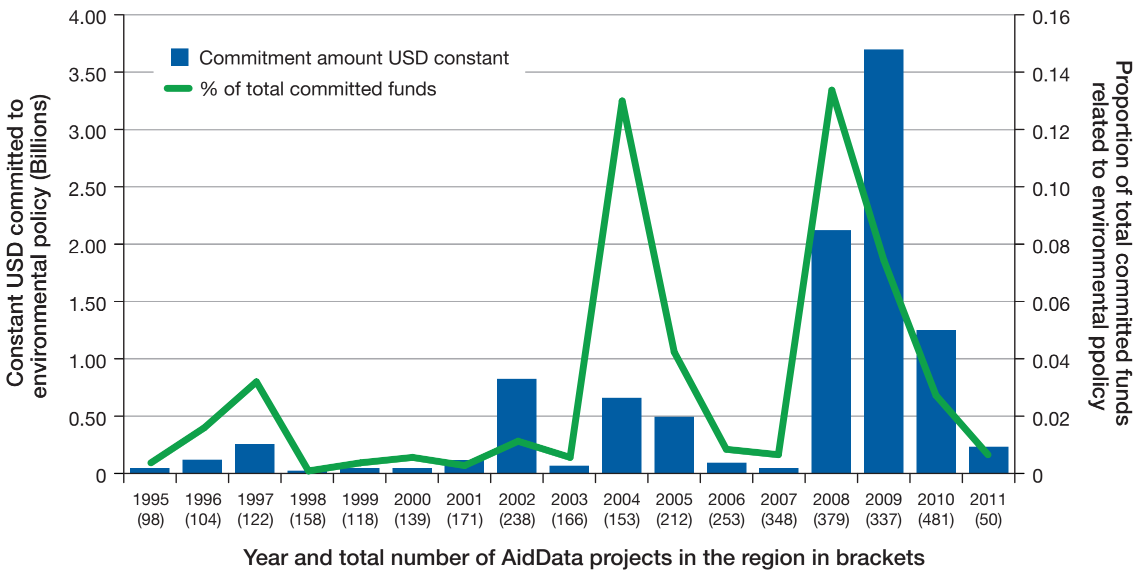


Figure 20.1. Absolute and proportional investment in Latin America and the Caribbean in environmental policy related projects by donors on AidData between 1995 and 2010 (source: Tierney et al. 2011).

Finally, the LAC region benefits from investments derived from the programmes of work of many different environmental and conservation organizations, such as WWF, Conservation International (CI), The Nature Conservancy (TNC), GEF and many others. The CBD estimated the total annual spending on conservation for the region at USD 632 million per year (2001-2008), with USD 203 million per year going to Central America, mostly from international donors and bilateral cooperation, USD 395 million per year to South America, mostly from domestic resources, and USD 33 million per year to the Caribbean, mostly from domestic resources (Bellot-Rojas 2014).

In conclusion, international commitments of funds to the region to support biodiversity conservation continued to increase up to 2010 (the latest year that data is available for). GEF allocations to the region are large and there is also international support from many international NGOs. Countries in the region also have considerable national resources for conservation and this is a priority activity for a number of countries, as their economies are underpinned by eco-tourism, or through their national commitments to the environment. Despite these efforts it seems that the region is not fully on track to meet Target 20 by its deadline in 2020, although some progress has been made, with recent set-backs due to economic challenges in a number of countries in the region.

Box 20.1: Project Finance for Biodiversity (BIOFIN).

In 2012 Project Finance for Biodiversity (BIOFIN) was implemented. A series of assessments are undertaken for the countries implementing BIOFIN in order to define the biodiversity finance gap, in part determined by the costs of implementing the country's NBSAP. Based on the outcome of the assessments, a strategy to mobilise the required financial resources is designed. BIOFIN is being implemented in 30 countries globally, including nine in the LAC region (Belize, Chile, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Mexico and Peru) (BIOFIN 2016).

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Box 20.2: Honduras Action Plan 2008-2021.

In order to integrate its implementation of various Multilateral Environmental Agreements (MEAs), including the CBD and the Ramsar Convention, the Government of Honduras has prepared an Action Plan for 2008-2021. It is based on a Self-Assessment of National Capacity to Comply with MEAs, which identified potential synergies, and national requirements for capacity building. The outputs from the GEF-funded project "Piloting Integrated Processes and Approaches to National Reporting to the Rio Conventions", which developed and piloted an efficient, integrated methodology for reporting in relation to a variety of MEAs, were heavily utilised in development of the Action Plan. The Action Plan establishes the National Environment and Natural Resources Secretariat as a central coordinator, improves the technical and scientific input into information held by the Conventions, and proposes a communication strategy which includes a strengthening of the dialogue between the government and scientists working in academia (UNEP 2015b).

6. OPPORTUNITIES AND RECOMMENDATIONS FOR THE FUTURE

Since 2010, countries in Latin America and the Caribbean have made considerable efforts to implement the *Strategic Plan for Biodiversity 2011-2020* at both the national and regional level. There are many individual examples of success from the region, and this section presents some of the main opportunities to make further progress. Some of these can be implemented and yield results before 2020, whereas others will require more time to achieve lasting results. Some areas with considerable potential to deliver outcomes are outlined below.

Mainstream biodiversity across governments and productive sectors.

Making biodiversity, in particular its existence and use values, a part of daily decision making in LAC countries requires mainstreaming within policies, institutions, laws, regulations and productive sectors such as, agriculture, fisheries, tourism and forestry. This entails placing biodiversity goals into decision making processes and the inclusion of government agencies not directly related to biodiversity, such as the Ministries of Finance, Agriculture, Infrastructure, Tourism and Education, amongst others. There are various initiatives underway in the region to do this.

In 2015, the WHO and the CBD launched the document "Connecting Global Priorities: Biodiversity and Human Health, The State of Knowledge Review" (WHO and SCBD 2015). This document presents 77 key messages containing information on the need to maintain ecosystems and species capable of providing environmental services, such as: the production of food, goods, and medicinal plants; the balance and containment of emerging diseases; the ability to adapt to global environmental and climate change; and the cultural and health benefits provided by natural habitats. Actions and synergistic global policies were introduced, as well as new tools and research needed to face the challenges identified. The development of this document stemmed from the "Capacity-building regional workshop on the interlinkages between biodiversity and health," conducted by the WHO, the CBD and the Fiocruz foundation, in Manaus (Brazil), attended by many LAC decision makers who suggested ways for this agenda to be implemented (CBD 2012).

Mainstream biodiversity into business practices

In a similar way to mainstreaming biodiversity into national accounting, there is also a need and an opportunity to work with businesses and financial institutions to ensure that biodiversity values are considered within the decisions making made by companies that are based and/or operate in the region. There are examples of voluntary certification schemes that start to address the biodiversity impact of business operations in productive sectors such as forestry, fisheries and aquaculture. Moreover, the investments into oil and gas exploration and exploitation are regulated in some companies by the International Finance Corporation under Performance Standard 6, which relates to the "Biodiversity Conservation and Sustainable Management of Living Natural Resources" (IFC 2012).

Build forest carbon conservation partnerships

Across the LAC region, forests, particularly tropical forests, provide ecosystem assets of global significance (Dickson et al. 2014). In addition to their role in storing carbon, supporting livelihoods and providing a variety of ecosystem services, forests also have a key role in conserving biodiversity. Efforts to create a financial value for forest carbon while investing in low-carbon sustainable development pathways, such as REDD+, can also contribute to achieving social and environmental benefits including the conservation of biodiversity. To fully take advantage of the opportunities there will need to be continued political commitment to the conservation, restoration and sustainable management of forests in the region in the coming years. Financing will also need to be available to back these commitments and achieve the multiple goals of climate change mitigation and biodiversity conservation. The LAC region is very well placed to benefit from forest protection mechanisms such as REDD+ as it contains huge areas of forest and countries that are committed to forest conservation and sustainable development, and have the financial and technical skills to make the financial flows from REDD+ work at national to local levels.

Share water payments scheme expertise in the region

Several of the countries in the region (Mexico and Costa Rica in particular) have developed long term and sustainable programmes of payment for ecosystem services (PES). Their expertise is considerable and to a large extent they are global leaders in these efforts, particularly around water payment schemes that provide benefits back to communities. Their experience provides guidance for other countries in the region, and can be disseminated and promoted elsewhere through South-South and Triangular cooperation efforts. Where possible, this existing expertise could be used to develop similar PES schemes as they contribute to solving the challenge of making this intervention work after the donor funding has ended.

Sustainably develop the water resources in the region

Within LAC, the broader Amazon region, the Cuenca de la Plata basin, and the Andes mountain chain in particular have great potential to contribute to the integral sustainable development through hydroelectric power generation, irrigated agricultural production, aquaculture and transportation. Capitalising on this potential to generate sustainable benefits for the region, and the millions of people who live in it, while avoiding the damages that might occur to hydrology, local populations, biodiversity and habitats requires careful planning. There have already been considerable efforts at conservation planning and integrated water and coastal areas management in many of the ecoregions and broader regions of LAC, and further implementing these plans will be a great contribution to sustainably developing critically important terrestrial, freshwater and marine areas.

Link tourism to development planning in coastal nations

Many of the island nations in the region have considerable income from tourism, often linked to the coastal environment, including coral reefs and mangroves. These values need to be better mainstreamed into the economic planning of these countries so that the benefits of a healthy environment are fully recognised in development decision making. The emerging discipline of natural resource accounting starts to make explicit links between the natural resources of a nation and its other forms of capital, considering their status and trends. This may be particularly important in the various island nations, but can also provide a broad benefit across the region by better recognising the value of natural resources and services within the national economies of the region.

Invest in raising public awareness of biodiversity values

Across the LAC region awareness of the values and importance of biodiversity varies. In some countries the awareness is higher than in other parts of the world, and this encouraging trend can be further developed elsewhere. Awareness can be raised through various means: formal education in schools; workshops at different levels; mainstreaming biodiversity into government policies; incentives; campaigns by civil society and non-governmental organizations; partnership with private sector; enhancing the training in colleges and universities; and developing national ecosystem accounting as part of mainstreaming biodiversity and ecosystem services across government. Many of these means are already being used by some countries in the region. All such efforts are key to ensure understanding and appreciation of ecosystems and natural resources, and are a fundamental requirement for taking appropriate decisions and changing behaviour.

Strengthen protected areas networks and biological corridors

Although most countries in the region have been successful in creating protected area networks, in many cases these still need strengthening to ensure that they deliver the conservation benefits that they are intended to provide. Although the protected areas and biological corridors in the region have helped stem biodiversity loss and maintained terrestrial and marine ecosystems, they also face challenges related to management effectiveness, connectivity between reserves and resource availability and sustainability. The region has also developed and designed community-managed reserves which have expanded greatly in recent years, providing an important addition to the existing protected area network.

Enhance the implementation of biodiversity-related Conventions to build institutional capacity

Evidence of enhancement and implementation of biodiversity related conventions through strategies and action plans can be seen in countries from the LAC region. Overall, there is a need to support actions for mitigation of degraded ecosystems, capacity development programmes, technology transfer, assessment of ecosystems services to strengthen the science-policy interface for decision making and building new partnerships. There is considerable potential within the region to mobilise sustainable financing from various sources including national governments, regional and global funds and private businesses, amongst others.

Enhanced environmental rule of law and regulation enforcement

Regulatory and institutional frameworks at the national level are fundamental to promote biodiversity conservation and sustainable use, including with regard to MEAs, as much of their implementation on the ground has to be done by the parties of the MEAs through domestic legislative and institutional arrangements. Furthermore, not only is the adoption and ratification of relevant MEAs and the development of appropriate legal instruments important, but the mechanisms for compliance and enforcement of such instruments are also key. This requires strengthening of capacities and enhanced cooperation and coordination between all relevant actors, in particular the enforcement community, prosecutors and judges.

Increase available resources for biodiversity

Effective and sustainable conservation practices require secure finacing and capacity, and in some countries within the LAC region there is a lack of resources available for this activity when competing with other national priorities. In the region there has been significant financing provided by donor countries and the international community and this has had a measurable impact. However, there is still a need to increase the available resources and influence policy-makers to allocate sufficient financing and budget to biodiversity conservation and sustainable use. In addition to government resources, an increase in resources used to involve and engage civil society and communities in conservation activities would also help promote the achievement of the Aichi Biodiversity Targets in the region.

Increase multi-sectoral coordination

Within the LAC region it is important that government, civil society, private sector, academia and the intergovernmental agencies improve the communication and coordination related to work on biodiversity conservation. Countries need better mechanisms to document and report on this multi-sector contribution towards the Aichi Biodiversity Targets.

Enhance the availability of data to measure the Aichi Biodiversity Targets

One of the constraints in the region is the availability of consistent and comparable data to measure progress towards a number of the targets. This is clear from the dashboard of progress presented at the start of this document, which shows some targets which cannot be reliably measured across the region. A combination of globally derived data (e.g. from remote sensing) and national data collection efforts are required to address this issue and make the targets easier to measure in the lead up to 2020.

Promote South-South and Triangular cooperation

The importance of regional and cross-continental networks and collaborations to strengthen science in the LAC region is clear (Arzt 2014). In 2014, CONABIO, Humboldt Institute and INBio signed a "Memorandum of Understanding on Cooperation in Biodiversity" in order to establish the base for cooperation to promote knowledge generation, conservation and sustainable use of biodiversity and natural resources, while improving scientific and technical exchange on issues of interest to the Parties. They developed reports about scientific and technical cooperation and their contribution in the framework of CBD.

Within the region, levels of capacity and development vary, but initiatives for capacity building have been growing in many countries; Peru is prioritising science and innovation in its National Council for Science, Technology and Technological Innovation (CONCYTEC) budget, Chile has taken examples from developed countries such as Australia to boost research and investment in coastal protection, and Venezuela is working to restore interest and funding to research by investing over 2 per cent of its GDP in science and technology over recent years (Artz 2014).

Cooperation between countries in the region is also growing and there are many examples of successful initiatives presented in the second "Report on South-South Cooperation in Ibero-America" developed by the Ibero-American General Secretariat (SEGIB) (Xalma and López 2015). South-South cooperation has been identified as a tool for the implementation of the CBD *Strategic Plan for Biodiversity 2011-2020* (CBD 2010), and is often more appropriate than collaborations with northern partners and countries with different socio-economic backgrounds.

Countries in the region which have stronger capacity building play a key role in supporting other less developed LAC countries, with five countries accounting for almost 85 per cent of all bilateral South-South and Triangular Cooperation projects analysed by the SEGIB in 2013, and Brazil and Argentina together accounting for more than 50 per cent of the total (Xalma and López 2013). In addition to their role in capacity development within the LAC region, some of the stronger countries also have a role to play in biodiversity conservation capacity building in other parts of the Southern Hemisphere, such as Africa.

7. CONCLUSION

In conclusion, the LAC region is making significant efforts to implement policies and laws and to put in place the plans and actions on the ground to achieve the 20 Aichi Biodiversity Targets. These are ambitious targets. While some, such as Targets 11, 16 and 17, appear to be on track to be met by 2020, other targets are not currently on track and will require further effort to be achieved. It is also clear that the region has developed considerable capacity and expertise in various kinds of conservation response, ranging from PES for water, REDD+ for carbon, remote sensing of forest change, eco-tourism, protected areas and community-based and private conservation approaches. These successes from the region provide the basis for regional and Triangular cooperation and South-South capacity building, with involvement from all levels of society to improve the consideration and planning for biodiversity conservation and the achievement of the Aichi Biodiversity Targets by 2020.

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Global Integrated Collection Assessment and Planning Workshop for Canids and Hyaenids

Omaha, NE, US, 19 – 20 March 2016

Final Report

Workshop organized by: AZA Canid and Hyaenid Taxon Advisory Group; EAZA Canid and Hyaenid Taxon Advisory Group; ZAA Carnivore Taxon Advisory Group; IUCN SSC Canid Specialist Group; IUCN SSC Hyaenid Specialist Group; and the IUCN SSC Conservation Planning Specialist Group (CPSG).

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Photo credits (front cover, left to right):

Row 1: African wild dog (Yorkshire Wildlife Park); Swift fox (M. Sovada); Darwin fox education (M. Zordan); Fennec fox research (Fitbit; R. Meibaum);

Row 2: Culpeo fox (Zoologico Nacional – Parque Metropolitano de Santiago, Chile); spotted hyena (Colchester Zoo); bush dog (M. Jacob); maned wolf (Temaiken Foundation);

Row 3: Dhole (B. Gupta); Mexican wolf (J. Fallon); striped hyena (T. Rehse); black-backed jackal (Amersfoort Zoo)

A contribution of the IUCN SSC Conservation Planning Specialist Group

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Global Integrated Collection Assessment and Planning Workshop for Canids and Hyenids

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SECTION 1

Executive Summary

Executive Summary

The global zoo community faces the continuous challenge of assessing and modifying their collections and conservation programs to better address the conservation needs of species in the wild. Ideally, each species would have an integrated conservation plan developed using the One Plan approach (OPA) to which zoos could turn for guidance. Such a plan would indicate which *ex situ* activities, if any, are recommended to support conservation of the species based on the IUCN *Guidelines on the Use of* Ex situ *Management for Species Conservation*. However, the majority of species are not yet covered by such an integrated plan, although formal application of the OPA and the IUCN *ex situ* guidelines in species conservation planning is gaining momentum, and the IUCN Species Survival Commission (SSC) is striving to scale up the development of such conservation action plans. In the meantime, to help address this issue, a joint effort between the IUCN SSC Conservation Planning Specialist Group and regional zoo associations has resulted in a new process called ICAP, or Integrated Collection Assessment and Planning workshop. Developed in the spirit of the One Plan approach, the ICAP process brings *in situ* and *ex situ* communities together to apply the decision process of the IUCN SSC Guidelines on the Use of *Ex situ* Management for Species Conservation to the task of regional or global collection planning. The ICAP process is designed to be flexible and applicable to large or small groups of taxa, with the resulting analyses and recommendations being more general or detailed as appropriate.

Over 30 participants representing six zoo associations (AZA, EAZA, ALPZA, PAAZA, ZAA and CZA), the IUCN SSC Canid and Hyaenid Specialist Groups, IUCN, wildlife agencies, field researchers, and recovery team members gathered in Omaha (19-20 March 2016) for the inaugural Global Integrated Collection Assessment and Planning (ICAP) workshop for Canids and Hyaenids. The workshop was organized in collaboration with the AZA Canid and Hyaenid Taxon Advisory Group (TAG), the corresponding EAZA and ZAA TAGs, and the IUCN SSC Canid, Hyaenid and Conservation Planning Specialist Groups.

All 43 canid and hyaenid taxa, including those not held in captivity, were assessed. Before the workshop, an information sheet was prepared for each taxon, which included a summary of the *in situ* status and threat processes, *ex situ* demographic and genetic status (globally and regionally), and previous recommendations for *ex situ* management for conservation as stated in existing action plans. These taxon sheets also included feedback from *in situ* experts who provided information through a carefully designed survey (based on the IUCN *ex situ* guidelines) regarding potential roles for *ex situ* management in the overall conservation of their focal taxa. During the ICAP workshop the participants assessed this information and through a facilitated plenary discussion identified potential direct and indirect *ex situ* conservation roles for each taxon. Each potential role was rated with respect to its relative conservation benefit to the taxon as well as the relative feasibility and risks of developing an *ex situ* program to meet the role. Based on a rapid analysis of the benefits vs feasibility and risks, the group reached consensus on which of the potential *ex situ* roles identified (if any) are recommended for each taxon, and formulated general and, where appropriate, regional zoo association-specific recommendations.

<u>Threatened taxa:</u> All eight threatened taxa with large (usually multi-regional) populations were recommended for one or more *ex situ* conservation roles (median # roles = 6) and some level of level of *ex situ* population management. Many of these taxa involved established regionally managed programs with existing *in situ* conservation links. ICAP recommendations broadened existing *ex situ* roles and options and helped to identify regional priorities for these taxa.

Six threatened taxa have small or no existing *ex situ* populations. Development of sustainable *ex situ* breeding populations generally was not recommended due to low feasibility and/or high risk;

however, for some taxa proactive activities were recommended to develop husbandry expertise, monitor wild populations, and establish criteria to trigger *ex situ* population establishment if conditions or status in the wild change. *Ex situ* roles not requiring live animals (e.g., local education outreach, *in situ* support) were often recommended for these threatened taxa.

Non-threatened taxa: Nine non-threatened taxa are held in relatively large numbers within zoos (>100 individuals). ICAP recommendations within this category included: reduction or elimination of the *ex situ* population and replacement with another taxon; limited, well managed *ex situ* population with targeted conservation education messages; regional program only for locally threatened subspecies; and *in situ* support.

For many of the 20 non-threatened taxa with a small or no *ex situ* population, no *ex situ* population or role was identified, with the caveat that this should be re-evaluated if status in the wild changes. Several exceptions emerged, however, such as recommended regional programs utilizing confiscated or rescued animals that provide opportunities for benefits with high feasibility and low risk and costs, and identified roles to use non-threatened taxa as surrogates for research, husbandry and conservation education for threatened taxa.

In total, ten of the 43 taxa evaluated were recommended for some degree of interregional collaboration to either: a) build global/multi-regional long-term breeding insurance populations of threatened species (African wild dog, maned wolf, bushdog and dhole - the first three of which have an international studbook (ISB)); or b) make management of some non-threatened species more effective (sustainability) and efficient (space) (fennec fox, spotted hyena, bat-eared fox); or c) develop targeted education messaging across all four hyaenid taxa. Regional *ex situ* populations (in range countries only) were recommended for an additional 19 taxa to best address conservation needs. Eleven taxa (mostly non-threatened taxa currently held in large numbers) were recommended to maintain well managed but limited *ex situ* numbers; these represent instances in which there is little conservation cost (e.g., exhibit spaces not readily available to other species), some conservation benefit (as surrogates for threatened species or for conservation messaging), and/or taxonomic uncertainties under investigation. Ten taxa were recommended for no *ex situ* management unless status in the wild changes.

Following the ICAP workshop, each representative was tasked with bringing these recommendations to the relevant bodies within their respective regional zoo and aquarium associations for discussion, and ideally for incorporation within the regions' structures and processes for regional collection planning and *ex situ* program management. The result of this global ICAP workshop is intended to enhance the conservation of canid and hyaenid species by: a) providing guidance to zoos and aquariums on conservation priorities for collection planning, conservation education messaging, research, *in situ* field support, and integration of *in situ* and *ex situ* efforts; and b) promoting collaboration among regional zoo associations, field-based conservationists, and IUCN SSC Specialist Groups. By providing a facilitated process for implementation of the IUCN *ex situ* guidelines, the ICAP resulted in recommendations that, in comparison with previous 'traditional' RCPs, were more varied, detailed and tailored to the conservation needs for the species as determined by consensus among an international group of *in situ* and *ex situ* experts. The ICAP also lead to a better understanding among all stakeholders of the spectrum of possible *ex situ* contributions to conservation.

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SECTION 2

ICAP Process

The ICAP Process: Canids and Hyaenids

Introduction

The world is continuing to experience rapid losses of species and populations. Many of the extant populations are undergoing significant declines (Schipper *et al*. 2008; Ceballos *et al*. 2015; WWF 2016) and are becoming increasingly small and fragmented and thus vulnerable to genetic and demographic stochasticity (Gilpin and Soulé 1986; Soulé *et al.* 1986; Lacy 2000). A growing number of species can thus be expected to require intensive management of individuals and populations alongside other conservation actions to ensure their long term persistence (IUCN SSC 2014). Furthermore, the traditional dichotomy between *in situ* and *ex situ* conservation is becoming much more of a continuum of intensive management circumstances (Redford *et al*. 2012, 2014). Institutions and organizations specializing in intensive management at the level of individuals and populations, such as professional zoos and aquariums and their regional and global associations, therefore have increased opportunities and impetus to contribute to conservation.

Two recent developments are particularly important to help zoos and aquariums meet this renewed call for contribution to *ex situ* conservation.

The professional zoo and aquarium world is currently experiencing a paradigm shift (Baker *et al.* 2011; CBSG 2011; Barongi *et al*. 2015). Since the mid-1980s cooperative breeding programs in zoos and aquaria largely followed the "ARK paradigm". The default goal typically was to maintain (mostly) closed, long-term insurance populations that are demographically stable and large enough to maintain 90% of the gene diversity of the source population for 100-200 years (Soulé *et al.* 1986). Animals that are part of these programs would predominantly be kept on exhibit in many different zoos and aquaria within a region. Regional evaluations of the progress of programs against the ARK paradigm's default genetic and demographic goals showed that many did not reach these self-sustainability criteria (Lees and Wilcken, 2009; Leus *et al*., 2011; Long *et al.* 2011). On the one hand, this led to increased efforts and new initiatives to improve population sustainability (e.g. the AZA Task Force on the Sustainability of Zoo-based Collections (Dorsey *et al*. 2013); PVA analysis of AZA's animal programs (Johson *et al*. 2014), and the establishment of WAZA's Global Species Management Plans (Gusset 2013). Perhaps more importantly, it caused a growing realization that a "one size fits all" approach (an *a priori* assignment of the same role, goals and structure to each program) was perhaps no longer the most appropriate way forward (e.g. Baker *et al*. 2011; de Man *et al*. 2016).

Simultaneously, the concept of integrated conservation is being given renewed attention. Conservation planning processes for *in situ* and *ex situ* populations often run largely in parallel (Redford *et al*. 2012, 2014); *in situ* stakeholders come together to develop conservation strategies and action plans to ensure viable *in situ* populations, and *ex situ* stakeholders do the same to ensure viable *ex situ* populations. This parallel approach may result in both communities missing out on the opportunity to make use of each other's wide range of expertise and experience: *in situ* plans may pay insufficient attention to the potential need for intensive population management (*in situ* and/or *ex situ*), while *ex situ* plans may not be optimally designed to make the strongest conservation contribution. Rather, the precise roles and goals of each *ex situ* program should be carefully defined within the overall conservation plan for the species, by all parties involved, and its form and function should be tailored to maximize the chances of fulfilling the role(s) identified (de Man *et al.* 2016; Traylor-Holzer *et al.* 2018). To help facilitate this more integrated approach to conservation, the Conservation Planning Specialist Group (CPSG) of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN) has coined and is promoting the "One Plan Approach" (OPA) to species conservation planning: "the joint development of management strategies and conservation actions for all populations of a species by all responsible parties to produce a single, comprehensive conservation plan for a species" (Byers *et al.* 2013).

This process of evaluating when it would be appropriate for the conservation plan for a threatened species to include *ex situ* management, and what precise form this should take, is challenging. To assist conservation practitioners with this, the IUCN SSC recently revised its "Guidelines on the Use of *Ex situ* Management for Species Conservation", designed to help conservationists evaluate if, when and how *ex situ* management would be a valuable component of the overall conservation strategy for a particular taxon. The five-step process outlined in the guidelines provides a more formal, informed, and transparent decision-making process on if *ex situ* activities are a beneficial and appropriate component of an overall species conservation strategy, and ensures that *ex situ* activities that are recommended are tailored in form and function to the conservation needs of the species (Traylor-Holzer *et al.* 2013; McGowan *et al*. 2017).

Ideally all threatened species would be covered by an integrated conservation action plan, developed according to the One Plan approach (OPA) and applying the IUCN *ex situ* guidelines. This would make it clear to professional zoos and aquaria which species require some form of *ex situ* management for conservation and which of those are best delivered by the zoo community. Despite a steady growth in the number of taxa for which this is the case, and current aim of the IUCN SSC to scale up the development of such conservation action plans, the majority of species are not yet covered by such an integrated plan. In the meantime, zoos and aquaria face the continuous challenge of managing their living collections and of assessing and modifying their *ex situ* efforts to better serve the conservation of species in the wild.

To help address this issue, a joint effort between CPSG and regional zoo associations has resulted in a new process called ICAP, or Integrated Collection Assessment and Planning workshop. Developed in the spirit of the OPA, the ICAP process brings *in situ* and *ex situ* communities together to apply the decision process of the IUCN *ex situ* guidelines to the task of regional or global collection planning. The ICAP process is designed to be flexible and applicable to large or small groups of taxa, at global or regional/local level, with the resulting analyses and recommendations being more general or detailed as appropriate.

This Global ICAP for Canids and Hyaenids marks the launch of this new process. The workshop was organized in collaboration with the AZA Canid and Hyaenid Taxon Advisory Group (TAG), the corresponding EAZA and ZAA TAGs, and the IUCN SSC Canid, Hyaenid and Conservation Planning Specialist Groups. All 43 canid and hyaenid taxa, including those not held in captivity, were assessed by ICAP participants representing six zoo associations, the Canid and Hyaenid Specialist Groups, wildlife managers, and field researchers. The list of participant to the workshop, as well as a list of non-participants that were contacted for input before the workshop, can be found in Appendix 1.

Five-step decision process in the IUCN SSC Guidelines

Both the pre-workshop preparation and the actual workshop workflow of the ICAP process is structured around the IUCN SSC Guidelines on the Use of *Ex situ* Management for Species Conservation, which utilizes a five-step decision process to determine if and which *ex situ* activities might be appropriate to be included in overall conservation strategy for the species. These five steps are (IUCN 2014; McGowan *et al.* 2017; Traylor-Holzer *et al*. 2018):

1. Conduct a thorough status assessment (of both *in situ* and any known *ex situ* populations) and threat analysis.
2. Identify potential roles that *ex situ* management can play in the overall conservation of the species.

3. Define the characteristics and dimensions of the program needed to fulfill the identified potential conservation role(s).
4. Define the resources and expertise needed for the *ex situ* management program to meet its role(s) and appraise the feasibility and risks.
5. Make an informed and transparent decision as to which *ex situ* roles and activities (if any) to retain within the overall conservation strategy of the species

The description of the methodology below describes how this step process was adjusted and applied in the context of the ICAP workshop.

Taxon sheets

For each of the 43 Canid and Hyaenid taxa assessed, the data gathered and recommendations made were recorded on a taxon sheet (see Sections 4-6). Before the workshop, information gathered on the *in situ* and *ex situ* status, *in situ* threats, and previously published *ex situ* roles/recommendations was summarized on the taxon sheets, as was the feedback received through email consultation among *in situ* colleagues regarding potential *ex situ* roles for conservation. During the workshop, each partially completed taxon sheet was reviewed and discussed. This formed the basis for the generation of the list of potential direct and indirect conservation roles for *ex situ* management and the evaluation of the program characteristics and relative benefit, feasibility and risk of each of the roles. Following the workshop, the identified roles and their evaluation, as well as additional comments and the final recommendations made, were added to each taxon's sheet. Details on the methodology for each of these steps can be found below.

Pre workshop preparation

In situ status

For each taxon, the IUCN Red List category of threat and population trend was recorded, as well as a summary of the status information on the full Red List account. In 2015 the Red List information was updated for all of the hyaenids and most of the canids. In 2017, the IUCN Red List status for Darwin's fox was changed from Critically Endangered (CR) to Endangered (EN). For this report, the status was left as Critically Endangered as this was the listing at the time of the global ICAP workshop; the recommendations made are relevant to either status. No Red List assessments were available for the Mexican and Iberian wolf subspecies, but given their importance to respectively the AZA and EAZA communities, these taxa were also included in the ICAP workshop. Because relatively few taxa were threatened according to the IUCN definition (Critically Endangered, Endangered or Vulnerable), for the global Canid and Hyaenid ICAP specifically, taxa listed as Near Threatened were included in the threatened category. Throughout this ICAP report any counts for the number of threatened species therefore include those in the Near Threatened category.

In situ threats

Ex situ activities can help to address the threats or challenges that a species is experiencing in four different ways (IUCN 2014; McGowan *et al*. 2017; Traylor-Holzer *et al*. 2018):

- *By addressing the causes of primary threats* (for example through specifically designed research, training or conservation education activities that directly impact the causes of these threats).
- *By offsetting the impact of primary and/or stochastic threats* on the population (for example through activities that help to improve survival (of particular life stages), reproductive success and/or gene diversity retention or gene flow).
- *By buying time* in cases where the wild population is in severe decline and the chance of sufficiently rapid reduction of primary threats is slim or uncertain or has been inadequately successful to date (for example through rescue or insurance populations)

- *By restoring wild populations* once primary threats have been sufficiently addressed (for example by reintroductions).

In order to precisely identify *ex situ* roles that best address the threats and challenges faced by the taxon, it is therefore important to not merely consider the IUCN Red List category of threat, but to also consult the more detailed descriptions of the threat processes in the full Red List account and, where relevant, to consult additional sources or data obtained through *in situ* stakeholders. A summary of the main threats faced by each taxon, extracted from the above sources, was recorded on the taxon sheet.

Potential *ex situ* roles

Under the principle of the OPA, *in situ* and *ex situ* specialists should together evaluate the most appropriate actions to save a species and, within that, identify any direct or indirect roles for *ex situ* conservation. However, in the context of an ICAP workshop where a large number of taxa is being evaluated at the same time, it is not possible or effective to invite all *in situ* specialists for all taxa. In order to canvas as wide a representation of the *in situ* community as possible, *in situ* specialists were surveyed by email ahead of the workshop.

Using the knowledge of the TAGs, zoo associations and the IUCN SSC Canid and Hyaenid Specialist Groups, a list was created of 57 *in situ* specialists working with particular taxa. Regardless of whether they would attend the ICAP workshop or not, each was sent a survey asking them to identify potential direct and indirect conservation roles for *ex situ* activities within the conservation needs of the canid and hyaenid species of their expertise. The survey was sent for both threatened and non-threatened taxa because: a) there might be recent changes in status and threats that are not yet reflected in the IUCN Red List; and b) non-threatened species can play a role in the conservation of threatened species, for example as model species. Twenty-four of the 57 (42%) *in situ* specialists completed the survey (Appendix I).

The survey package sent was composed of the following (see Appendix II):

- a cover letter with an introduction to the ICAP workshop;
- a document defining and describing the different kinds of direct conservation roles (based on the role descriptions in the IUCN *ex situ* guidelines (IUCN 2014) and the Amphibian Ark Conservation Needs Assessment Process (http://www.amphibianark.org/pdf/AArk_Conservation_Needs_Assessment_tool.pdf)) and indirect *ex situ* conservation roles;
- an advanced draft of the relevant taxon sheet(s) with the summary of the *in situ* status and threats, the *ex situ* status, and any previously published *ex situ* roles or recommendations; and
- a questionnaire with seven questions that asked the *in situ* expert to identify potential direct and indirect *ex situ* conservation roles for the taxa of their expertise.

All feedback from the survey was summarized on the taxon sheets.

Prior *ex situ* recommendations

With the help of TAGs, zoo associations, CPSG and the IUCN SSC Canid and Hyaenid Specialist Groups, published canid or hyaenid conservation strategies and action plans were gathered and consulted to extract any existing *ex situ* recommendations or mandates. This included documents such as regional, national or local governmental plans, IUCN SSC Canid or Hyaenid Specialist Group plans, CPSG Population and Habitat Viability Assessments (PHVAs), CPSG Conservation Assessment and Management Plans (CAMPs), and plans by international or local NGOs or conservation alliances. Information on existing *ex situ* recommendations or mandates was summarized on the taxon sheets.

Ex situ status

The main global, regional or national zoo associations with managed *ex situ* programs were contacted to inquire if they were maintaining a studbook or *ex situ* program for one or more of the canid and hyaenid species. For those species with a studbook or managed program, they were asked to submit as many of the following data sources as possible:

- A backup of the SPARKS or PopLink studbook database (with a notification of the currentness date, the geographic or association filter that should be used to delineate the managed population, and the date span that should be selected for demographic analysis);
- The most recent studbook publication;
- The most recent yearly report or equivalent report for the region;
- The most recent breeding and transfer plan, long-term management plan or equivalent document for the region; and
- Any other region specific documents/registries that contain population information and/or that indicate the roles and goals of the *ex situ* population in the region. In preparation for the ICAP meeting, the ALPZA and JAZA regions conducted a canid and hyaenid survey among their member institutions. In addition, the Central Zoo Authority (CZA) of India provided information from their registry and studbook databases.

In cases in which no studbook is held or no studbook data were available, and no region specific survey or census/registry data was available, the species holdings report and population overview report of the Species360 Zoological Information Management System (ZIMS) database was consulted for data from Species360 member institutions from that region (as of March 2016). The studbook datasets, ZIMS database, and other documents were analyzed to extract the following population parameters when they were available and sufficiently reliable:

- Population size (males, females, unknown sex)
- Number of living wild-born individuals
- Current gene diversity retained (% of the wild source population)
- Number of founders (unrelated wild-born individuals with living descendants)
- Number of potential founders (living unrelated wild-born individuals without living descendants)
- Percentage of the pedigree known
- Population trend or, when available, lambda. In the *ex situ* status table "lambda" refers to a short-term lambda (yearly growth rate) of the last 5 years. For some taxa there is also a 'LT' or long-term lambda value stated in this field, which is for a variable time period, judged by the analyst (using census data) to cover the period when the population of that taxon was of sufficient size to be able to calculate a valid lambda.
- Number of holding institutions
- Level of population management within the region
- Data source

When a parameter was not available, could not be calculated, or was insufficiently reliable due to data quality issues, a "?" was recorded. When more than one data source was available for a region (e.g. both international and regional studbooks), the most current and comprehensive source was selected to complete the *ex situ* status for that region. The *ex situ* status of the taxon was summarized in a few lines above the *ex situ* status table.

Workshop process

At the start of the workshop, participants were presented with:

a) the taxon sheets, which included for each taxon the summary of the *in situ* status and threats, the *ex situ* status, potential *ex situ* conservation roles identified through the pre-workshop survey and any previously published *ex situ* roles or recommendations;
b) a workshop manual (Appendix III) containing:
   - definition of the One Plan approach;
   - five decision steps in the IUCN SSC Guidelines on the Use of *Ex situ* Management for Species Conservation;
   - nine questions investigating potential direct and indirect *ex situ* conservation roles sent to the *in situ* experts prior to the workshop;
   - descriptions of the main types of direct conservation roles (based on the role descriptions in the IUCN *ex situ* guidelines (IUCN SSC 2014) and the Amphibian Ark Conservation Needs Assessment Process (http://www.amphibianark.org/pdf/AArk_Conservation_Needs_Assessment_tool.pdf) and indirect *ex situ* conservation roles; as well as a number of questions to investigate potential non-conservation roles for *ex situ* management;
   - guidance to determine characteristics and resources of the *ex situ* population needed to fulfil proposed roles – and to examine relative benefit, feasibility and risks;
   - guidance on what to take into account when trying to reach consensus as to which *ex situ* roles to recommend for the taxon;
   - list of the canid and hyaenid taxa ranked by their evolutionary distinctiveness score; and
   - table of the canid and hyaenid taxa ordered according to their threat status, population size and presence in captivity.

The agenda of the ICAP workshop can be found in Appendix III. The meeting opened with welcoming remarks, participant introductions and several introductory presentations. Then all 43 taxa were discussed, beginning with the threatened canid species, followed by all four hyaenid species and concluding with the non-threatened canid species

For each species the following process was followed:

1. Presentation of the previously gathered information on the taxon sheet. Suggested comments/changes/additions from the workshop participants were recorded.
2. Facilitated plenary discussion to identify potential direct and indirect *ex situ* conservation roles, and rating of the benefit to the conservation of the species of any roles proposed.
3. If at least one role was identified, facilitated plenary discussion to:
   a) Identify the characteristics, scope, and resources of the *ex situ* population needed to fulfil the identified role(s);
   b) Rate the feasibility (considering, for example, existing *ex situ* population, husbandry challenges, technical or logistical challenges, availability of skilled staff, availability of sufficient financial and other resources) and risks (e.g. vulnerability to catastrophes, consequences for wild population, occupying *ex situ* space for other species that need it more, human health and safety risks, political risks, risks for social or public conflicts) of each proposed role; and
4. Formulation of recommendations:
   a) Reaching consensus on which of the potential *ex situ* roles identified (if any) are recommended, based on an analysis of the benefits vs feasibility and risks.
   b) Formulating of recommendations generally, and where appropriate, for specific regional zoo association(s).

The results of this process are reported in the *ex situ* role table, comments/issues section and recommendations section of each taxon sheet.

At the end of the workshop, time was taken to survey all species for which direct and/or indirect conservation roles were recommended (generally or for one or more specific regions) and to evaluate the overall feasibility of implementing those roles.

Post-workshop follow up

Following the workshop, each representative was tasked with bringing formulated recommendations to the relevant bodies within their respective regional zoo and aquarium associations for discussion, and ideally for incorporation within the regions' structures and processes for regional collection planning and *ex situ* program management. The result of this global ICAP workshop is intended to enhance the conservation of canid and hyaenid species by: a) providing guidance to zoos and aquariums on conservation priorities for collection planning, conservation education messaging, research, *in situ* field support, and integration of *in situ* and *ex situ* efforts; and b) promoting collaboration among regional zoo associations, field-based conservationists, and IUCN SSC Specialist Groups.

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SECTION 3

Summary Results

Summary of ICAP Workshop Results

The ICAP process save guarded against automatic assumptions regarding: a) which taxa to maintain, phase out, not acquire or replace simply based on numbers already in zoos and the threat status; and b) the *ex situ* conservation role to be assigned to each taxon. It resulted in much more tailored and variable recommendations across the 43 taxa, with different (or no) roles assigned to different taxa and the same taxon often receiving variable roles for different regions involved (Table 1). Carefully relating potential roles to the status and threat analysis of the taxa also provided much needed detail. For example, rather than a role simply being described as "education", "awareness" or "research", details such as target audiences, core messages and research topics were identified.

The workshop recommendations can be summarized as follows:

- All eight threatened taxa with large (usually multi-regional) populations were recommended for one or more *ex situ* conservation roles (median # roles = 6) and some level of *ex situ* population management. Many of these taxa involved established regionally managed programs with existing *in situ* conservation links (e.g., Mexican wolf). ICAP recommendations broadened existing *ex situ* roles and options and helped to identify regional priorities for these taxa.
- Six threatened taxa have small or no existing *ex situ* populations. Development of sustainable *ex situ* breeding populations generally was not recommended due to low feasibility and/or high risk; however, for some taxa proactive activities were recommended to develop husbandry expertise, monitor wild populations, and establish criteria to trigger *ex situ* population establishment if conditions change. *Ex situ* roles not requiring live animals (e.g., local education outreach, *in situ* support) were often recommended for these threatened taxa.
- Nine non-threatened taxa are held in large numbers within zoos (>100 individuals). ICAP recommendations within this category included: reduction or elimination of the *ex situ* population and replacement with another taxon; limited, well managed *ex situ* population with targeted conservation education messages; regional program only for locally threatened subspecies; and *in situ* support. This global ICAP workshop did not systematically investigate non-conservation roles that taxa can be assigned, such as biological education, basic research, attractive exhibit species, etc. However, the same five-step process can be used to evaluate the suitability and feasibility of such roles. Regional Collection Planning (RCP) processes with an ICAP-based format (or starting from the outcome of a global ICAP workshop) may wish to consider incorporating the investigation of non-conservation roles.
- For many of the 20 non-threatened taxa with a small or no *ex situ* population, no *ex situ* population or role was identified, with the caveat that this should be re-evaluated if status in the wild changes. Several exceptions emerged however, such as recommended regional programs utilizing confiscated or rescued animals that provide opportunities for benefits with high feasibility and low risk and costs, and identified roles to use non-threatened taxa as surrogates for research, husbandry and conservation education for threatened taxa.

In total, ten of the 43 taxa evaluated were recommended for some degree of interregional collaboration to either: a) build global/multi-regional long-term breeding insurance populations of threatened species (African wild dog, maned wolf, bushdog and dhole- the first three of which have an international studbook (ISB)); or b) make management of some non-threatened species more effective (sustainability) and efficient (space) (fennec fox, spotted hyena, bat-eared fox), or c) develop targeted education messaging across all four hyaenid taxa. Regional *ex situ* populations (in range countries only) were recommended for an additional 19 taxa to best address conservation needs. Eleven taxa (mostly non-threatened taxa currently held in large numbers) were recommended to maintain well managed but limited *ex situ* numbers; these represent instances in which there is little conservation cost (e.g., exhibit spaces not readily available to other species), some conservation benefit (as surrogates for threatened species or for conservation messaging), and/or taxonomic uncertainties under investigation. Ten taxa were recommended for no *ex situ* management unless status in the wild changes. These results benefited from the global scope of the assessment, as there were substantial regional differences in recommendations across these taxa

Table 1. Summary of the *ex situ* conservation roles and programs recommended by the Global Canid and Hyaenid ICAP, broken down into threatened vs non-threatened taxa, and according to relative size of current *ex situ* holdings. Threatened = EW/CR/EN/VU/NT; Non-threatened = LC for IUCN Red List category of threat. Italicized numbers represent potential future roles.

	Threatened		**Not Threatened**	
Recommended Roles	**Large *Ex Situ* Population (N=163-696) (8 taxa)**	**Small *Ex Situ* Population (N=0-13) (6 taxa)**	**Large *Ex Situ* Population (N=127-1172) (9 taxa)**	**Small *Ex Situ* Population (N=0-65) (20 taxa)**
DIRECT				
Insurance (living)	6	1 *(+1)*	0	3
Insurance (GRB)	2	1	0	0
Source	2-3 *(+2)*	0	0	0
Rescue	*1*	*1*	0	0
Research	4	0	1	2
Genetic analysis	6	1	3	1
Training	2	1	0	0
Education	7	4	4	5
INDIRECT				
Research	4	1	0	5
Education	5	1	5	8
In situ support	3	3	2	7
Median # roles/taxon	6	2	2	1
***Ex Situ* Living Population Recommendation**				
Multi-regional metapopulation	4	0	3	0
In-range country only/ rescues	3	3	0	8
Limited *ex situ* numbers	2	1	7	1
Potential in-range population	0	1	1	3
No *ex situ* population	0	1	1	8

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SECTION 4

Taxon Sheets: Large Canids

Taxon Sheets: Large Canids (≥ 10 kg)

14 Taxa Assessed

For the purposes of this ICAP workshop, we have included the Red List category of Near Threatened (NT) under "Threatened" taxa along with Vulnerable (VU), Endangered (EN), Critically Endangered (CR), and Extinct in the Wild (EW). Using this categorization:

Seven of the 14 large canid taxa are listed as Threatened on the IUCN Red List. Six of these are held in captivity in significant numbers (i.e., at least 100 individuals).

- Three taxa are actively managed in multiple regions, with an International Studbook for two of these three.
- Two taxa are actively managed only in their native range (and in conjunction with *in situ* recovery programs).

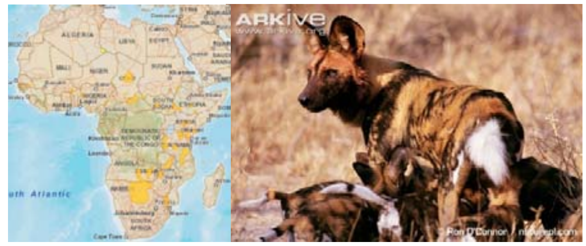
Of the seven non-threatened taxa, three are held in captivity in significant numbers, most notably the gray wolf (~1200 individuals in 8 regions).

The table below lists the estimated global *ex situ* population size for each large canid taxon (in parentheses). Taxon sheets are presented in alphabetical order, first for threatened taxa and then for non-threatened taxa. These sheets summarize *in situ* status and threats, *ex situ* demographic and genetic status, prior *ex situ* conservation recommendations, and ICAP assessment of potential *ex situ* roles, benefit, risks, feasibility, and recommendations.

	Current *Ex Situ* Population Size			
Status	**Large pop (>100)**	**Small pop (40-100)**	**Very small pop (<40)**	**Not in captivity**
Threatened	African wild dog (696) Dhole (277) Dingo (163) Maned wolf (371) Mexican gray wolf (243) Red wolf (202)			Ethiopian wolf
Non-threatened	Coyote (127) Golden jackal (200) Gray wolf (1172)	Iberian wolf (50)	Black-backed jackal (33) Side-striped jackal (1) Singing dog (37)	

AFRICAN WILD DOG
Lycaon pictus

THREATENED SPECIES
IUCN Red List: Endangered
Population trend: Declining



Disappeared from much of their former range throughout Sub-Saharan Africa. Virtually eradicated from North and West Africa and greatly reduced in Central and Northeast Africa. Largest remaining populations are in Southern Africa.

Threats: Primary threat is habitat fragmentation, which increases contact with humans and domestic animals, resulting in conflict and transmission of infectious disease. Low densities and conflict with other large predators (interspecific competition, direct mortality) make the species vulnerable to stochastic events. Techniques for effective disease prevention is among the knowledge gaps.

Potential Ex Situ Roles:
Direct Conservation: Insurance Population, Research, Training, Conservation Education.
Vaccination and reproduction research. Training vets and technical assistance. Insurance population, particularly in range states. Workshops linking *in situ* and *ex situ* conservation efforts. Genetic analysis.
Indirect Conservation: Technical Expertise, Fundraising.
Providing funds and technical equipment to *in situ* projects.

Ex Situ Status:
Present in captivity in most regions (global *ex situ* population = 696 animals). Successful breeding in captivity; stable global population; International Studbook maintained by PAAZA. In addition, semi-free ranging packs are intensively managed in small reserves in Africa as a meta-population. Techniques for effective contraception in these small reserves is a knowledge gap.

	AZA / North America	ALPZA / Latin & SAmerica	EAZA / Europe	PAAZA / Africa	AZAA / UAE	SEAZA / Singapore	JAZA / Japan	ZAA / Austral-asia	Total Global *Ex Situ* Pop
Population size (M.F.U)	**154 (84.70)**	**5 (4.1)**	**275 (158.114.3)**	**157 (95.58.4)**	**22 (10.10.2)**	**8 (7.1)**	**10 (5.5)**	**65 (28.31.6)**	**696 (391.290.15)**
Living wild-born	?	?	?	?	?	?	?	?	?
Gene diversity	92.9%	?	87%	94%	76.7%	72.3%	76.3%	87.9%	96.2%
# Founders	24	?	23	38	22	9	8	23	47
# Potential founders	0	?	0	0	0	0	0	0	0
% pedigree known	91%	?	51%	85%	78%	69%	100%	84%	72%
Population trend/ lambda	1.054 LT 0.917	1.05	1.063	1.056 LT 0.973	1.051	1.05	1.051 LT 0.969	1.052 LT 0.902	1.073 (LT 1.00)
# institutions	37	2	47	11	2	1	1	10	111
Management	SSP managed program	No formal program	EEP managed program	No longer formal program	No formal program	No formal program	No formal program	ASMP managed program	
Data source	*2016 ISB*	*2016 ISB*	*2016 ISB*	*2016 ISB*	*2016 ISB*	*2016 ISB*	*2016 ISB*	*2016 ISB*	*2016 ISB*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Insurance	MODERATE	HIGH	MODERATE	Keep large, genetically diverse *ex situ* population as insurance. At present no interest/need in range states to use as a source for population restoration. Boom/bust growth a challenge in zoos. Some genetic and reproductive health issues.
Research Vaccine trials; distributing vaccines to free-range dogs; *ex situ* reproductive control (effects on physiology and pack dynamics); molecular genetics	HIGH	HIGH (genetics) MODERATE (health)	MODERATE	Molecular genetics to map *in situ* and *ex situ* gene diversity/structure to guide management. Much can be done with *ex situ* population (studying/recording/ sharing experiences w/ management interventions already happening).
Training Field restraint and veterinary techniques	HIGH	HIGH	LOW	Expertise already exists in some range countries; needed in others
Education In range	Not rated	Not rated	Not rated	Done by in-country NGOs
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Education Outside range	HIGH	HIGH	LOW	Improve public perception of large carnivores
Support in situ work Financial, resources and/or expertise	HIGH	HIGH	LOW	Happening already but good to expand.

Comments/Issues:

- There are additional individuals in semi *ex situ*/*in situ* meta-population situation in South Africa – they are in the wild, but in protected areas and managed. Individuals can be identified but are not tracked regularly. There is reluctance to move dogs between zoos and these populations in either direction. The original founders of the metapopulation were of zoo population origin.
- Consistent reproduction is a challenge in some regional zoo populations. There is still much to be learned regarding the effects of various methods of reproductive control on physiology, anatomy and pack dynamics. The "boom and bust" population dynamics (large litters followed by no reproduction) often require additional institutional space.
- A considerable amount of work has already been carried out *ex situ* with regard to vaccine testing and other veterinary protocols. *Ex situ* community needs more specific requests – is more needed or are the results not reaching the right stakeholders?

Workshop Recommendations:

1. Increase collaboration between regional zoo populations to manage the global *ex situ* population. With a more unified *ex situ* plan, potentially the larger regional populations could be sources to smaller regions (SEAZA, JAZA, etc.) in order to manage space more effectively, stabilize reproduction, and increase population sustainability.
2. Continue to work with semi-*ex situ* meta-populations in South Africa with a view to using *ex situ* animals as a source population should the need for that arise.

3. Continue/complete molecular genetics research to map *in situ* and *ex situ* gene diversity/ structure and resolve pedigree gaps, in order to guide management (ensuring *ex situ* gene diversity is representative of *in situ* diversity).
4. Continued research in reproduction and contraception.
5. Discuss with *in situ* partners what specific aspects of disease ecology, veterinary medicine and/or vaccine testing needs remains to be completed.
6. Increase support for *in situ* conservation.
7. Improve education initiatives in all regions (outside and inside range countries).

DHOLE
Cuon alpinus

THREATENED SPECIES
IUCN Red List: Endangered
Population trend: Declining

Native to South and SE Asia.

Threats: Declining in most areas due to prey base depletion, habitat loss, persecution due to livestock depredation, disease transmission from domestic dogs, and possibly interspecific competition.

Potential Ex Situ Roles:
Direct Conservation: Insurance Population, Research, Training, Conservation Education. Zoos can raise awareness of the threats to this species and its ecosystem and use their expertise (social science) in dealing with human-dhole conflicts.
Indirect Conservation: Technical Expertise, Fundraising. Provide expertise and raise funds for *in situ* conservation efforts. IUCN SSC Canid Specialist Group (CSG) Dhole Working Group recommends a PHVA to gather data and develop conservation and research priorities for the species (funding for PHVA needed).

Prior Ex Situ Recommendations: Recommended for Nucleus I population (50-100 animals with GD >98%, requiring periodic immigrants from wild) (1992 CAMP). 1998 Mammals of India CAMP recommended an *ex situ* population with 90% GD for 100 years for *C.l. laniger* and *C.l. primaevus* with periodic reinforcement. *C.l. dhekhanensis* recommended for education, research and husbandry. Research on reproductive biology and behavior has been conducted in captivity; much research still needed (2004 CSG Action Plan).

Ex Situ Status:
Present in captivity in Europe with small populations in several other regions (estimated global *ex situ* population = 363 animals). Good reproduction in captivity with growing global population. Managed program in EAZA. Subspecies status is unclear and likely mixed in captivity; EEP recommends managing putative northern (e.g., China) and southern (e.g., India, Cambodia) groups separately.

	AZA / North America	EAZA / Europe	CZA / India	SEAZA/ SE Asia	JAZA / Japan	Total Global *Ex Situ* Pop
Population size (M.F.U)	**33 (12.15.6)**	**279 (144.118.17)**	**64**	**31 (19.11.1)**	**9 (3.6)**	**363 (185.154.24)**
Living wildborn	?	?	Many	?	?	?
Gene diversity	?	?	?	?	?	~83.9%
# Founders	?	?	?	?	?	7
# Potential fdrs	?	?	?	?	?	?
% pedigree kn	0%	Low	?	?	?	Very low (3%?)
Pop lambda	1	1.04	?	?	?	1.044
# institutions	5	46	7	3	5	62
Management	No formal program	EEP managed	No formal program	Not managed	No formal program	
Data source	*2016 EAZA Regional SB*	*2016 EAZA Regional SB*	*2016 CZA info*	*2016 ZIMS*	*2016 JAZA report*	*2016 EAZA Regional SB*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Insurance	HIGH	HIGH (CZA); MODERATE(EAZA) High if managed as a species-level insurance population	LOW (CZA) HIGH (EAZA)	CZA likely one subspecies; does not replace another species or harm wild pop; EAZA status dependent on outcome of genetic testing
Source	Not rated	Not rated	Not rated	Future potential for release in India
Research Genetic, taxonomic, health	HIGH	MODERATE Genomics project started in Europe	LOW	Need institutional support and resources; samples unlikely from the wild
Training Field restraint	HIGH	HIGH (AZA)	LOW	Already occurring in AZA
Education In range	HIGH (India)	HIGH Either on-site or outreach (underway)	LOW	Target government to increase support; control feral dogs; active outreach
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Education Outside range	HIGH	HIGH	LOW	Improve public perception of large carnivores
Fundraising	HIGH	MODERATE	LOW	Funds for *in situ* projects (India); AZA research

Comments/Issues:

- Taxonomic status (# of subspecies) is unclear; the decision to manage on the species or subspecies level will have implications for feasibility, value and structure of *ex situ* programs.
- CZA: zoos periodically receive problem/rescue animals, which may be a source of new founders. Began a breeding program 4 years ago and they maintain a studbook. Likely Indian subspecies.
- EAZA: Managed as two subspecies (Northern and Southern); molecular work is needed to sort out taxonomy and pedigree; if mostly Northern, then unique from Indian population.
- AZA: Animals originally came from EAZA, so may be a genetically less valuable population and will need genetic testing. AZA and smaller regions (SEAZA and JAZA) could provide resources and funds as well as support the larger regional populations.

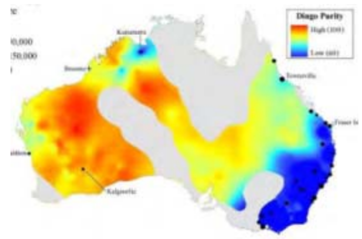
Workshop Recommendations:

1. Molecular analysis needs to be completed to determine taxonomic status for dholes.
2. CZA is recommended to maintain and possibly expand an intensively-managed *ex situ* breeding population as an insurance population and potential future source population.
3. EAZA is recommended to maintain an intensively-managed *ex situ* breeding population as an insurance population (pending results of molecular work).
4. AZA is recommended to maintain their current population; likely role is training and research if genetically redundant (testing needed) and therefore could remain as a small population supporting larger populations (together with SEAZA and JAZA).
5. Research, Education and Fundraising roles can be applied in all regions.
6. Regional programs are encouraged to support *in situ* projects. Contact Brij Gupta regarding projects in India (to secure habitat and prey); contact Nucharin Songsasen regarding projects in SE Asia.

DINGO
Canis lupus dingo

THREATENED SPECIES
IUCN Red List: Vulnerable (due to hybridization)
Population trend: Decreasing

Native to Australia, with extensive hybridization with domestic dogs. Considered a subspecies of gray wolf, as is the domestic dog *C. l. familiaris*.



Threats: Persecution, habitat loss and hybridization with domestic dogs

Potential Ex Situ Roles: No responses for this species prior to workshop

Prior Ex Situ Recommendations: Recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) as part of species meta-population (1992 CAMP). Extensive hybridization means that DNA testing is necessary to determine purity of captive individuals used for a breeding program (2010 Dingo Report, Australian government).

Ex Situ Status:
Present in captivity in 3 regions (global *ex situ* population = 163 animals); degree of hybridization unclear. Dingos and dingo hybrids breed well in captivity. Many breeding sites outside of zoos, including the Dingo CARE Network (100 pure individuals) and Bargo Dingo Sanctuary.

	AZA / North America	EAZA / Europe	ZAA/ Australasia	Total Global *Ex Situ* Pop
Population size (M.F.U)	**29 (14.15)**	**50 (17.33)**	**84 (35.48.1)**	**163 (66.96.1)**
Living wild-born animals	?	?	?	8
Gene diversity	?	?	?	?
# Founders	?	?	?	?
# Potential founders	?	?	?	?
% pedigree known	?	?	?	5%
Population trend/ lambda	?	?	?	Increasing
# institutions	10	15	23	48
Management	Not managed	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:

The following direct and indirect potential conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education (ZAA region) Messaging about risk of loss through hybridization; unique subspecies vs. reputation as "pest"	**HIGH**	**HIGH**	**LOW**	If solely education role for now, taxonomic purity of current *ex situ* population less important; an education program may facilitate the transition to additional roles in future (if required) by building/keeping public engagement.

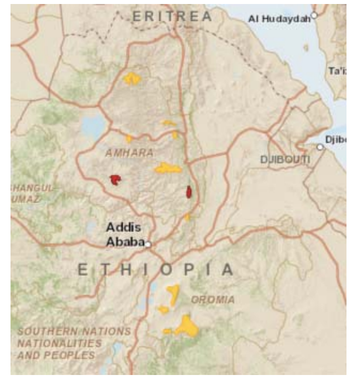
Comments/Issues:

- Considered a pest species in many regions of its native range; currently not considered a conservation priority by the Australian government or ZAA.
- In other regions the species is/can be held as geographical/cultural representative; this type of messaging can utilize the current population regardless of its unclear hybridization status. No managed program is needed at this time.

Workshop Recommendations:

1. If the taxon does become a conservation priority and *ex situ* activities for conservation are appropriate/required (for insurance or other roles), this will be taken on by ZAA and partners, in cooperation with the Australian government.
2. An *ex situ* population of this species in other regions (non-ZAA) is not actively encouraged, as it could impact *ex situ* space needed for other species (including non-canids). However, if an institution does have the species, educational messaging should be linked to that utilized in ZAA.

ETHIOPIAN WOLF
Canis simensis



THREATENED SPECIES
IUCN Red List: Endangered
Population trend: Declining

Restricted to seven isolated mountain enclaves in the highlands of Ethiopia. 2004 CSG Action Plan lists as the most threatened canid with least amount of genetic variation.

Threats: Continuous loss of habitat due to high-altitude subsistence agriculture and overgrazing is the major threat. Recent declines due to disease epizootics, with road kills and persecution as secondary threats. Rabies and distemper are concerns. Threats exacerbated by species' specialization to the Afro-alpine ecosystem. Just below the threshold for uplisting to Critically Endangered.

Potential Ex Situ Roles: **Direct Conservation: Captive Breeding**
An in-country program may be the only option for an *ex situ* breeding program, if needed, as plans to establish breeding programs abroad have been repeatedly rejected by Ethiopia.
Indirect Conservation: Funding, Education. Zoos can help fund research to address knowledge gaps in behavior, physiology and ecology under human disturbance so that impacts are understood and can be mitigated. Zoos can raise public awareness of rare species (through surrogate captive species) and need for habitat protection.

Prior Ex Situ Recommendations:

1992 Canid, Hyaena and Aardwolf CAMP: Recommended that an *ex situ* population be established to preserve 90% GD for 100 years, developed with 1-5 years (Nucleus I). Resolution by AZA Canid TAG, CSG and others to establish an integrated in-country and out-of-country captive breeding program, with pledged support from foreign zoos to assist in-country program development. Ideally populations to be managed as a meta-population along with *in situ* populations. WCS submitted proposal to establish nucleus population in the US. Neither initiative was supported by Ethiopian government to allow exportation for out-of-range populations.

1997 Ethiopian Wolf Status Survey: Potential role for captive breeding to mitigate species extinction risk as part of a meta-population management strategy. Feasibility assessment concluded that population management is essential, with *ex situ* breeding required: 1) to develop a genetically pure population as insurance against species extinction; and 2) to produce potential founders for eventual release into the wild (reintroduction and reinforcement). Proposal for an in-country captive breeding facility was developed in concert with Born Free Foundation, and a recommendation was made to develop a gamete bank. Problem-oriented research is needed to manage wolves *in situ* and *ex situ*. Zoos in breeding program to provide financial and technical support *to in situ* conservation needs. Use as a flagship species for conservation education for Ethiopian wildlife.

1999 Ethiopian Wolf PHVA: No *ex situ* population needed yet, but maintain preparedness for captive breeding facility construction if it becomes a higher priority (lower priority action).

2004 Canid Status Survey and Conservation Action Plan: Recommendation to consider the feasibility of establishing a captive breeding population to provide insurance against extinction in the event of catastrophe (whether political or climatic), weighed against the option of accomplishing this through intensive management of wild populations; must not replace, hinder or compromise *in situ* conservation efforts. Examine possibility of preserving gene diversity through cryopreserved gamete bank (with collection done opportunistically and without negative impacts on species *in situ* conservation).

2011 Ethiopian Wolf National Action Plan: Collection and long-term storage of sperm to retain genetic diversity and provide options for genetic supplementation and meta-population management.

Ex Situ Status:
Not represented in captivity in ZIMS database or surveyed regional zoo associations. No historical holdings recorded. Attempts to create a captive population were abandoned around 2004 due to lack of permission from the government of Ethiopia. Status of an in country GRB unknown; no GRB for this species is known to exist outside Ethiopia, although training of Ethiopians in this area by AZA and other scientists has occurred as recently as 2014. See reports listed above for captive plan proposals.

Workshop Assessment of Ex Situ Roles and Activities:

The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Insurance (GRB)	**LOW (w/out captive pop) MODERATE (w/captive)**	**LOW (w/out captive pop) MODERATE (w/captive)**	**HIGH - MODERATE**	Would require: - technical expertise, protocols, facilities, biosecurity, good record keeping, etc. - sustainable, secure banking - financial investment - access to wolves to develop techniques (can develop to some degree with other species) and collect samples; sampling of wild individuals holds risk.
Insurance (Living)	**HIGH**	**LOW**	**HIGH**	May be more difficult to breed/manage; limitations in applying husbandry expertise from other species. Would need to obtain founders, which may hold risks to the wild population. Best to occur in range country; holds socio/ political/ stability challenges. Would require skilled staff, facilities, funding, security. Cumulative risk is considerable.
Training (GRB)	**LOW**	**HIGH**	**LOW**	Benefit could become moderate if an *ex situ* population existed. Skilled people available.
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Research Vaccines	Not rated	Not rated	Not rated	If an *ex situ* population were established, conduct research regarding vaccines. Risky to do with new *ex situ* population during learning/ startup phase. Currently vaccines are being provided to domestic dogs and Ethiopian wolves in the wild.

Comments/Issues:

- Given the small, fragmented nature of this population, workshop participants believed an *ex situ* insurance population could have strong conservation benefits (mitigate against catastrophes in the wild etc.), should the correct circumstances present themselves.
- Look into PAAZA member in Ethiopia; could this facility play a role for education and funding?

Workshop Recommendations:

1. The global zoo community supports the continued recommendation for an *ex situ* insurance population (live individuals and/or GRB) in Ethiopia, should there be support for this among the species specific stakeholder group and should the right circumstances be present.
2. The global zoo community is available to help draft a plan for an insurance population (living individuals and/or GRB) that thoroughly analyses feasibility and develops risk mitigates strategies. It may be beneficial to have such a plan available in case the need arises quickly. Work together with Ethiopian Wolf Conservation Programme, IUCN SSC Canid Specialist Group and PAAZA (and if possible/suitable PAAZA member(s) in Ethiopia).
3. Work with Ethiopian Wolf Conservation Programme and the IUCN SSC Canid Specialist Group to identify other *in situ* needs (e.g. rabies vaccine testing) and funding and technical support.
4. Continue support, or increase as needed, for in country capacity building for GRB.

MANED WOLF
Chrysocyon brachyurus

THREATENED SPECIES
IUCN Red List: Near Threatened
Population trend: Unknown

Native to South America (Argentina, Bolivia, Brazil, Paraguay, Peru, Uruguay)

Threats: Habitat loss and alteration (to agriculture), human persecution due to livestock losses and cultural beliefs, increasing vehicular traffic (road kills), and pathogens contracted from domestic animals.

Potential Ex Situ Roles: **Direct Conservation: Conservation Education**, ***Ex situ* research and Training**. In case threats in the wild fail to be managed, then: **Insurance Population**, **Population restoration** and **Assisted colonization**.
Indirect Conservation: **Research** in reproduction and epidemiology; **Training** in field vet procedures, **Expertise:** testing new identification and monitoring tags, **Education/awareness** in zoos (e.g. Friends of the Maned Wolf campaign in SZB 2015); destruction of savannah; **Fundraising** for educational materials and to continue the Friends of the Maned Wolf Project (and expand globally).

Prior Ex Situ Recommendations: Continue collaborative international efforts to maintain an *ex situ* population sufficient to retain 90% GD for 100 years, developed within 1-5 years (1992 CAMP). As of 2004, captive research had been done on physiology, nutrition, disease, behavior and husbandry, with some research still ongoing. 2005 PHVA recommended *ex situ* population conservation roles that included research as a base to studies in the wild, accommodation of non-releasable confiscated animals, and possible genetic source for future reintroduction. Zoos can assist in preparing education material to be distributed in protected areas, tourism agencies, lodges and hotels, containing orientations about how to reduce possible ecotourism's negative impacts over maned wolf populations. The Maned Wolf Argentine Group held regional workshops that developed recommendations for conservation in the wild and management in captivity and efficient conservation education strategies.

Ex Situ Status:
Present in captivity in 3 regions in significant numbers, with small numbers held in Africa and Asia (global *ex situ* population = 371 animals). Successful breeding in captivity; stable population; International Studbook maintained by EAZA.

	AZA/North America	ALPZA/Latin & So America	EAZA / Europe	JAZA / Japan	ZAA / Australasia	Other (misc.)	Total Global *Ex Situ* Pop
Population size (M.F.U)	**88 (45.43)**	**106* (45.61)**	**136 (69.65.2)**	**5 (3.2)**	**21 (13.8)**	**15 (7.8)**	**371[1] (182.187.2)**
Living wild-born	0	51*	0	0	0	0	51[1]
Gene diversity	92.2%	96.4%	93.5%	69.3%	79.8%	n/a	96.5%[2]
# Founders	31	62	34	26	28	n/a	75[2]
# Potential fdrs	0	50	0	0	0	0	50[1]
% pedigree kn	100%	91%	100%	100%	100%	n/a	97%[2]
Pop trend	Stable/1.0	0.920	Declining	Declining	Stable	n/a	Stable[2]
# institutions	31	40	65	1	4	6	147[1]
Management	SSP managed	No formal program	EEP managed	No formal program	Monitored program	Not managed	International Studbook (ISB)
Data source	*2014 AZA B&T plan*	*2014 ISB*	*2014 ISB*	*2014 ISB*	*2014 ISB*	*2014 ISB*	*[1]Column sums; [2]2014 ISB*

M.F.U = # males.females.unknown sex

**2016 ALPZA survey indicates 20 (11.9) individuals in 6 institutions, with 14 institutions interested in holding species*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education In range: Agro-business; link between soy production and other industrial agriculture and loss of grassland/ savannah Wolf killing/poaching Car collision	HIGH	HIGH	MODERATE	By range state zoos; Agro-business: target local governments, producers/industries, as well as consumers Killing and road kill: target local population (already an education program in place in Brazil – bring people to the zoo so they can see the wolves)
Insurance	MODERATE	HIGH	LOW	Currently not yet of critical importance; however potentially local population declines and extinctions. Some taxonomic/genetic uncertainty.
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Education Outside range: Agro-business: link between soy production and loss of grassland/ savannah	MODERATE	HIGH	LOW	By non-range state zoos; target mainly importers and consumers
Research Epidemiology/sensitivity to pathogens/disease ecology Assisted reproductive technologies Genetic structure both *in situ* and *ex situ*	HIGH	HIGH	MODERATE	Disease risk from domestic dogs/animals. Disease/ vaccine research already happening in Brazil. AR techniques could help with intercontinental gene exchange. Bank genetic samples *ex situ.*

Comments/Issues:

- There is concern that the population in the wild is (at least locally) declining, with potential local extinctions.
- The *ex situ* population in Brazil is very aged. Despite the high number of wild origin individuals, breeding has been restricted because of space limitations. There also seems to be some loss of husbandry expertise.
- If the currently large, genetically diverse, global *ex situ* population is left to deteriorate, it would be much harder to rebuild later, should the situation *in situ* become/turn out to be more drastic.
- Conservation education is needed to educate the local governments, producers/companies, as well as consumers about the link between soy products and other industrial scale agriculture and loss of the savannah habitat needed for maned wolves. This message is being brought to the public by some zoos within the species range, even some without maned wolves, but it needs to expand. Perhaps ZAA could share some advice from their successful palm oil campaign regarding targeting large corporations?
- Some research efforts relating to disease epidemiology and assisted reproductive techniques are under way. Taxonomic issues related to possible sub-species have been raised, but not answered. Any significant genetic structure/subspecies taxonomy identified would have consequence for the *ex situ* program.

Workshop Recommendations:

1. While the insurance role is not yet critical, it is recommended to maintain the already large, genetically diverse, *ex situ* population, in case the fear for (at least regional) population decline and local extinctions is validated.
2. Organize discussion among all regional zoo associations holding this species to identify how best to cooperate to make the global *ex situ* population as efficient and connected to *in situ* efforts as possible.
3. Develop a more formal program within the Brazilian Zoo Association (SZB)/ALPZA. Brazil holds large numbers of wild origin individuals and, while space is restricted, it is important that these individuals can breed and pass on the "captured" genetic diversity to future generations before they are too old to do so. Descendants could be sent to other regional zoo associations to improve the (genetic) insurance value of the global population, thereby also reducing the total number of spaces needed worldwide. All of this would likely involve the appointment of a studbook keeper based in South America to better manage the population and provide a central point of communication with international partners.
4. All regions: carry out conservation education related to the effects of industrial agro-business on habitat loss for the species (target local governments, producers/industries, consumers as appropriate).
5. Brazil/ALPZA: carry out conservation education related to retaliatory wolf killing and road kill.
6. All regions: bank biosamples (for genetic/taxonomic research).
7. All regions: discuss possible collaborations to further the research on pathogen susceptibility, vaccines etc., as well as AR techniques development – involve veterinary advisors.

MEXICAN GRAY WOLF
Canis lupus baileyi

THREATENED SPECIES
IUCN Red List: Least Concern as a species; regionally threatened subspecies (Extinct in the Wild, except for two reintroduced populations)
Population trend: Increasing through 2014

Native to southwest US and Mexico. Functionally extinct in the wild in 1970s. Small reintroduced populations established in the US (1998) in Arizona and New Mexico, and in Mexico (2012), from SSP-managed captive-bred stock. Wild population 2015 estimate is 97 wolves.

Threats: Ongoing persecution and restricted available habitat for re-establishment of populations; potential inbreeding impacts especially in wild.

Potential Ex Situ Roles: **Direct Conservation: Ark, Rescue, Population Restoration, Insurance Population, Research, Education.** A few wild wolves were captured in Mexico 1977-1980 to establish a captive breeding program (ark). This captive population remains the sole source population for reintroduction efforts, and can provide genetic migration between reintroduced populations in the US and Mexico until they become naturally connected. A secure *ex situ* population allows a 'nonessential experimental' status for the wild population, which allows greater flexibility in managing this politically challenging species. Recovery in the wild is highly reliant on the continued success of this program. Captive breeding facilities conduct most of Mexican wolf education and awareness programs, reaching many millions of people annually.

Prior Ex Situ Recommendations: 1990 PHVA and 1992 CAMP outlined requirements for an *ex situ* program that would serve as a genetic reservoir and also source population for restoration.

Ex Situ Status: Present in captivity only in the US and Mexico (global *ex situ* population = 243 animals). Managed by the AZA SSP in collaboration with Mexico (binational program) and with USFWS (USA) and SEMARNAT (Mexico). Reproduction in captivity and source population for reintroduction and reinforcement to the wild. Challenges with low reproduction and demographic instability related to space issues. Gamete banking underway in US and Mexico (since 1991 for sperm and 2008 for oocytes). Research topics include infertility, taste aversion, and morphology (2014 Mexican Wolf Recovery Program Report).

	AZA/ALPZA/AZCARM/AMACZOOA	Total Global *Ex Situ* Pop
Population size (M.F.U)	**243 (112.121.10)**	**243 (112.121.10)**
Living wild-born founders	0	0
Gene diversity	83.3%	83.3%
# Founders	7	7
# Potential founders	0	0
% pedigree known	99.3%	99.3%
Population trend/ lambda	Stable	Stable
# institutions	54	54
Management	SSP managed	
Data source	*2015 AZA B&T report*	*2015 AZA B&T report*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Source	**HIGH**	**HIGH**	**MODERATE**	Needs for release can affect feasibility and risk
Insurance Living wolves & GRB	**HIGH**	**HIGH**	**LOW short-term** **MODERATE** to **HIGH** long-term	Low founder base limits this role in the long term
Research Genetic, taste aversion, assisted reproduction	**HIGH**	**HIGH**	**MODERATE**	Benefits are high especially for ART and GRB
Education At local level	**MODERATE**	**HIGH**	**LOW**	Target local people (especially children of ranchers) on how to live with wolves
Assisted Colonization	**Not rated**	**Not rated**	**Not rated**	Currently under discussion

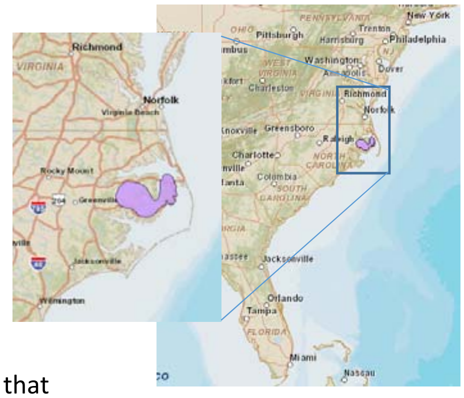
Comments/Issues:
- North American program currently in 'population restoration' phase.
- If releases are reduced or stopped, the *ex situ* population is affected because of space constraints, the necessity to reduce reproduction, and potential resulting negative impacts on future reproductive success.

Workshop Recommendations:
1. Recommend to continue the high intensity program in the US and Mexico.
2. Maintain or expand the population, with a goal of 300 wolves.
3. Increase the number of institutions within this region.
4. Increase the number of breeders and effective population size (Ne).

RED WOLF
Canis rufus

THREATENED SPECIES
IUCN Red List: Critically Endangered
Population trend: Increasing

Native to southeastern US. Extinct in the wild by 1980, but was reintroduced in 1987 into a restricted area (peninsula) in eastern North Carolina from captive-bred stock.



Threats: Lack of available habitat for population expansion and hybridization with coyotes are primary threats. Human-induced mortality (road kills and hunting) can be significant.

Potential Ex Situ Roles: **Direct Conservation**
Genetic Reservoir, Source Population for Restoration

Prior Ex Situ Recommendations: Maintain *ex situ* population that retains 90% GD for 100 years (1992 CAMP). 1999 PHVA recognized the increasingly significant role of the *ex situ* population as the only repository of the original genetic composition of the species in the face of hybridization in the wild. Recommendations included increased breeding and population expansion, demographic and genetic considerations as a source population for release, and the development of a Genome Resource Bank (GRB) action plan. The 2004 CSG Action Plan reiterated the roles to safeguard the genetic integrity of the species and provide animals for reintroduction or reinforcement. Management strategies include gamete banking and cross-fostering of captive-born pups to wild females. A meta-population PVA (both *in situ* and *ex situ* populations) is underway as a collaborative effort between USFWS and the zoo community (SSP and population modelers).

Ex Situ Status:
Present in captivity only in the US (global *ex situ* population = 202 animals). Reproduction in captivity and source population for restoration to the wild.

	AZA/ North America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**202 (91.111)**	**202 (91.111)**
Living wild-born animals	0	0
Gene diversity	89.1%	89.1%
# Founders	12	12
# Potential founders	0	0
% pedigree known	100%	100%
Population trend/lambda	Stable	Stable
# institutions	45	45
Management	SSP managed	SSP managed
Data source	*2015 AZA B&T report*	*2015 AZA B&T report*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect potential conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Insurance	HIGH	MODERATE	LOW	PVA results suggest at least 330 individuals. Space limitations
Rescue In case loss of socio-political support to conserve taxon in the wild	HIGH	MODERATE	MODERATE	Creating emergency spaces is feasible. Risk to *ex situ*: coyote hybrids, overrepresented alleles, disease. Risk to *in situ*: loss of wild population and their "political space" in the landscape
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Research Assisted reproduction techniques, inflammatory bowel disease, taxonomy	MODERATE	HIGH	LOW	
Education Advocacy, raising profile/awareness	HIGH (especially local)	HIGH	LOW	

Comments/Issues:

- Fewer than 50 individuals left in the wild. Last reintroduction in North Carolina in summer 2015; currently no further releases planned.
- While taxonomy continues to be debated and researched, the IUCN SSC Canid Specialist Group and other experts currently still consider them a distinct species.
- PVA modeling suggests the *ex situ* insurance population should hold at least 330 wolves.
- Socio-political issues are raising doubts/discussion as to whether to continue conserving this taxon in the wild. Genetic drift may have resulted in different alleles being retained in the *in situ* population than the *ex situ* population. In the worst case scenario there may be a need to rescue a subset of the *in situ* individuals to conserve potentially rare genetics; it would also provide a demographic (reproductive) boost to the *ex situ* population.
- The majority of the remaining individuals of this species on Earth are living *ex situ* in one country and regional zoo association. The spread over different institutions mitigates stochastic demographic risks. However, finding and reliably keeping sufficient space in one region may be a challenge. Involving more than one region may benefit space capacity but brings increased logistical complexity of genetically managing a pack living species across regions/countries.

Workshop Recommendations:

1. Maintain the high intensity program in US for now while trying to expand the population within AZA. Consider/discuss the possibility of a population in other regional zoo association to assist with space and sustainability goals.
2. A written plan should be in place for a rescue scenario.
3. Maintain and/or increase research and educational efforts.

BLACK-BACKED JACKAL
Canis mesomelas

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Endemic to Africa in two separate subpopulations in East Africa and in southern Africa. Generally widespread and opportunistic.

Threats: No major threats. Persecuted for livestock depredation and as rabies vectors (very susceptible to rabies and may transmit it to livestock), but control efforts have little effect on population numbers.

Potential Ex Situ Roles: No responses for this species prior to the workshop.

Prior Ex Situ Recommendations: Black-backed Jackals have been maintained in captivity for species diversity in African plains exhibits and for testing rabies vaccine efficacy in the past (2004 CSG Action Plan).

Ex Situ Status:
Present in small numbers in captivity in 4 regions (estimated global *ex situ* population = 33 animals). Reproduction in captivity. Monitored species in EAZA.

	AZA / No America	EAZA / Europe	PAAZA / Africa	JAZA / Japan	SEAZA / SE Asia	Total Global *Ex Situ* Pop
Population size (M.F.U)	**5 (3.2)**	**13 (10.3)**	**5 (4.1)**	**3 (2.1)**	**7 (3.4)**	**33[1] (22.11)**
Living wild-born animals	?	?	?	?	?	5[2]
Gene diversity	?	?	?	?	?	?
# Founders	?	?	?	?	?	6[2]
# Potential founders	?	?	?	?	?	?
% pedigree known	?	?	?	?	?	15%[2]
Population trend/ lambda	?	Declining	?	?	?	Stable[2]
# institutions	2	8	2	2	3	17[1]
Management	Not managed	Monitored EAZA program	Not managed	No formal program	Not managed	
Data source	*2016 ZIMS*	*2015 EAZA report*	*2016 ZIMS*	*2016 JAZA report*	*2016 ZIMS*	*[1]column sums; [2]2016 ZIMS*

M.F.U = # males.females.unknown sex

<u>Workshop Assessment of Ex Situ Roles and Activities</u>:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- Monitored in EAZA, because of its role as an education species to highlight African habitat. AZA uses bat eared fox for this role.
- Enigmatic on display; yet interest by the public in jackals waxes and wanes so it is hard to keep them at a minimum level required for a sustainable population, especially if a region has multiple jackal species, e.g., EAZA.
- EAZA decided in their last regional collection plan (RCP) that they would phase this species out so the space could be utilized by golden jackals.
- There may be some benefit to hold a small global population, especially within the species' range countries, for educational messaging about canids and carnivores.

<u>Workshop Recommendations</u>:
No *ex situ* population or role identified at this time; should re-evaluate if status in the wild changes.

COYOTE
Canis latrans

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Increasing

Widespread distribution throughout North America, Mexico and into Central America. Abundant throughout its range and increasing in distribution as humans modify the landscape. Able to exploit human-modified environments.

Threats: No current threats throughout the range. Hybridization with dogs may be a threat near urban areas. May hybridize with gray wolves in the northeast US and with red wolves in the southeastern US.

Potential Ex Situ Roles: **Indirect Conservation: Education, Research**
Currently used beneficially in various education and research activities.

Prior Ex Situ Recommendations: Research into possible introgression with red wolf (2004 CSG Action Plan).

Ex Situ Status:
Present in captivity in 2 regions (global *ex situ* population = 127 animals). Not managed. Good reproduction and survival in captivity. IUCN Red List states >2,000 in zoos, wildlife centers and other *ex situ* facilities throughout their range.

	AZA / North America	ALPZA / AMACZOO Latin & South America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**107 (59.46.2)**	**17(+3) (12.8)**	**127[1] (71.54.2)**
Living wild-born animals	?	?	76[2]
Gene diversity	?	?	?
# Founders	?	?	4[2]
# Potential founders	?	?	72?[2]
% pedigree known	?	?	63%[2]
Population trend/ lambda	?	?	Declining[2]
# institutions	34	8	42[1]
Management	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ALPZA report & 2016 ZIMS*	[1]*column sums;* [2]*2016 ZIMS*

*M.F.U = # males.females.unknown sex. *additional contracepted individuals indicated in ()*

<u>Workshop Assessment of Ex Situ Roles and Activities</u>:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- IUCN Red List states >2000 in zoos, wildlife centers, and other *ex situ* facilities throughout their range – this is clearly an educated guess as most of these facilities do not participate in ZIMS or other census type databases. It is unlikely there will ever be a method to obtain an accurate *ex situ* number outside of ZIMS and/or zoo associations.
    - An additional challenge is that many of the coyotes held in non-zoos (or unaccredited zoos) are non-permanent, e.g. rescue and release.
    - Best way to proceed is to make certain that what is under our control is accurately accounted for.
        - ALPZA survey is current as of 2016; AZA census will be updated as part of the AZA-wide survey for canid and hyaenids scheduled in 2017.
- AZA has not recommended a coyote population for over a decade, no AZA institution is breeding coyotes, but active phase out and replacement with a threatened canid species has not been a past focus.
    - AZA needs to investigate if coyote spaces are suitable for canids in managed programs, and how many of these are confiscated/rescued and are legally required to be held at that institution.
- Most, if not all, of the research questions for coyote are being handled at Utah State (Dr. Eric Gese), so this is not a primary role needed for zoo populations, although the zoo population can be used for genetic research (previous research has been done).
- Coyote are very appealing to the public and thus are used to discuss our connection with nature. Also they can be utilized to discuss educational messaging about human-adapted species (in contrast to threatened species that decline in human dominated landscapes).

<u>Workshop Recommendations</u>:

1. No *ex situ* population or role identified at this time; should re-evaluate if status in the wild changes.
2. AZA should investigate space and current role of coyotes in AZA institutions and actively work to reduce coyote numbers such that more spaces are available to managed species.
3. Institutions with this species should be encouraged to focus on conservation messaging.

GOLDEN JACKAL
Canis aureus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Increasing

Native to North and East Africa; Middle East; and Central, South and Southeast Asia.

Threats: Wide ranging and opportunistic. However, steady decline in all non-protected areas due primarily to change in land use (industrialization, intensive agriculture and urbanization).

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: Recommended for use in education and awareness to emphasize differences with wolves and to raise awareness of the jackal in the Arabian peninsula (2000 Arabian Carnivore CAMP). Low priority for *ex situ* breeding.

Ex Situ Status:
Present in captivity in 4 regions (estimated global *ex situ* population = 200 animals). Reproduction in captivity. Common in Indian zoos.

	EAZA / Europe (incl. AZAA)	PAAZA / Africa	CZA / India	ZPO / Thailand	SEAZA (other than ZPO)	Total Global *Ex Situ* Pop
Population size (M.F.U)	**45 (16.19.10)**	**13 (5.4.4)**	**93 (25.27.41)**	**31 (13.13.5)**	**18 (3.4.11)**	**200[1] (62.67.71)**
Living wild-born animals	?	?	?	?	?	44[2]
Gene diversity	?	?	?	?	?	?
# Founders	?	?	?	?	?	23[2]
# Potential fdrs	?	?	?	?	?	>30?[2]
% pedigree known	?	?	?	?	?	41%[2]
Population trend/ lambda	Declining	?	?	?	?	Stable[2]
# institutions	16	2	16	4	6	47[2]
Management	Monitored EAZA program	Not managed	No formal program	No formal program	Not managed	
Data source	*2015 EAZA report*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	[1]*column sums;* [2]*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- There have been suggestions that there may be 2-3 subspecies (African vs. South Asia) or (African vs. South Asia vs. SE Asia).
    - The CZA animals are of Asian origin and PAAZA animals are of African origin. However, not all EAZA animals are of known origin. This could have implications, if there is ever a need to manage by subspecies, e.g., due to local extinctions, and therefore if EAZA is to focus on this species (in lieu of black-backed jackals), this should be examined.
- Institutions with this species should be encouraged to focus on raising awareness of jackals, their role in the ecosystem, and their similarities/differences from other canids.

Workshop Recommendations:

1. Investigate the origin of animals in the EAZA population via records or molecular work.
2. CZA and EAZA should consider if a reduction in numbers of golden jackals would benefit the *ex situ* dhole population during regional planning.

GRAY WOLF
Canis lupus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to North America, Europe and Asia. Originally the world's most widely distributed mammal, but is now extinct in much of Western Europe and the US (loss of about one third of historic range). Regionally threatened or extirpated.

Threats: Deliberate persecution and poisoning due to depredation on livestock along with habitat loss and fragmentation.

Potential Ex Situ Roles: **Conservation education** relating to public attitudes towards wolves and their persecution. **Fund raising** for *in situ* conservation research.

Ex Situ Status:
Present in captivity in all regions (estimated global *ex situ* population = 1172 animals) for all subspecies except for *C.l. baileyi* (Mexican) and *C.l. signatus* (Iberian). Good reproduction in captivity. Historically increasingly globally but recent stabilization/slight decline.

	AZA / North America	ALPZA / Latin & So. America	EAZA / Europe	AZAA / UAE	CZA / India	SEAZA / SE Asia	JAZA / Japan	KAZA / South Korea	Total Global *Ex Situ* Pop
Population size (M.F.U)	**155 (80.74.1)**	**23(+2) (13.12)**	**807 (432.347.28)**	**54 (21.33)**	**47 (23.24)**	**9 (6.3)**	**59 (29.30)**	**16 (5.11)**	**1172[1] (609.534.29)**
Living wild-born animals	?	?	?	?	?	?	?	?	~50?[2]
Gene diversity	?	?	?	?	?	?	?	?	?
# Founders	?	?	?	?	?	?	?	?	>100[2]
# Potential founders	?	?	?	?	?	?	?	?	?
% pedigree known	?	?	?	?	?	?	?	?	<12%[2]
Population trend/lambda	?	?	?	?	?	?	?	?	Stable/ decline[2]
# institutions	46	7	155	4	12	4	12	1	241[1]
Management	Not managed	Not managed	Not managed	Not managed	Not managed	Not managed	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ALPZA rpt*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 JAZA rpt*	*2016 ZIMS*	[1]*column sums* [2]*2016 ZIMS*

M.F.U = # males.females.unknown sex

**additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education In range	MODERATE?	HIGH	HIGH	Conservation education to change public attitude, reduce persecution, and promote recovery
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Education Outside range	MODERATE?	HIGH	HIGH	Conservation education to change public attitude toward wolves

Comments/Issues:
- Largest *ex situ* global population of all canid species.
- Not all gray wolf 'space' can be utilized for other wolf taxa due to governmental restrictions, program requirements and standards (e.g., requirements for potential release candidates for Mexican wolves, red wolves).
- As a Least Concern species it is not a conservation priority except for certain regional/subspecies populations, such as Iberian and Mexican wolves.
- Some gray wolf space should be made available to other species in need; this needs active investigation.

Workshop Recommendations:
1. Genetic analysis is needed for the EAZA population. Phase out generic wolves and focus on specific subspecies (e.g., Iberian, Scandinavian).
2. Zoo regions are recommended to focus their efforts on regional wolf subspecies or species over generic gray wolves.
3. Regions should evaluate the consequences and benefits of their current investment in gray wolves and compare the conservation benefits of focusing these resources on different species.
4. There is no recommendation to eliminate the *ex situ* gray wolf population completely, but the generic population should be reduced and better managed taxonomically and genetically, especially where it takes resources from other, more conservation needy taxa.

IBERIAN WOLF
Canis lupus signatus

NON-THREATENED SPECIES
IUCN Red List: Least Concern as a species; regionally threatened subspecies
Population trend: Uncertain

Subspecies of gray wolf that inhabits the forest and plains of the Iberian Peninsula (northern Portugal and northwestern Spain).

Threats: Illegal hunting and persecution

Potential Ex Situ Roles: An insurance population for potential reintroductions from zoos and breeding centers. Research to improve husbandry techniques and management of the subspecies, which will aid potential reintroductions. Regional education programs to highlight threats to this regional subspecies.

Ex Situ Status:
Present in captivity only in Europe (global *ex situ* population = 50 animals). Managed by the EAZA EEP. Reproduction in captivity, with strong historical growth but recent decline (aging population). Additional rescued animals held in ex situ facilities in Portugal.

	EAZA / Europe	Total Global *Ex Situ* Pop
Population size (M.F.U)	**50 (31.17.2)**	**50[1] (31.17.2)**
Living wild-born founders	1?	1?[2]
Gene diversity	?	?
# Founders	13	13[2]
# Potential founders	?	?
% pedigree known	22%?	22%?[2]
Population trend/ lambda	Declining	Declining[2]
# institutions	13	13[1]
Management	EEP managed program	
Data source	*2015 EAZA report & 2016 ZIMS*	*[1]2015 EAZA report; [2]2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Insurance	**HIGH**	**HIGH**	**LOW**	Held in regional, in-country zoos and rescue centers
Research Husbandry	**HIGH**	**HIGH**	**LOW**	Research to improve *ex situ* husbandry and management
Education In range	**HIGH**	**HIGH**	**LOW**	Awareness of a regionally distinct wolf subspecies

Comments/Issues:
- Aggression in *ex situ* population needs to be addressed.
- Additional rescued wolves are held in non-EAZA *ex situ* facilities; there is collaboration but currently no exchange of animals between these facilities and EAZA.
- Regional countries/range states to manage this subspecies.

Workshop Recommendations:
1. Regional countries should continue to manage an *ex situ* population for this subspecies at a regional level.
2. Collaboration between zoos and rescue centers is recommended to maintain an insurance population.
3. Research is recommended to improve husbandry practices and reduce aggression issues.

SIDE-STRIPED JACKAL
Canis adustus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to Sub-Saharan Africa, from West Africa to southern Africa.

Threats: High reproductive rate and dietary flexibility allow this species to adapt and recover from population crashes. Its only vulnerability would be cases of extreme habitat modification or intense disease epidemic.

Potential Ex Situ Roles: No responses for this species prior to the workshop.

Prior Ex Situ Recommendations: Captive specimens of this species were used for testing rabies vaccine efficacy in the past. Less is known about this species compared to the other two jackal species, but a study in Zimbabwe investigated their role in rabies transmission (2004 CSG Action Plan).

Ex Situ Status:
Only 1 living specimen (captive-born female) in captivity in South Africa (PAAZA). Past holdings and breeding in US (1960s) and South Africa (1990s, 2008).

Workshop Assessment of Ex Situ Roles and Activities:
No potential *ex situ* conservation roles were identified at the ICAP workshop.

Comments/Issues:
Due to the lack of specimens in captivity and the relatively stable and widely distributed wild population, there is no direct conservation value of developing an *ex situ* program for this species. *Ex situ* resources can be better used if invested in other species.

Workshop Recommendations:
Not recommended for *ex situ* management unless status in the wild changes (declines).

SINGING DOG
Canis lupus hallstromi

NON-THREATENED SPECIES
IUCN Red List: Not assessed
Population trend: Unknown

Native to New Guinea, with likely only a small number left in the wild. Controversial taxonomy; hybridizes with domestic dogs. Serve as companion animals.

Threats: Hybridization, unknown status in the wild.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: Ongoing captive studies on hybridization (2004 CSG Action Plan).

Ex Situ Status:
Present in captivity in 2 regions (global *ex situ* population = 37 animals).
None held in native Australia.

	AZA / North America	EAZA / Europe	Total Global *Ex Situ* Pop
Population size (M.F.U)	**32 (19.13)**	**5 (2.3)**	**37 (21.16)**
Living wild-born animals	0	0	0
Gene diversity	?	?	?
# Founders	?	?	?
# Potential founders	0	0	0
% pedigree known	0%	0%	0%
Population trend/ lambda	Aging pop	Aging pop	Aging pop
# institutions	14	3	17
Management	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

<u>Workshop Assessment of Ex Situ Roles and Activities</u>:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- Not assessed on IUCN Red List due to controversial taxonomy; currently considered a subspecies of grey wolf.
- Aging *ex situ* population due to lack of breeding recommendations in AZA zoos. Species has not been recommended in last two AZA Regional Collection Plans due to IUCN Red Listing, plus there has been no request for an *ex situ* population from the IUCN SSC Canid Specialist Group.
- Companion Animal Society in America readily breeds this species. There is some question if the 32 singing dogs in North America are in AZA zoos or in Companion Animal Society in America facilities. This will be determined during the AZA-wide survey for canid and hyaenids scheduled in 2017.
- For Australian-themed exhibits, singing dog are interchangeable with dingos, and this species is of less conservation concern than pure lineage dingos.

<u>Workshop Recommendations</u>:

1. No *ex situ* population or role identified at this time; should re-evaluate if status in the wild changes, but any *ex situ* work should be focused in ZAA.
2. If a canid is needed for Australian-themed conservation messaging, then the priority should be on pure lineage dingos.

Global Integrated Collection Assessment and Planning Workshop for Canids and Hyenids

Omaha, NE, USA
19 – 20 March 2016

Final Report

SECTION 5

Taxon Sheets: Small Canids

Taxon Sheets: Small Canids (< 10 kg)

25 Taxa Assessed

For the purposes of this ICAP workshop, we have included the Red List category of Near Threatened (NT) under "Threatened" taxa along with Vulnerable (VU), Endangered (EN), Critically Endangered (CR), and Extinct in the Wild (EW). Using this categorization:

Five of the 25 small canid taxa are listed as Threatened on the IUCN Red List. Of these:
- One taxon is held in significant numbers and in multiple regions (with at least one region actively managing the taxa), and has an international studbook.
- Two taxa are held in captivity in low numbers and only in their native range.
- Two taxa are not currently held in captivity.

For the purposes of this ICAP workshop, we have included the Red List category of Near Threatened (NT) under "Threatened" taxa.

Of the 20 non-threatened taxa, five are held in captivity in significant numbers, four in modest numbers, eight in low numbers, and three are not currently present in captivity.

The table below lists the estimated global *ex situ* population size for each small canid taxon. Taxon sheets are presented in alphabetical order, first for Threatened taxa and then for non-threatened taxa. These sheets summarize *in situ* status and threats, *ex situ* demographic and genetic status, prior *ex situ* conservation recommendations, and ICAP assessment of potential *ex situ* roles, benefit, risks, feasibility, and recommendations.

	Current *Ex Situ* Population Size			
Status	**Large pop (>100)**	**Small pop (40-100)**	**Very small pop (<40)**	**Not in captivity**
Threatened	Bush dog (163)		Island fox (5) Sechura fox (13)	Darwin's fox Short-eared dog
Non-threatened	Arctic fox (155) Bat-eared fox (169) Fennec fox (362) Raccoon dog (300) Red fox (435)	Corsac fox (65) Grey fox (48) Sand fox (49) Swift fox (65)	Bengal fox (7) Blanford's fox (28) Cape fox (6) Chilla (4) Crab-eating fox (20) Culpeo fox (22) Kit fox (15) Pampas fox (3)	Hoary fox Pale fox Tibetan fox

BUSH DOG
Speothos venaticus

THREATENED SPECIES
IUCN Red List: Near Threatened
Population trend: Declining


Native to northern and central South America into Panama. Widespread but rare. Almost qualifies as Vulnerable.

Threats: Serious perceived threats include: 1) human encroachment and habitat conversion; 2) decline in prey due to illegal poaching and predation by domestic dogs; and 3) increased risk of lethal disease contracted from domestic dogs. Disease can have serous impacts due to its group living social system.

Potential Ex Situ Roles:
Direct Conservation: Insurance Population, Research, Conservation Education. *Ex situ* program in professional zoos. Assurance against disease risk to the wild population. Captive studies help understand species like bush dogs that are difficult to observe in the wild. Valuable in raising public awareness in this seldom seen species within its range and potentially reduce disease threats from domestic dogs. Potentially in future: **Population restoration; Assisted colonization**.
Indirect Conservation: Conservation Education, Research, Fundraising. Valuable in raising public awareness in this unique, little known and seldom seen, species inside and outside of its range and its conservation threats. Research in reproduction and epidemiology. Fund raising for education materials and for existing and additional local projects, including through the IUCN SSC Canid Specialist Group (CSG) project's page and also the IUCN Amazonian Canid Working Group.

Prior Ex Situ Recommendations: Recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) as part of species meta-population (1992 CAMP). Brazilian National Action Plan (in prep.) calls for *ex situ* conservation program to be developed by subcommittee.

Ex Situ Status:
Present in captivity in 4 regions (global *ex situ* population = 200 animals). Successful breeding in captivity; growing population; cooperative management regionally and inter-regionally; International Studbook maintained by EAZA.

	AZA / North America	ALPZA / Latin & South America	EAZA / Europe	JAZA / Japan	Total Global *Ex Situ* Pop
Population size (M.F.U)	**21 (15.6)**	**36 (20.13.3)**	**115 (58.52.5)**	**28 (15.13)**	**200 (108.84.8)**
Living wild-born	?	5 (5.0)	?	0	5+
Gene diversity	74.0%	81.2%	79.1%	76.1%	87.6%
# Founders	8	1	11	10	15
# Potential fdrs	0	3	0	0	3
% pedigree kn	100%	97%	100%	100%	100%
Population trend	0.981	0.982	1.01	0.983	1.021
# institutions	8	10	26	6	50
Management	SSP managed program	No formal program	EEP managed program	JAZA managed program	
Data source	*2015 ISB*	*2015 ISB*	*2015 ISB*	*2015 ISB*	*2015 ISB*

*M.F.U = # males.females.unknown sex; *additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Insurance	**HIGH**	**LOW-MODERATE**	**MODERATE**	*Ex situ* population is small/ declining in some regions. Few founders now and few coming in. Challenges in husbandry and husbandry skills transfer. But important role in light of current conditions.
Source	**HIGH**	**LOW**	**MODERATE**	Ideally from *ex situ* population in range countries, but this is not feasible until this is more robust.
Research Transfer of and susceptibility to domestic dog diseases; genetic structure/ taxonomy	**HIGH**	**LOW-MODERATE**	**MODERATE**	Provide samples, expertise, resources, veterinary/ research network.
Education In range: make people aware of the consequences of human actions on bush dogs and their habitat	**HIGH**	**MODERATE**	**LOW**	Messaging: risks from domestic dogs, hunting of bush dog prey for human consumption, industrial agribusiness, etc.
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Research General biology, life history, demographics	Not rated	Not rated	Not rated	Also assist with developing methods to be used *in situ* (e.g., for tracking)
Education Outside range: consumer awareness of the impact of sugar cane and soy extraction on habitat	Not rated	Not rated	Not rated	Target mainly importers and consumers.

Comments/Issues:

- Despite increasing field studies (employing camera traps, scat detection dogs, etc.) still relatively little is known about the precise status (e.g. census numbers, population sizes and trends) and biology of this species in the wild. This can be partly explained by their highly nomadic nature.
- Bush dogs appear to be highly susceptible to a number of domestic dog diseases:
  - In Brazil, researchers have been following populations for 10-15 years, and from time to time all individuals seem to disappear. They found high infection rates with, and mortality from, sarcoptic mange in areas where bush dogs have close contact with domestic dogs. It is suspected that sometimes the population is not able to recover.
  - A few years ago there was an outbreak of leishmaniasis that killed a large part (and most of the founders) of the Brazilian *ex situ* population.
  - Research is needed to address the disease transfer problems from domestic dogs, including mange, throughout the range, not just in Brazil.

- At least in Brazil (outside the Amazon), there appear to be areas of suitable habitat for the bush dog if the population could be increased/restored. Camera trap studies suggest that the distribution in the Amazon is less patchy (fewer "empty" areas), but there is no clear information on population trends there.
- Considering the declining population trend overall, the relative scarcity of information from the wild, and their apparent susceptibility to domestic dog diseases, an *ex situ* insurance population is seen to be a high priority for this species. However, the global *ex situ* population needs to be strengthened for it to fulfil that role. The current population is too small, with too few founders and faces challenges such as social group management (pair formation, cooperative rearing, etc.) and short reproductive life span.
- There are indications that subpopulations in the wild may have genetic particularities that need to be investigated. Zoos could assist with providing molecular tools and research support to address this question. Results could be of consequence to the *ex situ* population and its proposed role as insurance or source.

Workshop Recommendations:

1. All regional zoo associations: hold discussions to determine how to build a global meta-population that is robust enough to function as an insurance and source. This includes somewhat increasing the size of regional populations (apart from EAZA) and strengthening *ex situ* efforts within the range countries (Brazil/ALPZA). These are the regions that would receive any new founders and that would be best placed to function as source populations. Other regional zoo associations should assist with this goal in any way possible (skills, technology and information transfer, etc.).
2. All regions: investigate ways to contribute to research into disease issues, genetic structure/taxonomy and general life history (demographic parameters). Work together where possible.
3. Increase and focus educational messaging (domestic dog disease transmission, industrial agriculture, hunting prey species, etc.).

DARWIN'S FOX
Pseudalopex fulvipes

THREATENED SPECIES
IUCN Red List: Critically Endangered
Population trend: Declining

Endemic to Chile (Los Lagos), South America. Disjunct distribution with two populations: an island population in Chiloé National Park (90% of population) and in coastal mountains of Nahuelbuta National Park on the mainland.

Threats: Island population is relatively safe inside the park; foxes in surrounding areas are vulnerable to logging, fragmentation and poaching. The small mainland population is vulnerable to the presence of domestic dogs in the park as potential disease vectors or direct attack. Total population size (both populations) is fewer than 250 mature individuals.

Potential Ex Situ Roles:
Direct Conservation: Population Restoration, Insurance Population, Research, Training
An *ex situ* program based in Chile, either in a specific *ex situ* facility or in in-country professionally managed zoo(s) – would be most desirable, because it would target the specific public that may advocate the mitigation of the major threats to the conservation of this fox. Some roles could be played by zoos outside of Chile, where fundraising could be more profitable (e.g., US).
Indirect Conservation: Education. There is a need for awareness of this species. Conservation education and fundraising initiatives could be implemented by the zoo community.

Prior Ex Situ Recommendations:
Recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) as part of species meta-population (1992 CAMP). The 2004 CSG Action Plan recommends captive breeding as a component of the urgent conservation action needed for this species. Genetic work needed to assess potential interbreeding with other mainland fox species and to investigate past bottlenecks to inform future management.

Ex Situ Status:
Not represented in captivity in ZIMS database or surveyed regional zoo associations. Only one record of a captive specimen in ZIMS (male, in 1973 in the US). Temuco Zoo held a male and a female until their release in October 2000 in Chiloé. Currently (as of 2016), the only known captive Darwin's Foxes are kept by Fundación Fauna Andina near Villarrica, Chile. These animals have been rescued from dog attacks and illegal ownership. Fortunately, in this facility successful reproduction has been achieved in two consecutive years.

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Prepare to be ready for Insurance if needed Not recommended currently but be prepared if need arises	**HIGH (of the insurance)**	**LOW – MODERATE (of the insurance)**	**MODERATE – HIGH (of the insurance)**	Focus in range country. Currently none in zoos and only a few elsewhere *ex situ*. Some experience with rescued individuals and good experience with other fox species. PVA could help determine feasibility of starting new population without harming *in situ* population. Risks could be reduced with a good plan. Would take considerable resources.
Prepare to be ready for Rescue if needed Currently only individuals rescued for individual welfare reasons (e.g. injured in dog attacks or illegally owned)	**HIGH (to be prepared)**	**MODERATE (to be prepared)**	**LOW (to be prepared)**	Such individuals and the husbandry experience gathered with them, have the potential to form the nucleus of a rescue population for conservation. Monitor the wild population and *ex situ* specialists to develop a plan and "trigger criteria" to "switch on" the conservation rescue role when needed.
Education In range: Target audience to help mitigate threats (domestic dogs, poaching, killing by landowners/farmers, habitat destruction)	**HIGH**	**HIGH**	**LOW**	Do not need live Darwin foxes for this; can be done without foxes or by using other species. There is already a National Day of Darwin Foxes that is celebrated by local zoos (without having foxes).
Training Sampling wild foxes, learn husbandry skills with sporadic rescue individuals or other fox species	**HIGH**	**MODERATE**	**MODERATE - HIGH**	Need expertise from captive community; socio-political issues involved with removing Darwin's foxes from wild and brings risk to wild population. Can use other species as model.

Comments/Issues:

- There was a reassessment meeting held in Chile in Oct 2015. Camera traps identified individuals in new locations between northern and southern distribution. This information was shared with IUCN, and post-ICAP workshop this species was reclassified as Endangered on the IUCN Red List. However, given this is a small fragmented population, caution is merited.
- In the wild domestic dogs come into contact with, and hunt foxes (injuries and disease risks). Local governments are vaccinating domestic dogs, but private people owning dogs are not always open to this.
- Some hybridization with Chilean foxes is assumed.
- Chile is working on Action Plan for this species.
- Genetic research is needed to determine if island and mainland populations are different subspecies; this would be of consequence for any insurance/rescue plans in future.

Workshop Recommendations:

1. *In situ* support and any *ex situ* efforts should be focused within Chile.
2. No managed *ex situ* population is recommended at this moment, but preparations should be in place to react quickly if needed. The *in situ* population should be monitored and *ex situ* specialists in collaboration with ALPZA are recommended to draft a plan and a set of "trigger criteria", so that if implementation of a rescue population (or insurance population) is needed quickly, the plan details needed actions. The international zoo community can help with advice, technical expertise, planning expertise, population modelling financial support, etc.
3. Continue and expand educational initiatives in range country/local zoos targeted towards threat mitigation.
4. Both range and non-range zoos are recommended to support training activities and support *in situ* research and monitoring.

ISLAND FOX
Urocyon littoralis (clementae)

THREATENED SPECIES
IUCN Red List: Near Threatened
Population trend: Increasing

Restricted to six of the California Channel Islands off the coast of southern California, US. Four sub-species suffered catastrophic declines in the mid- 1990s, but all have since recovered due to captive breeding and reintroduction, relocation of golden eagles, and vaccination against canine diseases.

Threats: Restricted range and low genetic variability leave these small populations vulnerable to new diseases from the main-land and other stochastic processes. Considered a 'conservation reliant' species, requiring careful monitoring and rapid management interventions to persist.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: San Nicholas, San Miguel and San Clemente ssp. recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) (1992 CAMP). *Ex situ* breeding on the Channel Islands began in 1999 on San Miguel, and then on Santa Rosa (2000), Santa Catalina (2001), and Santa Cruz (2002), with assistance from AZA zoos. Reintroductions occurred from 2001-2008 and were very successful in combination with concurrent efforts to reduce threats due to predation and disease. Foxes reached pre-decline levels on San Miguel and Santa Cruz 12 years after declines brought them perilously close to extinction. The *ex situ* population also served as a research population for reproductive, genetic and disease research (2004 CSG Action Plan).

Ex Situ Status:
Present in captivity only in the US (global *ex situ* population = 5 animals), San Clemente Island subspecies. Research on captive populations led to important understanding of unique reproductive biology of the species. Captive stock of several subspecies (Santa Cruz, Santa Rosa, San Miguel) were returned to the wild.

	AZA /North America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**5 (3.2)**	**5 (3.2)**
Living wild-born animals	3	3
Gene diversity	?	?
# Founders	?	?
# Potential founders	?	?
% pedigree known	?	?
Population trend/ lambda	Declining	Declining
# institutions	4	4
Management	??	??
Data source	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education	HIGH	HIGH - w/ foxes LOW - w/out foxes	LOW	Having foxes in AZA zoos is not required for the educational messaging, but it would make this easier and studies show it makes the message more effective.
***In situ* support** Technical expertise, community rescue preparedness, monitoring, etc.	HIGH	HIGH	LOW	Few staff members on the island. Lots of help from Santa Barbara Zoo already. Risk for zoos to put efforts elsewhere as status of the species improves (species perceived to no longer need (much) help.

Comments/Issues:
- All *ex situ* breeding was on the islands prior to the down listing; AZA facilities were key to the captive breeding efforts by providing expertise as well as funding as needed. Current California law prohibits an *ex situ* breeding population on the mainland of the US (as species is listed as Endangered in CA).
- AZA facilities still help with trapping and with projects on islands.
- Three populations were delisted and one down-listed, but this means that the USFWS funding and support may decrease/end, which would then be needed from elsewhere. These island populations will likely remain vulnerable. Each island is managed by different entities (sometimes even more than one for each island).
- Animals that are non-releasable do come into zoos, but in low numbers. There is currently an SSP for this species, but with the restrictions from the state of CA, this may not continue. Regardless, AZA should have a written plan in place if the need arises again to provide expertise or space for island foxes.
- Existing extensive educational efforts by AZA zoos are important to the conservation of this species.

Workshop Recommendations:
1. Education efforts are more powerful by having an island fox for the public to see, but the low numbers in AZA are not sustainable so educational messaging should not rely on the species in mainland zoos. Gray fox may be a good alternative educational surrogate.
2. Educational messaging has and continues to be vital to the conservation of this species. Efforts should be focused within CA, but can include other states.
3. Maintain support for funding, technical expertise and in-kind support (veterinary, surveys, etc.).
4. AZA should have a written plan in place if the need again arises to provide expertise or space for island foxes.

SECHURA FOX
Pseudalopex sechurae

THREATENED SPECIES
IUCN Red List: Near Threatened
Population trend: Unknown

Native to the coastal zones of Northwestern Peru and Southwestern Ecuador (South America).

Threats: Primary threats in Peru are the illegal market for pups, amulets and handicrafts made from body parts and persecution due to perceived predation on domestic fowl, goats and guinea pigs and stored goods. In Ecuador the primary threat is habitat loss and degradation due to agriculture and urbanization.

Potential Ex Situ Roles: No responses for this species prior to the workshop.

Prior Ex Situ Recommendations: Recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) as part of meta-population (1992 CAMP). Taxonomy being researched at the University of Lima (2004 CSG Action Plan).

Ex Situ Status:
Present in captivity only in South America (global *ex situ* population = 13 animals). Some reproduction in captivity.

	ALPZA / Latin & South America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**7(+6) (3.4)**	**7(+6) (3.4)**
Living wild-born animals	6 (3.3)	6 (3.3)
Gene diversity	?	?
# Founders	?	?
# Potential founders	?	?
% pedigree known	?	?
Population trend/ lambda	Stable	Stable
# institutions	3	3
Management	Not managed	
Data source	*2016 ALPZA report*	*2016 ALPZA / ZIMS*

M.F.U = # males.females.unknown sex

**additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
***In situ* support** Better understand current status	**HIGH**	**HIGH**	**LOW**	Does not require living individuals of this species. Could also be done with other fox species.
Research Understand species biology and husbandry requirements	**MODERATE**	**MODERATE**	**LOW**	By ALPZA range area institutions, using individuals that are brought in as rescues.
Education Especially on illegal wildlife trade and use for cultural purposes	**Not rated**	**Not rated**	**Not rated**	By ALPZA range area institutions, using individuals that are brought in as rescues – towards targeted audience.

Comments/Issues:

- Not confident the IUCN information about the species is current and/or accurate; current information is needed.
- Very restricted range (between Andes and the ocean).
- Little known about the species.
- Come into ALPZA zoos in range areas as rescued individuals; tend not to breed with these individuals (many are permanently contracepted).

Workshop Recommendations:

1. A proactively managed *ex situ* population inside or outside of range countries is not recommended currently. If status in the wild changes, there are animals within ALPZA to potentially start a formal program.
2. Recommended that ALPZA encourage local zoos that receive rescued individuals to:
   - Conduct conservation education to targeted audiences about illegal wildlife trade and use for cultural purposes.
   - Attempt limited breeding and develop/document husbandry practices to better understand species biology and husbandry requirements; because this species lives in a different ecotype it is not known if there is another “fox model” for this taxon – their husbandry requirements may be different. It would be valuable to have this established in case *in situ* work shows them to more severely threatened than previously thought.
3. Both ALPZA and other regions: encourage and support/fund field studies for this species to more confidently understand their current status (and biology).

SHORT-EARED DOG
Atelocynus microtis

THREATENED SPECIES
IUCN Red List: Near Threatened
Population trend: Declining

Scattered distribution in South America, from Colombia to Bolivia and Ecuador to Brazil. Favors undisturbed rainforests in the Amazonian lowlands.

__Threats__: Major threats are habitat loss (especially due to large-scale conversion in Amazonia), prey base depletion from hunting, and disease. No reports of widespread persecution.

__Potential Ex Situ Roles__: No responses for this species prior to the workshop.

__Prior Ex Situ Recommendations__:
1992 CAMP: Recommendation to develop a Nucleus I population (50-100 animals), with the goal to retain 90% GD for 100 years, assuming periodic immigration from the wild.

__Ex Situ Status__:
Not represented in captivity in ZIMS database or surveyed regional zoo associations. Past holdings and breeding in the US and France (1970s).

__Workshop Assessment of Ex Situ Roles and Activities__:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:
- There is some doubt/uncertainty whether the species is as rare as previously thought and whether it is "declining" or not. Identification in many camera trap studies. This species has a much broader range than Sechura fox. More *in situ* information is needed.
- Broad range in Amazon, but little known about this species.
- No one known to be currently working with this species *in situ*.
- No record of them recently in *ex situ* institutions, except for one in Lima, Peru several years ago.

__Workshop Recommendations__:
No *ex situ* population or role identified at this time; should re-evaluate if status in the wild changes.

ARCTIC FOX
Alopex lagopus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Circumpolar distribution in all Arctic tundra habitats. Most populations fluctuate widely between years in response to varying lemming numbers. Global population of several 100,000 animals.

Threats: Hunting for fur is a major mortality factor. May be affected by indirect threats such as disease and persistent organic pollutants if connected to marine ecosystems.

Potential Ex Situ Roles:
Education: Climate change.

Ex Situ Status:
Present in captivity in 2 regions in significant numbers (global *ex situ* population = 155 animals). Reproduction in captivity.

	AZA / North America	ALPZA / Latin & So America	EAZA / Europe	PAAZA / Africa	SEAZA / SE Asia	JAZA / Japan	Total Global *Ex Situ* Pop
Population size (M.F.U)	**64 (26.38)**	**1 (0.1)**	**75 (33.41.1)**	**1 (1.0)**	**10 (3.7)**	**4 (2.2)**	**155[1] (65.89.1)**
Living wild-born animals	?	?	?	?	?	?	6[2]
Gene diversity	?	?	?	?	?	?	?
# Founders	?	?	?	?	?	?	17[2]
# Potential founders	?	?	?	?	?	?	?
% pedigree known	?	?	?	?	?	?	13%[2]
Population trend/ lambda	?	?	?	?	?	?	Increasing[2]
# institutions	29	1	29	1	1	1	62[1]
Management	Not managed	Not managed	Monitored EAZA program	No formal program	Not managed	No formal program	
Data source	*2016 ZIMS*	*2016 ALPZA report*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 JAZA report*	[1]*column sums;* [2]*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:

The following direct and indirect conservation roles were identified at the ICAP workshop:

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	Not rated	Not rated	Not rated	Climate change messaging
***In situ* support**	Not rated	Not rated	Not rated	For this species and other arctic species

Comments/Issues:

- Do not always make a good *ex situ* exhibit. Can be held in mixed species exhibits or outdoor exhibits in cold climates so does not necessarily take space away from priority species.
- EAZA and AZA have this species primarily for climate change educational messaging, but it is also a hardy cold tolerant small canid species.
- Small threatened subpopulation in Sweden and Norway, but this subspecies is not found in zoos.
- Arctic Fox Working Group exists within the IUCN SSC Canid Specialist Group, and there are *in situ* projects that zoos can to link to and/or provide resources for.

Workshop Recommendations:

1. A proactively managed *ex situ* population is not recommended currently; should re-evaluate if status in the wild changes.
   - AZA and EAZA should consider limiting population to a low number.
2. Institutions with this species should be encouraged to focus on climate change messaging.
3. Consider support of *in situ* projects.

BAT-EARED FOX
Otocyon megalotis

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Disjunct distribution across the arid and semi-arid regions of Eastern and Southern Africa.

Threats: No major threats, but subject to subsistence hunting for pelts or due to being perceived as predators of small livestock. Populations fluctuate due to disease (especially rabies and canine distemper) or drought (which depresses insect numbers).

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: Recommended for Nucleus II population (i.e., 25-100 animals, good management of existing *ex situ* population) as part of meta-population management (1992 CAMP).

Ex Situ Status:
Present in captivity in several regions (estimated global *ex situ* population = 164 animals). Reproduction in captivity with historical growth; recent stabilization/slight decline globally. Managed programs in AZA and EAZA, with inter-regional collaboration. Importations have occurred throughout the history of the captive program along with successful breeding since 1970. Bat-eared foxes can co-exist well with other species and are frequently used in African plains zoo exhibits.

	AZA / North America	EAZA / Europe	PAAZA / Africa	CZA / India	ZPO / Thailand	SEAZA / Singapore	JAZA / Japan	Total Global *Ex Situ* Pop
Population size (M.F.U)	**54 (26.28)**	**83 (42.38.3)**	**10 (6.4)**	**2 (1.1)**	**13 (6.7)**	**2 (1.1)**	**1 (0.1)**	**165[1] (82.80.3)**
Living wild-born animals	?	?	?	?	?	?	?	7[2]
Gene diversity	91.1%	89.3%	?	?	?	?	?	?
# Founders	20	11	?	?	?	?	?	65[2]
# Potential founders	0	4	?	?	?	?	?	4?[1]
% pedigree known	85%	100%	?	?	?	?	?	?
Population trend/ lambda	Stable (0.991)	Stable	?	?	?	?	?	Recent decline[2]
# institutions	25	34	3	1	2	1	1	67[1]
Management	SSP managed program	EEP managed program	Not managed	Not managed	No formal program	Not managed	Not managed	Cooperation btn EAZA and AZA
Data source	*2015 EAZA combined SB*	*2015 EAZA SB*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 JAZA report*	*[1]column sums; [2]2016 ZIMS*

M.F.U = # males.females.unknown sex

<u>Workshop Assessment of Ex Situ Roles and Activities</u>:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	**Not rated**	**HIGH**	**LOW**	Importance of species to ecosystem, and threats to African savannah habitats

Comments/Issues:

- AZA and EAZA share a studbook database. Pending an MOU between AZA and EAZA, this species will be cooperatively managed with the main population in EAZA and a satellite population in AZA.
- The population in EAZA is thought to have come from the same general area in the wild, which would suggest most (or all) are of the same subspecies. This is not necessarily true for the AZA animals, and subspecies should be confirmed for all AZA and EAZA animals. A project to do this is pending. Depending on the results, a decision will need to be made if the *ex situ* population will be managed at the species level or if *O.m. virgatus* and *O.m. megalotis* will be managed separately.
- This species has the highest Evolutionary Distinctiveness score among canids.
- Discussions with the IUCN SSC Canid Specialist Group and carnivore biologists based in Africa suggest there are no *in situ* projects currently focused on this species.
- Not clear what species could replace this species in existing bat-eared fox enclosures, since they are typically mixed with other species.
- Share same niche as black-backed jackals and other carnivores, so fill educational role relating to African ecosystems and savannah habitats well, especially as they can be exhibited in naturalistic mixed species enclosures.

<u>Workshop Recommendations</u>:

1. Continue to work towards collaborative management of the AZA and EAZA populations with the intent of managing jointly to create a small, efficient and sustainable population.
2. Identify specific conservation education messaging, and share the conservation message about this species, African ecosystems and savannah habitats, and the threats to both canids and hyaenids and their habitat.

BENGAL (INDIAN) FOX
Vulpes benegalensis

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Declining

Endemic to the Indian Sub-Continent (Bangladesh, India, Nepal, Pakistan)

Threats: Loss of habitat due to agricultural and industrial uses, along with disease risk, low population density, population fluctuations due to prey availability, and sensitivity to human modification of habitat, may cause local extinctions.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: Captive population recommended for education, research and husbandry; not needed for genetic or demographic contributions (1998 Mammals of India CAMP). Research is needed on disease transmission, species ecology, population dynamics and behavior (2004 CSG Action Plan).

Ex Situ Status:
Present in captivity only in India (global *ex situ* population = 7 animals listed in ZIMS). Not managed. Reproduction in captivity in India in the past.

	CZA / India	Total Global *Ex Situ* Pop
Population size (M.F.U)	**7 (3.4)**	**7 (3.4)**
Living wild-born animals	2	2
Gene diversity	?	?
# Founders	0	0
# Potential founders	2	2
% pedigree known	33%	33%
Population trend/ lambda	Stable	Stable
# institutions	4	4
Management	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- Assumed that there are more in India, but in non-ZIMS/CZA facilities.
- An *in situ* researcher is working with this species – K. Bauman will contact them to follow up and put them in touch with EAZA and CZA.
- An *ex situ* population was recommended twice for research - in 1998 for husbandry and disease, and in 2004 for disease transmission, species ecology, population dynamics and behavior - but with no specifics nor a researcher to lead these initiatives it is hard to justify building an *ex situ* population, especially when *ex situ* small canid spaces for Asian species are uncommon outside of the species range. Therefore, it is left up to CZA to consider during their regional planning.
- Need to follow up with CZA to try to get accurate *ex situ* numbers, including those animals in non-ZIMS/CZA facilities.
- Given the declining trend locally, continue to monitor if *in situ* research projects are needed in that region that may need support or resources from the *ex situ* community.

Workshop Recommendations:
No *ex situ* population or role identified at this time; should re-evaluate if status in the wild changes or CZA feels differently from their regional perspective.

BLANFORD’S FOX
Vulpes cana

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Disjunct distribution, in southwestern Asia and in arid mountainous regions in the Arabian Peninsula.

Threats: No obvious major threats range-wide. Habitat loss, due mainly to expanding settlement and tourism development, and human persecution and indirection mortality pose localized threats.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: Recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) as part of species meta-population (1992 CAMP). Recommendations were made for research on reproductive behavior and for education and awareness to raise the profile of the species (2000 Arabian Carnivore CAMP). Better understanding is needed regarding susceptibility to disease and role in disease transmission (Sillero-Zubiri *et al*. 2004).

Ex Situ Status:
Present in captivity primarily in the UAE (global *ex situ* population = 28 animals). Not managed. Reproduction in captivity in the past in the US and Europe in the 1970s and 1980s. Successful breeding in the past at the Breeding Centre for Endangered Arabian Wildlife (UAE), Tel Aviv University Zoo, and Hai Bar Breeding Centre (Israel).

	EAZA / Europe	AZAA/ UAE	Total Global *Ex Situ* Pop
Population size (M.F.U)	**2 (1.1)**	**26 (16.10)**	**28 (17.11)**
Living wild-born animals	?	?	5
Gene diversity	?	?	?
# Founders	?	?	22
# Potential founders	?	?	?
% pedigree known	?	?	85%
Population trend/ lambda	?	?	Increasing
# institutions	1	4	5
Management	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- Never in large *ex situ* numbers outside their native range, with successful breeding at institutions within UAE.
- *Ex situ* population is reputed to be used for educational messaging about local wildlife, and some recent research into life history characteristics and disease at the Breeding Centre for Endangered Wildlife (Sharjah, UAE).
- Focus for the *ex situ* population should remain in range countries.

Workshop Recommendations:
No *ex situ* role identified at this time; should re-evaluate if status in the wild changes or AZAA feels differently from their regional perspective.

CAPE FOX
Vulpes chama

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Widespread in the central and western regionals of Southern Africa (Angola, Botswana, Namibia, South Africa).

Threats: No major threats. Changing agriculture practices have resulted in range extensions, as has expansion of semi-arid karroid vegetation during desertification. Widespread illegal indiscriminate use of agricultural poisons on commercial farms pose the main threat.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: None

Ex Situ Status:
Present in captivity only in one facility in Europe (global *ex situ* population = 6 animals listed in ZIMS). Not managed. Some reproduction in captivity in Europe in the past.

	EAZA / Europe	Total Global *Ex Situ* Pop
Population size (M.F.U)	**6 (3.3)**	**6 (3.3)**
Living wild-born animals	4	4
Gene diversity	?	?
# Founders	?	?
# Potential founders	3?	3?
% pedigree known	67%	67%
Population trend/ lambda	Stable	Stable
# institutions	1	1
Management	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:
- Only six held globally – all in Europe, but EAZA has no additional information these individuals. EAZA has recommended that institutions not hold this species, and are planning to phase the species out to focus instead on fox species with recommended *ex situ* roles.

Workshop Recommendations:
No *ex situ* population or role identified at this time; should re-evaluate if status in the wild changes.

CHILLA (SOUTH AMERICAN GREY FOX)
Pseudalopex griseus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Widespread in the plains and mountains on both sides of the Andes in Chile and Argentina, South America. Introduced on Falkland Islands.

Threats: Main threat in the past was commercial hunting, but hunting intensity appears to have declined. Illegal trapping still occurs in some areas to control predation on small livestock. The species is hunted for its pelt.

Potential Ex Situ Roles: **Indirect Conservation: Education**
Given the poor representation of the Darwin's fox and other South America foxes in professional zoos across the world, it would be advisable to set up an *ex situ* program, especially focusing on the need to mitigate the conflicts between foxes and local ranchers, a widespread problem for all these foxes.

Prior Ex Situ Recommendations: Recommended for Nucleus II population in range states (i.e., 25-100 animals, good management of existing *ex situ* population) by 1992 CAMP.

Ex Situ Status:
Present in captivity only in South America (global *ex situ* population = 6 animals). Some reproduction in captivity.

	ALPZA / Latin & South America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**2(+4) (4.2)**	**2(+4) (4.2)**
Living wild-born animals	1 (1.0)	1 (1.0)
Gene diversity	?	?
# Founders	?	?
# Potential founders	?	?
% pedigree known	?	?
Population trend/ lambda	Declining	Declining
# institutions	2	2
Management	Not managed	
Data source	*2016 ALPZA report*	*2016 ALPZA report / ZIMS*

M.F.U = # males.females.unknown sex

**additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	**HIGH**	**MODERATE**	**LOW**	
Insurance	**Not rated**	**Not rated**	**Not rated**	Model species?
Research disease	**Not rated**	**Not rated**	**Not rated**	

Comments/Issues:
- Only in ALPZA – 4 according to survey, but a lot in South America that are not listed. No knowledge of them being prevalent in Brazilian zoos.
  - Similar to other fox species in South American zoos – they come in as rescues, and some are not able to be released back to the wild (political or veterinary reasons).
- Although rescued chilla in zoos are not typically turned in from same region as Darwin's fox (even though the two species are sympatric), chilla could be a possible model species for Darwin's fox (and other less common South American fox species), providing an opportunity to develop husbandry protocols and small canid expertise at those institutions.
  - Whether ALPZA zoos have this capacity since many of the chilla are confiscations with a required hold by local government would need to be evaluated. Whether chilla would be a suitable model species for ALPZA should be considered during regional planning.
- There is very little known about disease risk/prevalence and transmission in this species; potential for the *ex situ* population to provide samples for a disease ecologist based at a university within the species range.
- An education message about South American fox species in general and living with canids, especially in agricultural areas, should be encouraged for all institutions that have this species.

Workshop Recommendations:
1. A proactively managed *ex situ* population outside of range countries is not recommended currently; should re-evaluate if status in the wild changes.
2. There are animals within ALPZA to potentially start a formal program. ALPZA should consider if this species might be a suitable model species and how it best fits within their regional plan for canids.
3. Recommended that ALPZA encourage local zoos that receive rescued individuals to:
   - Conduct conservation education to targeted audiences about foxes and discuss methods of coexistence.
   - Attempt limited breeding and document husbandry practices.
   - Possibly utilize the *ex situ* population to address questions about disease prevalence.

CORSAC FOX
Vulpes corsac

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Unknown

Native to the arid steppes of Northern and Central Asia. Generally widespread and common species. Little population information. May fluctuate greatly over short time periods in response to climatic events and in response to intensive harvesting. Listed as Near Threatened on Mongolian Red List due to decline resulting from overhunting.

Threats: Primary threat is overharvesting. Species is hunted intensively for its pelt, both traditionally and commercially. Other threats include livestock overgrazing and landscape development (which may reduce habitat quality), domestic dogs and disease.

Potential Ex Situ Roles: **Indirect Conservation: Research, Education**
Small scale funding for research projects by the zoo community would be useful, especially in areas where the species is declining. Zoos could promote awareness of the species and steppe ecosystems in Asia, highlighting that once common species, like corsac foxes, are declining in some areas due to some extent to consumer choices in the West.

Prior Ex Situ Recommendations: None recommended (2004 CSG Action Plan)

Ex Situ Status:
Present in captivity only in Europe (global *ex situ* population = 65 animals listed in ZIMS). Not managed. Breeds well in captivity. Easily habituated to humans.

	EAZA / Europe	Total Global *Ex Situ* Pop
Population size (M.F.U)	**65 (32.30.3)**	**65 (32.30.3)**
Living wild-born animals	0?	0?
Gene diversity	?	?
# Founders	4	4
# Potential founders	0?	0?
% pedigree known	4%	4%
Population trend/ lambda	Increasing	Increasing
# institutions	15	15
Management	Monitored EAZA program	
Data source	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

<u>Workshop Assessment of Ex Situ Roles and Activities</u>:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	Not rated	HIGH	LOW	Importance of and threats to steppe ecosystem
***In situ* support**	Not rated	Not rated	Not rated	For this species and other Asian species

Comments/Issues:
- Held in EAZA and non-EAZA zoos in Europe, but currently this species does not occupy space that could be used for other species (kept in mixed species exhibits).
- Used for education messaging as a representative of Asian steppe habitat. May be the only species in EAZA zoos from this habitat type. Can deliver the message about the importance of steppe ecosystem, threats, and how even common species can decrease under threat conditions.
- There is an active field project in Mongolia that may benefit from *ex situ* collaboration and small scale fundraising.

<u>Workshop Recommendations</u>:
1. Institutions holding this species should share the conservation message about this species, the Asian steppe habitat, and the threats to both foxes and their habitat.
2. Consider linking with *in situ* projects.

CRAB-EATING FOX
Cerdocyon thous

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to north and eastern South America; relatively common throughout its range, occupying most habitats. No population estimates are available but thought to be stable.

Threats: Main potential threat, albeit localized, is pathogenic infection from domestic dogs (contact with dogs at human refuse dumps in Serra da Canastra National Park). Fur is short and coarse and of no commercial value.

Potential Ex Situ Roles: **Indirect Conservation: Education, Research**
Given the poor representation of the Darwin's fox and other South America foxes in professional zoos across the world, it would be advisable to set up an *ex situ* program, especially focusing on the need to mitigate the conflicts between foxes and local ranchers, a widespread problem for all these foxes. Teach differences between fox species and that some are threatened – opportunity for range state zoos. Research on genetics and epidemiology can be important because species is sympatric with other canids.

Prior Ex Situ Recommendations: Recommend phase out of captive program (1992 CAMP)

Ex Situ Status:
Present in captivity only in South America (global *ex situ* population = 26 animals). Breeds well in captivity. Present in many zoos and private collections through South America.

	ALPZA / Latin & South America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**22(+4) (14.12)**	**22(+4)[1] (14.12)**
Living wild-born animals	11	11[1]
Gene diversity	?	?
# Founders	7?	7?[2]
# Potential fdrs	4?	4?[2]
% pedigree known	61%?	61%?[2]
Population trend/ lambda	Stable?	Stable?[2]
# institutions	6	6
Management	Not managed	
Data source	*2016 ALPZA report & 2016 ZIMS*	*[1]2016 ALPZA report; [2]2016 ZIMS*

*M.F.U = # males.females.unknown sex. *additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	**MODERATE**	**HIGH**	**LOW**	
Research	**Not rated**	**Not rated**	**Not rated**	As needed to supplement existing publications

Comments/Issues:
- No data available at the time of the ICAP meeting for holdings in Brazilian zoos that do not belong to ALPZA, but known to be very common in Brazilian zoos.
- Should be replaced with a species of more conservation concern with a defined *ex situ* role, e.g., Sechura or hoary fox, where possible (some confiscated individuals are required to be held by law).
- Active exhibit species, so good opportunity to educate guests (and guests love them).
- Research colony at the National Zoo in the late 1970s and 1980s, so husbandry should be well worked out for this species. There are many publications on this species, including spatial and disease ecology, diet, reproduction, vocalizations, natural history, and a few genetic studies. Question was posed as to whether researchers and zoo staff in range countries have easy access to these publications, if not, could those be provided to ALPZA as a resource?

Workshop Recommendations:
1. A proactively managed *ex situ* population is not recommended currently; should re-evaluate if status in the wild changes.
2. For the animals existing within ALPZA and Brazilian zoos, and rescue foxes:
   - If ability to change this species for another species exists, replace with another South American fox species of greater conservation concern.
   - If the ability to change is not legally allowed, then utilize the species for conservation education (to targeted audiences) about foxes and discuss methods of coexistence.
   - Utilize the *ex situ* population on an 'as needed' basis to address research questions not currently in the scientific literature, such as genetics or additional epidemiological questions.

CULPEO FOX
Pseudalopex culpaeus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to the Andes and hilly regions of South America (Argentina, Bolivia, Chile, Ecuador, Peru); largest fox.

Threats: Main threats are hunting and trapping for fur and persecution to reduce predation on livestock and poultry. Appears to withstand intensive hunting with the ability to rebound when hunting pressure is reduced. Predation by feral and domestic dogs may be a problem in some areas.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: None

Ex Situ Status:
Present in captivity only in South America (global *ex situ* population = 22 animals). Reproduction in captivity. Common in zoos in Chile and Argentina.

	ALPZA / Latin & South America	Total Global Ex Situ Pop
Population size (M.F.U)	**21(+1) (12.9)**	**21(+1) (12.9)**
Living wild-born animals	7 (4.3)	7 (4.3)
Gene diversity	?	?
# Founders	?	?
# Potential founders	?	?
% pedigree known	?	?
Population trend/ lambda	Increasing	Increasing
# institutions	5	5
Management	Not managed	
Data source	*2016 ALPZA report*	*2016 ALPZA report / ZIMS*

M.F.U = # males.females.unknown sex

**additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	**MODERATE**	**HIGH**	**LOW**	Importance of foxes and mitigation of threats
***In situ* support**	**Not rated**	**Not rated**	**Not rated**	For this species and other South American species

Comments/Issues:

- Common in zoos in Chile and Argentina.
    - Many are rescues and they are neutered or contracepted right away.
- High exhibit value given regional pride for this great species.
- Its size and charismatic nature provides a connection with guests, so the opportunity to utilize this species for education about foxes in general and/or conservation action that is needed, e.g. Darwin's fox, is high.
- Mange in domestic dogs affects culpeo foxes in wild.
    - Education about pet responsibility is a key message for this species.
- Potential role: capacity building to establish husbandry protocols and staff training but could do that with other species.
- Currently only a few *in situ* projects on this species being conducted within range countries.

Workshop Recommendations:

1. A proactively managed *ex situ* population is not recommended currently; should re-evaluate if status in the wild changes.
2. For the animals existing within ALPZA, and rescue foxes:
    - Utilize the species for conservation education (to targeted audiences) about conservation action for Darwin's fox and about South American foxes in general, focusing on methods of coexistence and responsible pet ownership (reduce disease transmission from domestic dogs).
3. Consider linking to *in situ* projects.

FENNEC FOX
Vulpes zerda

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to sandy deserts and semi-deserts of North Africa; smallest fox.

Threats: No known major range-wide threats causing population decline. Vulnerable to road kill with new construction. Trapped for exhibition or sale to tourists locally. New permanent human settlements may lead to local disappearance. Disturbance due to oil and gas drilling may become a future threat.

Potential Ex Situ Roles: **Indirect Conservation: Research, Education**
Studies of reproduction, nutrition, disease and genetics in captivity have helped better understand species biology. These projects also have helped develop and validate techniques for use with other fox species, such as the Darwin's fox. Zoos have sponsored field projects through WildCRU and Sahara Conservation Fund (SCF) for this little known species. Captive fennec foxes are charismatic education animals and valuable for illustrating canid biology and ecology, taxonomic differences in canids, and desert adaptations and ecosystems. Opportunities exist for an integration of *in situ* and *ex situ* strategies for this species.

Prior Ex Situ Recommendations: Recommended for Nucleus II population (i.e., 25-100 animals, good management of existing *ex situ* population) as part of meta-population management (1992 CAMP).

Ex Situ Status:
Present in captivity in almost all regions, with large populations in North America and Europe (estimated global *ex situ* population = 356 animals). Reproduction in captivity.

	AZA / North America	EAZA / Europe	PAAZA / Africa	ZPO / Thailand	SEAZA / SE Asia (excl. ZPO)	JAZA / Japan	ZAA / Australasia	Total Global *Ex Situ* Pop
Population size (M.F.U)	**146 (80.66)**	**150 (81.69)**	**4 (1.3)**	**9 (5.3.1)**	**4 (2.2)**	**30 (16.14)**	**13 (6.7)**	**356[1] (191.164.1)**
Living wild-born animals	?	?	?	?	?	?	?	21[2]
Gene diversity	93.8%	92.8%	?	?	?	?	?	?
# Founders	24	19	?	?	?	?	?	42[2]
# Potential fdrs	4	?	?	?	?	?	?	4+[1]
% pedigree kn	89%	53%	?	?	?	?	?	22+%[2]
Population trend/ lambda	1.08	1.03	?	?	?	?	?	Increasing[2]
# institutions	45	49	2	1	2	10	6	115[1]
Management	SSP managed	ESB managed	Not managed	No formal program	Not managed	No formal program	Not managed	
Data source	*2015 AZA B&T plan*	*2015 EAZA Regional SB*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 JAZA rpt*	*2016 ZIMS*	*[1]column sums; [2]2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	**HIGH**	**HIGH**	**LOW**	Importance of the Saharan ecosystem and threats; charismatic ambassador species for threatened species native range
Research	**MODERATE**	**HIGH**	**LOW**	Model for other fox species; much has already been accomplished, more could be done
***In situ* support**	Not rated	Not rated	Not rated	For this species and other North African species
Insurance	Not rated	Not rated	Not rated	Only *ex situ* desert fox species with good numbers and gene diversity

Comments/Issues:

- In Niger, at 2009 field study site, suggestion that increased oil and gas mining may have a negative effect; how significant an effect has not yet been quantified.
  - AZA and EAZA raised funds for the first ever field project of this species (and other Saharan small carnivores) in Niger.
  - The fennec has been utilized in garnering public interest in critically endangered species in the same region, e.g. addax.
- PAAZA numbers are not accurate; AZAA (Arabian Zoo and Aquarium Association) have fennecs that may not be included in the EAZA numbers – need to verify numbers to obtain an accurate global census.
- EAZA and AZA should discuss a target population size suitable for both regions with AZA likely reducing numbers some in the next 5 years.
- Model species for other fox species in zoos, especially in areas of husbandry and research (reproduction and behavior).
- Can be charismatic display and very popular education species (in AZA).
- Fennec spaces could possibly be used in the future for other species that are of a higher priority; in the meantime, knowledge can be gained.
  - Some spaces, especially those used for fennecs in an educational role in AZA, may not be easily exchangeable for other species (indoor only and/or size).

Workshop Recommendations:

1. The global *ex situ* population should be evaluated strategically to make sure that spaces and animals are managed effectively among the regions.
2. Zoo associations should work with the Sahara Conservation Fund, IUCN SSC Canid Specialist Group, and other regional zoo association Taxon Advisory Groups to develop a comprehensive, targeted educational program that can reach both range country and outside audiences and can be utilized for all species of desert fox and threatened Saharan species, e.g., addax, scimitar horned oryx, cheetah, red necked ostrich, vulture spp., etc.
3. Support *in situ* research, as so little is known about this species (and all Saharan carnivores), and continue to utilize the *ex situ* population to address research questions (for fennecs and other fox species), as needed.

GREY FOX
Urocyon cineroargenteus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Ranges from southern Central and Eastern Canada through much of the US and Central America to northern South America. Common in habitat less densely populated by humans or edge of urban settlements, where it is not excluded by other predators (coyotes and bobcats).

Threats: Habitat loss, fragmentation, and degradation may be problematic in regions of rapid human population growth with resulting habitat conversion to agricultural, industrial and urban uses.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: Recommend to phase out captive population (1992 CAMP).

Ex Situ Status:
Present in captivity in 2 regions (global *ex situ* population = 48 animals). Not managed. Reproduction in captivity. Common on display at wildlife farms and in private collections. Fare well in captivity.

	AZA / North America	ALPZA / Latin & South America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**40 (21.17.2)**	**6(+2) (4.4)**	**48[1] (25.21.2)**
Living wild-born animals	?	3	36[2]
Gene diversity	?	?	?
# Founders	?	?	5[2]
# Potential founders	?	?	31?[2]
% pedigree known	?	?	74%[2]
Population trend/ lambda	?	?	Stable[2]
# institutions	22	4	26[1]
Management	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ALPZA report*	[1]*Column sums;* [2]*2016 ZIMS*

M.F.U = # males.females.unknown sex

**additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- Strong suspicion that the ZIMS numbers for North America reflect primarily non-AZA institutions; guess for AZA is 20-25 grey foxes, but an AZA-wide survey for canid and hyaenids is scheduled in 2017 so exact numbers will be known then.
- Very common species in nature, but very little known about the species so the *ex situ* population could provide information for research projects, if needed.
- Hard to justify holding this species beyond facilities within its range. Even within the range questionable role for conservation, if not tied to island or another threatened fox species.
- Only conservation purpose might be as a representative for grey fox in general (*Urocyon cineroargenteus* AND *Urocyon littoralis*):
    - Could try to strategically place them where they could be transitioned to Island fox, if needed in the future.
        - May be a good "starter fox" for new institutions to hold before getting island foxes.
    - Look similar, but not identical to Island fox.
    - Could also be effective surrogate for Island fox educational messaging.

Workshop Recommendations:
No *ex situ* population or role identified at this time; should re-evaluate if status in the wild changes or AZA feels differently from their regional perspective.

HOARY FOX
Pseudalopex vetulus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Unknown

Native to the cerrado habitats of central Brazilian plateau and peripheral transitional zones.

Threats: No major threats at this time. Habitat loss of cerrado is 3% per year primarily due to agriculture; however, foxes may adapt to livestock pasture. Deforestation possibly not to have negative impact but requires monitoring.

Potential Ex Situ Roles: **Indirect Conservation: Research, Education:** Little known about this species (2004 CSG Action Plan). Research on reproduction, health, epidemiology and physiology needed. Little known to society – awareness.

Prior Ex Situ Recommendations: Recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) as part of species meta-population (1992 CAMP). No plans to reintroduce this species as of 2004 (CSG Action Plan).

Ex Situ Status:
Not represented currently in captivity in ZIMS database or surveyed regional zoo associations. Past holdings and reproduction in Brazil in the 1990s (ZIMS). Past *ex situ* population had high pup mortality possibly due to starvation (2004 CSG Action Plan).

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop:

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
***In situ* support**	Not rated	Not rated	Not rated	For this species and other South American species
Insurance	Not rated	Not rated	Not rated	

Comments/Issues:
- Although there are no records of this species in zoos currently (ZIMS or ALPZA member zoos), R. Cunha de Paula reported that a recent survey of Brazilian zoos (non-ALPZA members) listed 9 individuals (all rescues).
- Hoary foxes are often confused with the pampas fox.
- There are several studies of this species ongoing in the wild, being conducted primarily by Brazilian scientists. There is some evidence of population decline, and there is a proposal to change the species’ status to Near Threatened (pending).
- There has been interest expressed in establishing an insurance population in Brazilian zoos.

Workshop Recommendations:

1. A proactively managed *ex situ* population outside of range countries is not recommended currently; should re-evaluate if status in the wild changes.
2. There are animals in Brazilian zoos to potentially start a formal program. The Brazilian Zoo Association and ALPZA should consider if this species might be a suitable model species and how it best fits within their regional plans for canids.
3. Support of *in situ* projects through funding and other resources.

KIT FOX
Vulpes macrotis

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Declining

Native to western US and Mexico (North America). San Joaquin subspecies is only found in California

Threats: Main threat to long-term survival is habitat conversion, mainly to agriculture but also to urban and industrial development. Population densities fluctuate with annual environmental conditions. Populations of the Endangered (USFWS) San Joaquin kit fox subspecies are likely still declining due to continuing habitat loss, fragmentation and degradation.

Potential Ex Situ Roles: **Direct Conservation: Conservation Education**
Indirect Conservation: Funding, Expertise. Assistance in treating and rehabilitating San Joaquin kit foxes afflicted with sarcoptic mange (active epidemic). Expertise and funding for this effort.

Prior Ex Situ Recommendations: Recommended for Nucleus II population (i.e., 25-100 animals, good management of existing *ex situ* population) for the species in general. San Joaquin subspecies is recommended for Nucleus I population (50-100 animals with GD ≥98%, requiring periodic immigrants from wild) as part of species meta-population (1992 CAMP). Research on the San Joaquin kit fox subspecies is very active.

Ex Situ Status:
Present in captivity only in the US (global *ex situ* population = 15 animals listed in ZIMS). Not managed. Reproduction in captivity since the 1960s.

	AZA / North America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**15 (9.6)**	**15 (9.6)**
Living wild-born animals	12	12
Gene diversity	?	?
# Founders	6	6
# Potential founders	10?	10?
% pedigree known	100%	100%
Population trend/ lambda	Stable	Stable
# institutions	6	6
Management	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

<u>Workshop Assessment of Ex Situ Roles and Activities</u>:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education In range	**HIGH**	**HIGH**	**LOW**	For endangered San Joaquin subspecies; discuss effect of habitat loss/conversion
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
***In situ* support**	**HIGH**	**HIGH**	**LOW**	Zoos can provide expertise and resources and assistance for injured or sick individuals
Education Out of range	**HIGH**	**HIGH**	**LOW**	For endangered San Joaquin subspecies; discuss effect of habitat loss/conversion

Comments/Issues:

- Climate change and alternate energy implementation in current range could lead to species becoming of concern in the future.
- If an insurance population is required in the future, it could compete for space with swift foxes, but they have similar husbandry so we would be well positioned, if needed.
- An *ex situ* population of kit foxes is not required to discuss the educational messaging about this species regarding the threat from habitat loss/conversion to agriculture; swift fox (or other fox species) can be utilized for this.
- There is some question if the 15 kit foxes in North America are in AZA zoos. If they are, they may be part of rescue/rehabilitation programs in AZA zoos in California. This will be determined during the AZA-wide survey for canid and hyaenids scheduled in 2017.
- AZA zoos have the resources and expertise to assist with field-based animal needs, a point person should be identified to assist with these requests, as is being done with Island and Sierra Nevada red fox.

<u>Workshop Recommendations</u>:

1. A proactively managed *ex situ* population is not recommended currently; should re-evaluate if status in the wild changes.
2. For the animals existing within AZA, and rescue foxes:
    - o Investigate the possibility of shifting any AZA kit foxes in zoos to swift fox. Any remaining kit foxes should be within the range states, and combine holding this species with direct education and connection to the wild population through assistance with expertise and resources.
3. AZA should work with the IUCN SSC Canid Specialist Group Swift and Kit Fox Working Group to develop a comprehensive, targeted educational program that can reach both range states and outside audiences and can be utilized for both species.
4. As needed, AZA should work to provide resources for *in situ* efforts.

PALE FOX
Vulpes pallida

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Unknown

Native to semi-arid Sahel of Africa, bordering the Sahara to the north.

Threats: No major threats known, although they may be persecuted locally. Road kills and disturbance due to oil and gas drilling might become a future threat. Locally common.

Potential Ex Situ Roles: **Indirect Conservation: Research**
One of the least understood canids (2004 CSG Action Plan). Recent field research in Niger from WildCRU and Sahara Conservation Fund (SCF) sponsored by zoos (in connection with fennec fox project).

Prior Ex Situ Recommendations: None

Ex Situ Status:
Not represented in captivity in ZIMS database or surveyed regional zoo associations.
Past holdings in Europe (1960s).

Workshop Assessment of Ex Situ Roles and Activities:
No direct and or indirect conservation roles were identified at the ICAP workshop.

Comments/Issues:

- This is one of the least studied canids, but studies are difficult to conduct in many of the countries within the species' range for political and safety reasons; this is also true for fennec fox, which co-exists in most areas where the pale fox is found.
- Where possible, research for this species should be coupled with studies of other sympatric canids or focused on desert carnivores, as so little is known about all of these species.
  - A good example of this is the project WildCRU conducted in Niger (~2009-2011) in collaboration with the Sahara Conservation Fund; this project was organized and funded by zoos in AZA and EAZA, and included radio-collaring and monitoring of pale, fennec and Ruppel's foxes along with sand and African wild cats.
- Conservation education messaging about North Africa, the Sahara, and/or desert-adapted species should include this species, e.g., using fennec fox or addax as proxy, but an *ex situ* population is not needed at this time.

Workshop Recommendations:

1. No *ex situ* population or role was identified at this time; should re-evaluate if status in the wild changes.
2. Support *in situ* research as so little is known about this species (and all Saharan carnivores).

PAMPAS FOX
Pseudalopex gymnocercus

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Increasing

Native to South America (Argentina, Bolivia, Brazil, Paraguay, Uruguay). Tolerant of human disturbance and common rural areas, where introduced exotic mammals may form the bulk of its diet.

Threats: Non-selective control measures promoted by ranchers represent a threat to this species as well as bounty systems in the absence of scientific study on population dynamics and human impacts. Direct persecution is common even where illegal. The species appears to have adapted to massive habitat alteration throughout its range.

Potential Ex Situ Roles: **Indirect Conservation: Education, Research**
Given the poor representation of the Darwin's fox and other South America foxes in professional zoos across the world, it would be advisable to set up an *ex situ* program, especially focusing on the need to mitigate the conflicts between foxes and local ranchers, a widespread problem for all these foxes. Teach differences between fox species and that some are threatened – opportunity for range state zoos. Research on genetics and epidemiology can be important because species is sympatric with other canids. Taxonomic identification may be required in captivity because often confused with other species such as crab eating fox and hoary fox.

Prior Ex Situ Recommendations: 2004 CSG Action Plan notes that research is needed, as species ecology is largely unknown and taxonomy needs to be resolved.

Ex Situ Status:
Present in captivity only in South America (global *ex situ* population = 3 animals). The IUCN Red List notes that the species has been successfully bred in captivity in Argentina and (in 1999) was the best represented carnivore species in captivity in the country.

	ALPZA / Latin & South America	Total Global *Ex Situ* Pop
Population size (M.F.U)	**3 (1.2)**	**3 (1.2)**
Living wild-born animals	3	3
Gene diversity	--	--
# Founders	--	--
# Potential founders	3	3
% pedigree known	--	--
Population trend/lambda	Stable	Stable
# institutions	2	2
Management	Not managed	
Data source	*2016 ALPZA report*	*2016 ALPZA report / ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:

The following indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Research genetics	Not rated	Not rated	Not rated	To identify individuals in collections as well as address questions about hybridization and taxonomy
Education	Not rated	Not rated	Not rated	
Insurance	Not rated	Not rated	Not rated	Model species?
***In situ* support**	Not rated	Not rated	Not rated	For this species and other South American species

Comments/Issues:

- There are more individuals in South American zoos than what was found in ZIMS and the ALPZA survey. R. Cunha de Paula reports there are at least 20 in Brazilian zoos (non-ALPZA members).
- Frequently misidentified as crab-eating and hoary foxes (or the reverse); there is some suspicion that pampas and hoary foxes species can hybridize.
  - Research is needed to investigate this as well as other taxonomic issues.
- Although pampas foxes are not sympatric with Darwin's foxes, they could be a possible model species for Darwin's fox or other less common South American fox species, providing an opportunity to develop husbandry protocols and small canid expertise at those institutions.
  - Chilla may be a better choice for this.
- Individuals in zoos should be utilized to promote educational messaging about the diversity of South American fox species and co-existence with humans, especially in agricultural and ranching areas.
- There is very little known this species.
  - Potential for the *ex situ* population to provide samples for research conducted at a university within the species range should be considered. However, individuals in zoos should be definitively identified (may require genetic testing) prior to any sample/data collection.
  - Support for *in situ* projects could be beneficial.

Workshop Recommendations:

1. Survey presence in zoos in Brazil and other range countries (non-ALPZA facilities) so we have accurate global *ex situ* numbers for this species, especially given the fact pampas fox can be misidentified.
2. A proactively managed *ex situ* population outside of range countries is not recommended currently; should re-evaluate if status in the wild changes.
3. There are animals in zoos to potentially start a formal program. The Brazilian Zoo Association (SZB) and ALPZA should consider if this species might be a suitable model species and how it best fits within their regional plans for canids.
4. For individuals currently in zoos, institutions should be encouraged to:
   - Promote education educational messaging about the diversity of South American fox species, co-existence with humans, especially in agricultural and ranching areas.
   - Participate in research, as needed.
   - Support *in situ* projects through funding and other resources.

RACCOON DOG
Nyctereutes procyonoides

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to North and East Asia, including Japan; widely introduced into Europe.

Threats: Road kills, persecution, government attitudes, disease epidemics (scabies, distemper and rabies), and pollution are the major threats to the species across it range. Commercially farmed for fur in Finland.

Potential Ex Situ Roles:
Education: Regional/range state level management.

Ex Situ Status:
Present in captivity in 3 regions (global *ex situ* population = 300 animals). Reproduction in captivity. Japan maintains mostly Japanese subspecies *N.p. viverrinus* (n=138).

	EAZA / Europe	SEAZA / Southeast Asia	JAZA / Japan	Total Global *Ex Situ* Pop
Population size (M.F.U)	**137 (66.51.20)**	**8 (2.6)**	**155 (71.84)**	**300[1] (139.141.20)**
Living wild-born animals	19	?	14+	33+[1]
Gene diversity	?	?	?	?
# Founders	11	?	?	11+[1]
# Potential founders	8?	?	?	?
% pedigree known	24%	?	?	?
Population trend/ lambda	Increasing	?	Stable?	Increasing[2]
# institutions	41	1	40	82[1]
Management	Not managed	Not managed	No formal program	
Data source	*2016 ZIMS*	*2016 ZIMS*	*2016 JAZA report*	*[1]column sums; [2]2016 ZIMS*

M.F.U = # males.females.unknown sex

<u>Workshop Assessment of Ex Situ Roles and Activities</u>:
No potential *ex situ* conservation roles were identified at the ICAP workshop.

Comments/Issues:

- Taxonomy (subspecies) may be an issue, especially outside of Japan.
- The raccoon dog is under consideration to be added to the EU's list of alien invasive species and therefore is being phased out in EAZA/European zoos. EAZA should coordinate with JAZA to ensure that any individuals from EAZA needed for the JAZA population are made available during the phase out.
- Spaces currently occupied by raccoon dogs in European zoos are appropriate for cold-tolerant species (perhaps bush dogs or non-canid small carnivores).

<u>Workshop Recommendations</u>:

1. Phase out raccoon dogs in European zoos (in consultation with JAZA).
2. Identify cold-tolerant species that could replace raccoon dogs in European zoos (consult with Small Carnivore TAG regarding potential replacements).
3. Defer to JAZA on the regional decision how to manage this native species within Japanese zoos.

<u>Supporting Documents</u>

http://ec.europa.eu/environment/nature/invasivealien/index_en.htm

RED FOX
Vulpes vulpes

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Distributed across the entire northern hemisphere from the Arctic Circle to North Africa, Central America, and the Asiatic steppes. Introduced to Australia and New Zealand. Widest geographic range of any carnivore. Opportunistic and well adapted to agricultural and urban areas. Currently not under threat.

Threats: Main threats include habitat degradation, loss and fragmentation, exploitation, and direct and indirect persecution.

Potential Ex Situ Roles: *Identified only for the Sierra Nevada red fox (V.v. necator)*
Direct Conservation: Captive Breeding. This sub-species is in need of consideration for conservation interventions, potentially including *ex situ* breeding and translocations. A Sierra Nevada red fox conservation working group has been formed, including representatives of land and wildlife management agencies and academic institutions, and they are beginning a conservation strategy that will incorporate assessing the feasibility of such actions. Breeding could be at zoos or in species range.
Indirect Conservation: Capacity Building, Fundraising, Lobbying and Legislation. Zoos potentially can: provide knowledge, experience or training to build capacity for captive breeding; fundraising to contribute to high priority *in situ* projects; and networking and lobbying to influence opinions and legislation.

Prior Ex Situ Recommendations: Recommend phase out of captive populations (1992 CAMP).

Ex Situ Status:
Present in captivity in most regions (estimated global *ex situ* population = 389+ animals). Reproduction in captivity. Japan maintains mostly Japanese subspecies *V.v. japonica* (n=44). Widely kept in fur farms, small wildlife parks and zoos. Extremely shy and therefore often poor exhibit animals.

	AZA/North America	ALPZA/Latin & So Amer	EAZA / Europe	PAAZA / Africa	JAZA / Japan	KAZA/South Korea	Others ZPO & ZAA	Total Global *Ex Situ* Pop
Population size (M.F.U)	**94 (50.44)**	**6 (4.2)**	**178 (85.63.30)**	**9 (1.0.8)**	**48 (25.23)**	**46 (15.22.9)**	**8 (4.4)**	**389[1] (184.158.47)**
Living wild-born	?	?	?	?	?	?	?	129+[2]
Gene diversity	?	?	?	?	?	?	?	?
# Founders	?	?	?	?	?	?	?	39[2]
# Potential fdrs	?	?	?	?	?	?	?	?
% pedigree kn	?	?	?	?	?	?	?	45%[2]
Pop trend	?	?	?	?	?	?	?	Increasing[2]
# institutions	49	1	49	1	23	1	2	126[1]
Management	Not managed	Not managed	Not managed	Not managed	Not managed	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 JAZA report*	*2016 ZIMS*	*2016 ZIMS*	[1]*column sums* [2]*2016 ZIMS*

*M.F.U = # males.females.unknown sex; *additional contracepted individuals indicated in ()*

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified for the Sierra Nevada sub-species at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education In range	**HIGH**	**MODERATE**	**LOW**	For Sierra Nevada red fox sub-species
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Education Outside range	**HIGH**	**MODERATE**	**LOW**	For Sierra Nevada red fox sub-species
***In situ* support**	**HIGH**	**MODERATE**	**LOW**	Zoos can provide expertise and resources as needed

Comments/Issues:

- Strong suspicion that the ZIMS numbers for North America reflect primarily non-AZA institutions; the estimate for AZA is 25-40 red foxes, but a AZA-wide survey for canid and hyaenids is scheduled in 2017 so exact numbers will be known then.
- EAZA has a large population; they had already planned to recommend a phase-out in order to use those spaces for another small canid species with higher conservation need.
- Recently discovered Sierra Nevada subspecies is apparently in steep decline and the newly formed working group would like an *ex situ* population. This would not be a rescue situation, but more of a population restoration.
  - Questions exist about the feasibility of this request given the restrictions imposed by California Department of Fish and Game for threatened species and what has been the history of the Island fox program in that state.
  - Very little information was known about the specific needs at the time of the ICAP meeting, which is why feasibility is listed as moderate.
- Generally a challenging species to have in zoos as they are skittish, nervous, and shy. Reproduction does occur with the proper husbandry conditions. Note there is some overlap in husbandry knowledge with swift fox.
- Hard to justify holding this species beyond facilities within its range. Even within the range questionable role for conservation, if not tied to newly discovered subspecies in decline (Sierra Nevada red fox).
- An *ex situ* population of red fox is not required to discuss the educational messaging about this species or the Sierra Nevada subspecies; other canids can be utilized for this.
- AZA zoos have the resources and expertise to assist with the request for assistance from the Sierra Nevada Working Group to mitigate threats to this subspecies. A point person should be identified to assist with these requests, as has being done with Island and kit fox.

Workshop Recommendations:

1. Not recommended as an *ex situ* program at this time unless status in the wild changes.
2. Specific to the Sierra Nevada red fox subspecies, AZA should name a point person located at an AZA zoo in California to be the point of contact for the Sierra Nevada Red Fox Working Group. Resources and expertise should be provided as needed to this group.
3. Educational messaging should be targeted in California about the Sierra Nevada red fox subspecies.

SAND (RUPPELL'S) FOX
Vulpes rueppellii

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to desert and semi-desert regions of North Africa and mountains and fringes of the Sahara Desert. Thinly distributed across the Arabian Peninsula.

Threats: Direct and indirect persecution by hunting and indiscriminate use of poisons. In some regions, displaced by expanding red fox populations with human settlements.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: Maintain captive breeding populations in the UAE for public awareness and education (2000 Arabian Carnivore CAMP).

Ex Situ Status:
Present in captivity in 2 regions (global *ex situ* population = 49 animals). Not formally managed. Some reproduction in captivity in the region.

	EAZA (Europe) Other than UAE	AZAA/ EAZA In UAE	Total Global *Ex Situ* Pop
Population size (M.F.U)	**7 (3.4)**	**42 (20.22)**	**49 (23.26)**
Living wild-born animals	?	?	1
Gene diversity	?	?	?
# Founders	?	?	26
# Potential founders	?	?	?
% pedigree known	?	?	34%
Population trend/ lambda	?	?	Increasing
# institutions	1	4	5
Management	Not managed	No formal program	
Data source	*2017 ZIMS*	*2017 ZIMS*	*2017 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following indirect conservation role was identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	Not rated	Not rated	Not rated	Focus on in-range conservation messages

Comments/Issues:
- There was some question regarding the *ex situ* numbers listed, as most EAZA animals are physically located in UAE. Update: ZIMS (April 2017) shows 7 (3.4) at one EAZA-member facility in Spain and 42 in the UAE (updated numbers are presented in the table).
- This species is used for public awareness and education in the UAE (its native range).
- Conservation education focus should be on in-range education messages.
- Little attention is paid to North African habitats and animals in North American zoos; potential to collaborate with other TAGs (e.g., felids, antelope, etc.) on messaging.

Workshop Recommendations:
1. Encourage AZAA (Arabian Zoo and Aquarium Association) to continue to manage and address local education messages as they deem appropriate.
2. Encourage conservation messages for North African species and habitat (similar conservation message as for fennec fox). Perhaps collaborate with other TAGs (e.g., felids, antelope) on this.
3. Do not acquire in zoos outside of native range (UAE) unless status in the wild changes.

SWIFT FOX
Vulpes velox

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to short-grass and mixed-grass prairies of the Great Plains in North America. Populations are fragmented over much of its distribution. Extirpated from Canada by 1938; reintroductions since 1983 have established a small population in Alberta and Montana (sourced from captive breeding programs as well as wild-to-wild translocations). Reintroductions are being implemented in South Dakota and Montana.

Threats: Ongoing conversion of grassland prairies to cropland threatens to reduce and further fragment populations, primarily through impacts on prey availability, increased vulnerability of foxes to predation, and interspecific competition with other carnivores. Oil and gas development, urbanization, changes in farming practices and other ongoing habitat and land use changes are likely to negatively impact this prairie specialist species. Knowledge gap in disease transfer between sympatric canids (wild and domestic).

Potential Ex Situ Roles:
Direct Conservation: Conservation Education. Conservation education focused on landowners and managers in the prairies could increase the ability to successfully recover this species (viewed negatively as a nuisance).
Indirect Conservation: Education, Surrogate. Conservation education for zoo visitors could have a positive impact on swift fox recovery by enhancing understanding that the species is beneficial to regional biodiversity and to crop-growers by consuming insects and rodents. Non-releasable foxes are suitable for education programs and for gaining husbandry experience. Foxes from secure or increasing populations could serve as a surrogate for research applying to rarer fox species.

Prior Ex Situ Recommendations: Recommended for Nucleus II population (i.e., 25-100 animals, good management of existing *ex situ* population); possible reintroduction (1992 CAMP). The Swift Fox Conservation Team is reviewing the potential for reintroduction and other conservation actions.

Ex Situ Status:
Present in captivity in 2 regions (global *ex situ* population = 65 animals). Managed by AZA SSP program.

	AZA / North America	EAZA / Europe	Total Global *Ex Situ* Pop
Population size (M.F.U)	**60 (23.35.2)**	**5 (1.4)**	**65[1] (24.39.2)**
Living wild-born animals	2?	?	?
Gene diversity	91.5%	?	?
# Founders	18	?	18+[1]
# Potential founders	?	?	?
% pedigree known	97%	?	89%+[2]
Population trend/ lambda	1.03	?	Stable[2]
# institutions	22	2	24[1]
Management	SSP managed	Not managed	
Data source	*2015 AZA B&T plan*	*2016 ZIMS*	[1]*column sums;* [2]*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education	HIGH	HIGH	LOW	Good message Focus on landowners
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Education	HIGH	HIGH	LOW	Increase public understanding of prairie ecosystem and swift fox's role
Surrogate species	HIGH	HIGH	LOW	Serve as surrogate for research applying to rarer fox species
***In situ* support**	Not rated	Not rated	Not rated	
Insurance	Not rated	Not rated	Not rated	

Comments/Issues:

- Due to increasing population, swift foxes have been down-listed to threatened in Canada yet prairie ecosystems are under threat.
- US Swift Fox Conservation Team is monitoring the wild population in all 10 states; future reinforcement likely to use wild stock, so source population not needed.
- Captive population was started based on a recommendation from this team; SSP formed to support Swift Fox Conservation Team through educational efforts and was designed to be maintained as a small population, maintained at a sustainable level as an insurance population due to periodic imports/rescues, on an as needed basis.
  - Therefore, education should be the primary focus of this population given Team request and *in situ* needs. Messaging should be about this species (and potentially kit fox), and the threat from habitat loss/conversion to agriculture and the prairie ecosystem.
- AZA zoos have the resources and expertise to assist with field-based animal and research needs, in addition to potentially assisting with funding support.
- Husbandry practices for swift (and fennec fox) should be well documented to be utilized as the basis (with fennec fox husbandry) for any newly established *ex situ* fox program.

Workshop Recommendations:

1. A proactively managed *ex situ* population is recommended for this species to represent swift (and North American) foxes; continue a close association with the US Swift Fox Conservation Team.
2. AZA to work with the IUCN SSC Canid Specialist Group Swift and Kit Fox Working Group and the US Swift Fox Conservation Team to develop a comprehensive, targeted educational program that can reach both range states and outside audiences.
3. As needed, AZA should work to provide resources and assistance for *in situ* efforts.

TIBETAN FOX
Vulpes ferrilata

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Unknown

Native to the steppes and semi-deserts of North and Central Asia (China, India and Nepal).

Threats: No major threats, although poisoning programs of pikas (major prey species) in much of the Tibetan plateau is a concern and potential threat if continued. Mortality due to domestic dogs can be a threat in some areas.

Potential Ex Situ Roles: No responses for this species prior to the workshop

Prior Ex Situ Recommendations: None

Ex Situ Status:
Not represented in captivity in ZIMS database or surveyed regional zoo associations. No information to indicate historical holdings in captivity.

Workshop Assessment of Ex Situ Roles and Activities:
No potential *ex situ* conservation roles were identified at the ICAP workshop.

Comments/Issues:
Due to the absence of this species currently or historically in captivity, the lack of availability of individuals for an *ex situ* population, and non-threatened status of this species in the wild, there is no direct conservation value of developing an *ex situ* program. *Ex situ* resources can be better used if invested in other species.

Workshop Recommendation:
Not recommended for *ex situ* management unless status in the wild changes (declines).

Global Integrated Collection Assessment and Planning Workshop for Canids and Hyenids

Omaha, NE, USA
19 – 20 March 2016

Final Report

SECTION 6

Taxon Sheets: Hyaenids

Taxon Sheets: Hyaenids

4 Taxa Assessed

For the purposes of this ICAP workshop, we have included the Red List category of Near Threatened (NT) under "Threatened" taxa along with Vulnerable (VU), Endangered (EN), Critically Endangered (CR), and Extinct in the Wild (EW). Using this categorization:

Two hyaenids are listed as Threatened on the IUCN Red List, one of which is held in captivity in significant numbers (i.e., at least 100 individuals) and in multiple regions. Two hyaenids are non-threatened, one of which is held in captivity in significant numbers.

For the purposes of this ICAP workshop, we have included the Red List category of Near Threatened (NT) under "Threatened" taxa.

The table below lists the estimated global *ex situ* population size for each hyaenid. Taxon sheets are presented in alphabetical order, first for Threatened taxa and then for non-threatened taxa. These sheets summarize *in situ* status and threats, *ex situ* demographic and genetic status, prior *ex situ* conservation recommendations, and ICAP assessment of potential *ex situ* roles, benefit, risks, feasibility, and recommendations.

	Current *Ex Situ* Population Size			
Status	**Large pop (>100)**	**Small pop (40-100)**	**Very small pop (<40)**	**Not in captivity**
Threatened	Striped hyena (253)		Brown hyena (13)	
Non-threatened	Spotted hyena (275)		Aardwolf (6)	

BROWN HYENA
Hyaena brunnea

THREATENED SPECIES
IUCN Red List: Near Threatened
Population trend: Stable

Native to Southern Africa.

Threats: Deliberate and incidental persecution, related to perceived livestock depredation and traditional medicine use. Decline of mature individuals. Persecution led to local extinction in parts of southeastern Namibia, where increasing human-wildlife conflict may lead to further decline. Increased efforts to educate farmers and pastoralists that brown hyenas pose very little risk to livestock is likely to enhance conservation of this species.

Potential Ex Situ Roles:
Direct Conservation: Range State Education. Use *ex situ* individuals in range states to reduce reputation as livestock killers and to reduce keeping hyenas as pets in backyard zoos.
Indirect Conservation: Education, Fundraising, Expertise. Target education efforts to improve knowledge and image inside and outside of range states. Zoos can educate visitors in their own facilities and produce education materials for range state facilities. Use to raise funds for high priority *in situ* projects, in particular for range state researchers. Share expertise (e.g., research, capture veterinary assistance).

Prior Ex Situ Recommendations: Recommended for Nucleus I population held in Africa (50-100 animals with GD >98%, requiring periodic immigrants from wild) as part of meta-population (1992 CAMP).

Ex Situ Status:
Present in small numbers in captivity in 3 regions (global *ex situ* population = 13 animals). Not managed. Reproduction in captivity.

	EAZA / Europe	PAAZA / Africa	SEAZA (Taiwan)	Total Global *Ex Situ* Pop
Population size (M.F.U)	**7 (4.3)**	**4 (2.2)**	**2 (1.1)**	**13 (7.6)**
Living wild-born	?	?	?	5 (3.2)
Gene diversity	?	?	?	?
# Founders	?	?	?	4
# Potential fdrs	?	?	?	?
% pedigree kn	?	?	?	65%
Population trend/ lambda	?	?	?	Declining
# institutions	3	1	1	5
Management	Not managed	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect potential conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education In range	HIGH	LOW	LOW	Counter (perceived) livestock conflict issues; help improve public perception of hyenas (as worth saving). Since there are low numbers in zoos, this role will largely have to be delivered through other hyena species
Training/expertise / *in situ* support	HIGH	HIGH	LOW	Make expertise (e.g. on immobilizations, etc.) and resources available to *in situ* projects.
Insurance Potentially in future but currently not needed	LOW	LOW	HIGH	*In situ* population is stable; there is no established *ex situ* population to use as a basis; an expanded population of this species could take up space (and other resources) of other species more in need.
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Education Outside range	HIGH	LOW	LOW	Counter (perceived) livestock conflict issues; help improve public perception of hyenas (as worth saving) and channel carnivore conservation funding towards hyenas as well. Since there are low numbers in zoos, this role will largely have to be delivered through other hyena species

Comments/Issues:
- The population in the wild is currently stable and for most part needed habitat is intact and not overlapping with humans.
- Education is the primary need for this and all hyena species – to increase understanding of their role in the ecosystem, their relationship with other carnivores in terms of carcass availability, help people perceive them as worth conserving and help make carnivore conservation funding available to hyenas as well. Although brown hyenas pose little threat to livestock, they are still killed because of the perceived threat. Given the small population of brown hyenas, educational messaging will largely have to be achieved with striped or spotted hyenas.
- The Kansas City Zoo is supporting a brown hyena project on the Namibian coast. It would be very valuable to expand this type of support.
- Given the Near Threatened status, it would seem wise to continue monitoring if an insurance population may be needed in the future.

Workshop Recommendations:
1. Currently no proactive recommendation to increase the *ex situ* population of this species.
2. Zoo associations to use the populations of striped and spotted hyenas (as well as the few brown hyenas kept) to increase support (expertise, in kind and financial) to *in situ* projects on brown hyenas.
3. Zoo associations to use the populations of striped and spotted hyenas (as well as the few brown hyenas kept) to (in collaboration with the IUCN SSC Hyena Specialist Group) develop a comprehensive, targeted educational program that can reach both range country and outside audiences and can be utilized for all species of hyena.
4. Remain in contact with the IUCN SSC Hyena Specialist Group to monitor the potential future need for an insurance population of brown hyena.

STRIPED HYENA
Hyaena hyaena

THREATENED SPECIES
IUCN Red List: Near Threatened
Population trend: Declining

Native to North and East Africa, Middle East, and South Asia. Patchy distribution.

Threats: Deliberate and incidental persecution (especially poisoning) coupled with a decrease in wild and domestic carrion provided by other large carnivores in decline and changing livestock practices. Local extinctions in many localities and declining throughout its range. Almost qualifies as Threatened.

Potential Ex Situ Roles:
Direct Conservation: Range State Education. Use *ex situ* individuals in range states to reduce reputation as livestock killers and to reduce keeping hyenas as pets in backyard zoos. Well-designed public awareness programs have been very successful in changing attitudes to promote conservation (IUCN RL).
Indirect Conservation: Education, Fundraising, Expertise. Target education efforts to improve knowledge and image inside and outside of range states. Zoos can educate visitors in their own facilities and produce education materials for range state facilities. Use to raise funds for high priority *in situ* projects, in particular for range state researchers. Share expertise (rescue team and rehabilitation of injured animals, handling animals in the field, improved welfare in Iranian zoos).

Prior Ex Situ Recommendations: Recommended for Nucleus II population in range states (i.e., 25-100 animals, good management of existing *ex situ* population) as part of meta-population management (1992 CAMP). Maintain current collection for education purposes (2000 Arabian Carnivore CAMP).

Ex Situ Status:
Present in captivity in almost all regions (estimated global *ex situ* population = 243 animals). Managed program in EAZA. Good reproduction in captivity and stable/increasing slightly globally.

	AZA / No Amer	ALPZA/Latin & So Amer	EAZA / UAE & Europe	PAAZA/ Africa	CZA / India	SEAZA/ SE Asia	JAZA / Japan	Total Global *Ex Situ* Pop
Population size (M.F.U)	**23 (11.12)**	**24 (11.13)**	**79 (30.43.6)**	**9 (2.7)**	**86 (40.36.10)**	**16 (6.8.2)**	**6 (4.2)**	**243 (104.121.18)**
Living wild-born	?	?	?	?	?	?	?	>35
Gene diversity	?	?	88.3%	?	?	?	?	?
# Founders	?	?	13	?	?	?	?	24+
# Potential fdrs	?	Some?	1	?	Many?	?	?	Some
% pedigree kn	?	?	39%	?	?	?	?	?
Population trend/ lambda	?	?	1.038 (LT stable)	?	Declining	?	?	Increasing
# institutions	9	4	33	3	30	3	2	84
Management	Not managed	Not managed	EEP managed	Not managed	No formal program	Not managed	Not managed	
Data source	*2016 ZIMS*	*2016 ALPZA rpt*	*2015 EAZA ESB*	*2016 ZIMS*	*2016 CZA report*	*2016 ZIMS*	*2016 JAZA rpt*	[1]*column sums;* [2]*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect potential conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Direct Role(s)	Benefit	Feasibility	Risk	Notes
Education In range	HIGH	HIGH	LOW	Counter (perceived) livestock conflict issues. Help improve public perception of hyenas (as worth saving). In zoos, requires good attractive exhibits to improve image and a targeted effort.
Research Taxonomic	MODERATE	MODERATE	MODERATE	The taxonomy both *in situ* and *ex situ* needs clarification. Zoos can contribute with samples, expertise, resources.
Insurance Potentially in future but not currently needed	LOW	MODERATE	MODERATE	Currently low priority (still appear to be doing ok in many locations). Lack of taxonomic clarity and certainty complicates this.
Indirect Role(s)	**Benefit**	**Feasibility**	**Risk**	**Notes**
Research General species biology	MODERATE	HIGH	LOW	Relatively little known about this carnivore: research on zoo animals + support graduate students & project staff in range countries (modest funds reach a long way)
Education Outside range	HIGH	HIGH	LOW	Counter (perceived) livestock conflict issues. Help improve public perception of hyenas (as worth saving) and channel carnivore conservation funding towards hyenas as well (all species). In zoos, requires good attractive exhibits to improve image and a targeted effort.

Comments/Issues:

- Results of IUCN SSC Hyena Specialist Group supported camera trap studies in new locations (e.g.,in African and Nepal) suggest that the wild population may be in better shape than originally thought - the species was found in all locations studied. India may be an exception. There are a lot of human/hyena conflicts - the striped hyenas damage livestock, resulting in retaliatory killing and a declining population.
- There are likely different subspecies in the wild, but the *in situ* taxonomy is still unclear and uncertain and requires more research/ genetic testing. It is also not clear if certain subspecies are more vulnerable than others.
- The global zoo population counts almost 250 individuals, in seven regional zoo associations. There is no international studbook and both the taxonomic status of, and the level of genetic diversity within, the global population is unclear.
- The majority of the EAZA population is of unknown origin/subspecies and are likely a mix from African and Asian origins. A small subset is thought to be *H. h. sultana* (no molecular confirmation) and these are managed separately as a precaution, until taxonomy of the species is more clear. Breeding success seems to have declined in past few years, possibly due to inbreeding?
- CZA zoos only hold individuals from the Indian subspecies; they enter the zoos through rescues etc. Reproduction is very low. There are also individuals in rescue centers and non-CZA collections. With extra attention there is the potential to create a managed breeding population in CZA.
- There were recent imports to AZA from ZAA.

- This is one of few large carnivores about which relatively little is known. Zoos could really help build knowledge about their general biology (even with individuals of uncertain subspecies status).
- Education is the primary need for this and all hyena species – to increase understanding of their role in the ecosystem, their relationship with other carnivores in terms of carcass availability, help people perceive them as worth conserving and help make carnivore conservation funding available to hyenas. Hyenas can be popular –people travel to see them in the wild.

Workshop Recommendations:

1. Zoo associations to work with the IUCN SSC Hyena Specialist Group to develop a comprehensive, targeted educational program that can reach both range country and outside audiences and can be utilized for all species of hyena.
2. Conduct taxonomic investigation of the individuals *ex situ* and contribute to clarifying the *in situ* taxonomy.
3. Evaluate methods for increased communication between all regional zoo associations holding his species to manage cooperatively at a low level of intensity. Europe, UAE, and CZA have the largest focus on this species and it might make most sense for them to continue to provide the majority of the spaces for this taxon; AZA is likely to play a lesser, more supporting role with a very small population.
4. Conduct research into the general biology of the species.
5. Provide technical (e.g. veterinary) expertise and support as needed for smaller regional zoo associations or range countries (e.g. Iran) – e.g. help for injured and rescued individuals.

AARDWOLF
Proteles cristata

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Stable

Native to Sub-Saharan Africa in two distinct areas (northern and southern subspecies), dependent upon *Trinervitermes* termite distribution (principle food source).

Threats: Widespread (although not common) in numerous protected areas with no major threats leading to range-wide decline. Urbanization and farming practices that destroy termites may have negative impacts.

Potential Ex Situ Roles: **Indirect Conservation: Education, Fundraising**
Education efforts with aardwolves to improve knowledge and image inside and outside of range states can help other hyaenid species. Zoos can educate visitors in their own facilities and produce education materials for range state facilities. A surrogate species to raise funds for threatened hyaenids.

Prior Ex Situ Recommendations: Recommended for Nucleus II population in range states (i.e., 25-100 animals, good management of existing *ex situ* population) as part of species meta-population management (1992 CAMP). *Ex situ* population has since decreased from 36+ to 6.

Ex Situ Status:
A few specimens present in captivity in 2 regions (global *ex situ* population = 6 animals). Not managed. Reproduction in captivity in the past in the US and Europe in the 1970s and 1980s.

	AZA / North America	EAZA / Europe	Total Global *Ex Situ* Pop
Population size (M.F.U)	**2 (1.1)**	**4 (2.2)**	**6 (3.3)**
Living wild-born animals	2 (1.1)	4 (2.2)	6 (3.3)
Gene diversity	--	--	--
# Founders	0	0	0
# Potential founders	2	4	6
% pedigree known	100%	100%	100%
Population trend/ lambda			
# institutions	1	2	3
Management	Not managed	Monitored program	
Data source	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education	**LOW**	**LOW**	**HIGH**	Poor exhibit value

Comments/Issues:

- Smaller in size (and exhibit needs) than other hyaenids, but do not exhibit well. Striped or spotted hyaenas make better exhibits to link to identified educational needs for all hyaenids.
- Maintained in EAZA as a monitored species for education about hyaenid conservation, but most institutions would select another species to hold.
- Difficult species to maintain well in captivity (welfare concerns).
- If education (to improve the image of hyaenids) and not taxonomic uniqueness is the focus, then another hyaenid is a better choice.
- There is some husbandry knowledge to start a program if one is needed in the future.

Workshop Recommendations:
Not recommended for *ex situ* management unless status in the wild changes (declines).

SPOTTED HYENA
Crocuta crocuta

NON-THREATENED SPECIES
IUCN Red List: Least Concern
Population trend: Declining

Native to Sub-Saharan Africa.

Threats: Continuing decline outside protected areas (and within some protected areas) due to habitat loss and persecution (culling, trapping and poisoning). A pressing threat is the hyena's bad reputation, and a lack of knowledge and understanding of the status, threats and ecology of all hyena species.

Potential Ex Situ Roles: **Indirect Conservation: Education, Fundraising**
Education efforts with spotted hyenas to improve knowledge and image inside and outside of range states can help other hyaenid species. Zoos can educate visitors in their own facilities and produce education materials for range state facilities. A surrogate species to raise funds for threatened hyaenids.

Prior Ex Situ Recommendations: Recommended for Nucleus II population in range states (i.e., 25-100 animals, good management of existing *ex situ* population) as part of species meta-population management (1992 CAMP).

Ex Situ Status:
Present in captivity in almost all regions in modest numbers (estimated global *ex situ* population = 265 animals). Managed programs in AZA and EAZA. Good reproduction in captivity and increasing globally.

	AZA / North America	ALPZA / Latin & So America	EAZA / Europe	PAAZA / Africa	ZPO / Thailand	SEAZA / SE Asia	JAZA / Japan	ZAA / Austral-asia	Total Global *Ex Situ* Pop
Population size (M.F.U)	**55 (30.25)**	**26 (9.17)**	**102 (44.47.11)**	**20 (5.8.7)**	**21 (8.4.9)**	**13 (8.3.2)**	**15 (10.4.1)**	**13 (9.3.1)**	**265[1] (123.111.31)**
Living wild-born animals	?	18	?	?	?	?	?	?	8[2] (4.4)
Gene diversity	91%	?	91.4%	?	?	?	?	?	High?
# Founders	19	?	15	?	?	?	?	?	43[2]
# Potential fdrs	2	?	?	?	?	?	?	?	?
% pedigree known	66%	?	92%	?	?	?	?	?	36%[2]
Population trend/ lambda	0.938	?	1.042	?	?	?	?	?	Increasing[2]
# institutions	22	5	30	5	5	1	10	4	82[1]
Management	SSP managed	No formal program	EEP managed	Not managed	Not managed	Not managed	No formal program	Not managed	
Data source	*2015 AZA B&T plan*	*2016 ALPZA rpt*	*2015 EAZA Regional SB*	*2016 ZIMS*	*2016 ZIMS*	*2016 ZIMS*	*2016 JAZA rpt*	*2016 ZIMS*	*[1]column sums; [2]2016 ZIMS*

M.F.U = # males.females.unknown sex

Workshop Assessment of Ex Situ Roles and Activities:
The following direct and indirect potential conservation roles were identified at the ICAP workshop. Roles selected to pursue following benefit/feasibility/risk analysis are marked in green.

Indirect Role(s)	Benefit	Feasibility	Risk	Notes
Education In and outside range	**HIGH**	**HIGH**	**LOW**	Help improve public perception of hyenas (as worth saving) and channel carnivore conservation funding towards hyenas as well (all species). In zoos, requires good attractive exhibits to improve image and a targeted effort.
***In situ* support**	**Not rated**	**Not rated**	**Not rated**	Fundraising, especially for projects for threatened taxa (e.g., striped or brown hyenas)

Comments/Issues:
- Only hyaenid species managed in AZA.
- Eighteen of the 26 individuals in ALPZA are wild caught from Namibia (as part of an agreement between Cuba and Namibia).
- Active, social attractive exhibit species and is used to present carnivore biology in general; also have unique adaptations and has been used in non-conservation research.
- Education is the primary need/role for this and all hyena species – to increase understanding of their scavenger role in the ecosystem, their relationship with other carnivores in terms of carcass availability, help people perceive them as worth conserving and help make carnivore conservation funding available to hyenas. Messaging could be more closely linked to on-going field efforts.

Workshop Recommendations:
1. Zoo associations to work with the IUCN SSC Hyena Specialist Group to develop a comprehensive, targeted educational program that can reach both range country and outside audiences and can be utilized for all species of hyena.
2. Regional zoo programs should work together to manage each hyaenid species at the appropriate level using good demographic and genetic management.
3. Regional associations should collaborate with the IUCN SSC Hyaenid Specialist Group regarding transfer of conservation funds to support *in situ* conservation efforts for hyaenid species.

Global Integrated Collection Assessment and Planning Workshop for Canids and Hyenids

Omaha, NE, USA
19 – 20 March 2016

Final Report

SECTION 7

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ZIMS. 2016. Spotted Hyena (*Crocuta crocuta*) Population Overview Report. 28 Jan 2016. Zoological Information Management System, Species360: Bloomington, MN.

ZIMS. 2016. Striped Hyaena (*Hyaena hyaena*) Population Overview Report. 28 Jan 2016. Zoological Information Management System, Species360: Bloomington, MN.

Global Integrated Collection Assessment and Planning Workshop for Canids and Hyenids

Omaha, NE, USA
19 – 20 March 2016

Final Report

APPENDIX I

Workshop Participants and Agenda

ICAP Workshop Participant List

Participant	Institution	Email
Karen Bauman	Saint Louis Zoo (AZA)	Kbauman@stlzoo.org
Rogério Cunha de Paula	CENAP/ICMBio	rogerio.paula@icmbio.gov.br
Maggie Dwire	USFWS	Maggie.dwire@fws.gov
Danny de Man	EAZA	danny.de.man@eaza.net
Candice Dorsey	AZA	cdorsey@aza.org
Lisa Faust	Lincoln Park Zoo (AZA)	lfaust@lpzoo.org
Todd Fuller	University of Massachusetts (IUCN Canid Specialist Group)	tkfuller@eco.umass.edu
Heather Genter	Denver Zoo (AZA)	hgenter@denverzoo.org
Don Goff	Beardsley Zoo (AZA)	dgoff@beardsleyzoo.org
Brij Gupta	Central Zoo Authority India (CZA)	brijkishor68@yahoo.com
Christina Gorsuch	Cincinnati Zoo (AZA)	
Katharina Herrmann	EAZA	Katharina.Herrmann@eaza.net
Kay Holkamp	Michigan State University (IUCN Hyaenid Specialist Group)	holekamp@msu.edu
Kristin Leus	EAZA; CPSG (IUCN SSC)	krl@zoo.dk
Keith Lovett	Buttonwood Park Zoo (AZA)	KLovett@newbedford-ma.gov
Simon Marsh	Yorkshire Wildlife Park (EAZA)	s.marsh@yorkshirewildlifepark.com
Jennifer Mickelberg	Conservation Planning Specialist Group (IUCN SSC)	jmickelberg@zooatlanta.org
Kira Mileham	IUCN SSC	kira.mileham@iucn.org
Mike Quick	Sedgewick County Zoo (AZA)	Michael.Quick@scz.org
Tracy Rehse	National Zoological Gardens of South Africa (PAAZA)	tracy@nzg.ac.za
Tracy Rein	Endangered Wolf Center (AZA)	trein@endangeredwolfcenter.org
Kristine Schad	EAZA	kristine.schad@eaza.net
Adrián J. Sestelo	Jardín Zoológico de la Ciudad de Buenos Aires (ALPZA)	asestelo@zoobuenosaires.com.ar
Peter Siminski	The Living Desert (AZA)	psiminski@livingdesert.org
Gert Skipper	Adelaide Zoo (ZAA)	gskipper@zoossa.com.au
Nucharin Songsasen	Smithsonian Conservation Breeding Institute (AZA)	songsasenn@si.edu
Sara Sullivan	AZA Population Management Center (AZA)	Sara.Sullivan@CZS.org
Kathy Traylor-Holzer	Conservation Planning Specialist Group (IUCN SSC)	kathy@cpsg.org
Raymond van der Meer	Amersfoort Zoo (EAZA)	rvandermeer@dierenparkamersfoort.nl
William Waddell	Point Defiance Zoo and Aquarium (AZA)	William.waddell@pdza.org
Sam Wilson	Nebraska Game and Parks (US Swift Fox Conservation Team)	sam.wilson@nebraska.gov
Martin Zordan	Latin American Association of Zoological Parks and Aquariums (ALPZA)	direccion@alpza.com

Pre-Workshop Participant List

Pre-workshop survey materials were sent to a list of *in situ* experts prior to the meeting. The list of experts was generated by the Chairs of the IUCN SSC Canid and Hyaenid Specialist Groups. We gratefully acknowledge below those experts, who took the time to provide their expert opinions.

Name	**Institution**	**Affiliation**
Alireza Mahdari	Islamic Azad University	Member, IUCN SSC Hyaenid Specialist Group
Axel Moehenschlager	Calgary Zoo	Reintroduction& Translocation Working Group Chair, IUCN SSC Canid Specialist Group
Ben Sacks	University of California Davis	Taxonomy & Nomenclature Working Group Co-Chair, IUCN SSC Canid Specialist Group
Brian Cyper	Endangered Species Recovery Program California State University-Stanislaus	Island, Kit & Swift Fox Working Group Chair, IUCN SSC Canid Specialist Group
David Mech	U.S. Geological Survey, and University of Minnesota	Advisor to the Chair, IUCN SSC Canid Specialist Group; Past Chair Wolf Specialist Group
Eileen Dowd-Stukel	SD Game, Fish and Parks	Member, US Swift Fox Conservation Team
Greg Wilson	Canadian Wildlife Service	Member, US Swift Fox Conservation Team
Harriet T. Davies-Mostert	Endangered Wildlife Trust	Head of Conservation, Endangered Wildlife Trust
Ingrid Wiesel	Brown Hyena Research Project	Member, IUCN SSC Hyaenid Specialist Group
Jed Murdoch	University of Vermont	Program Coordinator, IUCN SSC Canid Specialist Group
Jerry Apker	Colorado Parks and Wildlife	Member, US Swift Fox Conservation Team
John Newby	Sahara Conservation Fund	CEO, Sahara Conservation Fund
Jorgelina Marino	University of Oxford	Ethiopian Wolf Working Group Chair
Karen DeMatteo	Washington University	Program Officer & Amazonian Canids Working Group Chair, IUCN SSC Canid Specialist Group
Kay Holkamp	Michigan State University	Chair, IUCN SSC Hyaenid Specialist Group
Maggie Dwire	U.S. Fish and Wildlife Service	Assistant Recovery Coordinator Mexican Wolf Program, U.S. Fish and Wildlife Service
Mauro Lucherini	Universidad Nacional del Sur	Southern Cone (Foxes) Working Group Chair, IUCN SSC Canid Specialist Group
Mike Phillips	Turner Endangered Species Fund	Wolf (North American) Working Group Chair, IUCN SSC Canid Specialist Group
Nucharin Songsasen	Smithsonian's National Zoo and Conservation Biology Institute	Dhole Working Group Chair, IUCN SSC Canid Specialist Group
Oliver Hoener	Leibniz Institute for Zoo and Wildlife Research	Member, IUCN SSC Hyaenid Specialist Group
Richard Yarnell	Nottingham Trent University	Member, IUCN SSC Hyaenid Specialist Group
Rogerio Cunha de Paula	CENAP/ICMBio	Maned Wolf Working Group Chair, IUCN SSC Canid Specialist Group
Stephanie Dloniak	Michigan State University	Member, IUCN SSC Hyaenid Specialist Group
Todd Fuller	University of Massachusetts Amherst	Member, IUCN SSC Canid Specialist Group

We also gratefully acknowledge all the regional zoo associations which contributed expertise and *ex situ* data prior to the meeting including: ALPZA, AZA, CZA, EAZA, JAZA, PAAZA, and ZAA.

Integrated Collection Assessment and Planning (ICAP) Workshop for Canids and Hyaenids

Omaha, 19-20 March 2016

DRAFT AGENDA
SATURDAY 19 MARCH
(8:00 am –5:00 pm)

8:00-8:15: Welcome and introduction to the workshop (*Karen Bauman, AZA Canid TAG, and Kathy Traylor-Holzer, CBSG*)

8:15-8:45: Participant introductions

8:45-9:00: Applying the One Plan Approach and the IUCN SSC Guidelines on the Use of *Ex Situ* Management for Species Conservation to collection planning (*Kristin Leus, CBSG Europe/EAZA*)

9:00-9:30: Workshop process:
- Preparations before the workshop (*Kathy Traylor-Holzer and Jennifer Mickelberg, CBSG North America/Zoo Atlanta*)
- Process during the workshop (*Kathy Traylor-Holzer and Kristin Leus, CBSG Europe/EAZA*)

9:30-5:00: ICAP process for the Threatened Canid and Hyaenid species (see workshop manual p. 8)

10:00-10:15am: Break
12:00-1:00pm: Lunch
3:00-3:15pm: Break

Process for each species:

1. Presentation of previously gathered information on the species
2. Facilitated plenary discussion on potential conservation and non-conservation roles, and rating of benefit of any roles identified (see manual pages 2, 3 and 4)
3. Facilitated plenary discussion to (see manual page 5):
   a) **Identify the characteristics, scope, and resources of the *ex situ* population needed to fulfil the identified role(s)**
   b) **Assess feasibility and risks**
4. Formulation of recommendations (see manual page 6):
   a) Reaching consensus on the which of the potential *ex situ* roles identified (if any) are recommended, based on an analysis of the benefits *vs* feasibility and risks
   b) Identifying recommended actions. These recommendations are non-binding and intended to be discussed post-workshop within the relevant regional zoo association.

SUNDAY 20 MARCH
(8:00 am – 5:00 pm)

8:00-5:00: ICAP process for the Non-Threatened Canid and Hyaenid species (see workshop manual p. 8)

10:00-10:15am:	Break
12:00-1:00pm:	Lunch
3:00-3:15pm:	Break

Process:

A. <u>**For each species with a large or small population** (see manual page 8):</u>

1. Presentation of previously gathered information on the species
2. Facilitated plenary discussion on potential conservation and non-conservation roles, and rating of benefit of any roles identified (see manual pages 2, 3 and 4)
3. Facilitated plenary discussion to (see manual page 5):
   - **a. Identify the characteristics, dimensions, resources of the *ex situ* population needed to fulfil the identified role(s)**
   - **b. Assess feasibility and risks**
4. Formulation of recommendations (see manual page 6):
   - a. Reaching consensus on the which of the potential *ex situ* roles identified (if any) will be retained, based on an analysis of the benefits *vs* feasibility and risks
   - b. Identifying recommended actions. These recommendations are non-binding and intended to be discussed post-workshop within the relevant regional zoo association.

B. <u>**For species with a very small population or not present in zoos** (see manual page 8):</u>

- Facilitated plenary discussion: generalized recommendation for the groups, or species by species approach
- In case of species by species approach, follow process under A in working groups – feedback in plenary session.

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APPENDIX II

Ex Situ Conservation Role Pre-Workshop Survey

Dear [*in situ* specialist – not attending the ICAP workshop]

We are contacting you because **we would like to call on your expertise to help us gather preparatory information** for an international multi-stakeholder meeting focused on global *ex situ* conservation for canid and hyaenid species, which is being convened by the IUCN SSC Conservation Breeding Specialist Group (CBSG), in collaboration with the IUCN SSC Canid and Hyaenid Specialist Groups and the Canid and Hyaenid Taxon Advisory Groups (TAGs) from the world's zoo associations. This new CBSG meeting format will integrate work of the various SSC Specialist Groups, *in situ* species specialists, and their corresponding regional zoo association partners in the application of the IUCN SSC *Guidelines for the Use of Ex Situ Management for Species Conservation*.

Some key objectives of this workshop include:

- To review and assess the conservation needs of canid and hyaenid species and identify any potential conservation roles for *ex situ* activities;
- To assess the current status of regional and global canid and hyaenid *ex situ* populations and their relative viability and management needs;
- To provide a framework for prioritization of *ex situ* resources to support canid and hyaenid conservation;
- To create opportunities for communication and networking among professionals working with canids and hyaenids; and
- To promote the One Plan approach to create an integrated conservation plan for canids and hyaenids by developing species-specific recommendations useful to strategic planning by the field conservation community and regional zoo associations.

We would specifically like to ask for your help with identifying any potential conservation roles for *ex situ* activities within the conservation needs of canid and hyaenid species so that this information can be considered during the workshop discussions.

The attached Document A describes a series of potential conservation roles of *ex situ* activities. The additional documents are separate information sheets for those species for which we would like your help and provide information for each regarding its current regional and global status in zoos. **<u>For each of the species, we ask that you carefully consult the potential conservation roles outlined in Document A and use these, together with your expertise on the *in situ* status and threats for the species involved, to formulate your opinion on the 7 questions below</u>.** We are extremely grateful for your valuable expert opinion and time spent to help identify *ex situ* conservation priorities for these species.

Please send your responses to these questions and any documentation to me (KBauman@stlzoo.org) **by 10 March**. Please let us know if you will not be able to respond and/or if you have suggestions for additional important contact persons for these species.

Best regards,

Karen Bauman
Chair, AZA Canid & Hyaenid TAG, and meeting co-convener

Dear [*in situ* specialist – attending the ICAP workshop]

Thank you for accepting our invitation to attend the international multi-stakeholder meeting focused on global *ex situ* conservation for canid and hyaenid species in Omaha, Nebraska (USA) on 19-20 March 2016. This workshop is being convened by the IUCN SSC Conservation Breeding Specialist Group (CBSG) in collaboration with the IUCN SSC Canid and Hyaenid Specialist Groups and the Canid and Hyaenid Taxon Advisory Groups (TAGs) from the world's zoo associations.

This new CBSG meeting format will integrate work of the SSC Specialist Groups, *in situ* species specialists, and their corresponding regional zoo association partners in the application of the IUCN SSC Guidelines for the Use of *Ex Situ* Management for Species Conservation. We are contacting you to help us gather some preparatory information, which will help us to structure the discussion and decision process at the workshop. Specifically, we are asking for your help with assessing and identifying any potential conservation roles for *ex situ* activities within the conservation needs of canid and hyaenid species. Preliminary compilation of information is essential in order for us to address over 40 taxa during the two-day meeting.

The attached Document A describes a series of potential conservation roles of *ex situ* activities. The additional documents are separate information sheets for those species for which we would like your help and provide information for each regarding its current regional and global status in zoos. **For each of the species, we ask that you carefully consult the potential conservation roles outlined in Document A and use these, together with your expertise on the *in situ* status and threats for the species involved, to formulate your opinion on the 7 questions below.** We are extremely grateful for your valuable expert opinion and time spent to help identify *ex situ* conservation priorities for these species.

Please send your responses to these questions and any documentation to me (KBauman@stlzoo.org) **by 10 March**. Please let us know if you will not be able to respond and/or if you have suggestions for additional important contact persons for these species.

Best regards,

Karen Bauman
Chair, AZA Canid & Hyaenid TAG, and meeting co-convener

FOR THREATENED SPECIES **(defined for this task as EW, CR, EN, VU, NT on the IUCN Red List)**

DIRECT CONSERVATION (i.e. the animals (or their biological samples) in the *ex situ* population play a conservation role)

1. Is there an existing conservation strategy/action plan for this species that calls for some form of *ex situ* management in support of conservation? If yes, please provide a copy of (the relevant section of) the plan.

2. Do you feel (and/or does an existing strategy/plan state) that *ex situ* management with one or more of the direct conservation roles described in Section I of Document A would be required for this species – and if so, which roles? *(One* ex situ *program may serve several conservation roles – either simultaneously or consecutively)*

   If yes, do you feel that the zoo community should help with:
   - Implementing an *ex situ* program located elsewhere than on zoo grounds (e.g. in a range country facility or another non-zoo environment)

   And/or:
   - Implementing an *ex situ* program in professionally managed zoos (this can range from one, to a few zoos, to a large cooperative program regionally or globally)

INDIRECT CONSERVATION (i.e. ways in which the expertise, knowledge, materials, staff, fund raising etc. present in the zoo community can contribute to *in situ* conservation activities).
Please note that a threatened species may be eligible for indirect conservation support from the zoo community even if it is currently not held by zoos.

3. After reading Section II of Document A, do you see a specific need for expertise, knowledge, materials, staff or other in-kind support from the zoo community to help implement a particular *in situ* conservation action, or address a particular *in situ* problem?

4. Is there a high priority *in situ* project for which small scale funding from the zoo community could make a lot of difference for the conservation of the species (that might perhaps have difficulty attracting funds from other sources?)?

5. Are there particular messages that you feel would be good for zoos to include in general conservation educational activities for the zoo visitors?

FOR NON-THREATENED SPECIES

6. Do you have reason to believe that this taxon, which is currently not listed as either EW, CR, EN, VU or NT, might recently have run into significant trouble, such that its current threat status might be more severe than is evident from its current IUCN Red List category?
   - If yes, please specify and answer questions 1-5 above

7. Do you think feel there is a need for this non-threatened species to function as a model, through *ex situ* activities, for a threatened species, for example to gain husbandry experience, for conservation-targeted research, conservation-targeted education, or "ecological replacement" (see Section I of Document A)?

Document A
Ex situ Conservation Roles

I. Direct Conservation Roles for *ex situ* management

These are situations in which living individuals (or their biological materials, such as a Genome Resource Bank) in the *ex situ* population play a direct conservation role. *Ex situ* management may take place either within or outside the species' geographic range, but is in a controlled or modified environment for some period of time (short term or long term) for a clearly defined conservation purpose at the population, species, or ecosystem level (see *IUCN SSC Guidelines for the Use of Ex Situ Management for Species Conservation* for more detailed explanation).

Simply keeping and/or breeding threatened Canid or Hyaenid species in captivity does not in itself equate to *conservation*. As part of a genuine Canid or Hyaenid conservation initiative, potential *ex situ* management strategies proposed should address the causes or consequences of one or more specific threats or constraints to the species' viability and conservation, as identified in a status review and threat analysis, and target improvement of its conservation status. This does not preclude these *ex situ* populations for conservation from having additional roles that are not necessarily, or only indirectly, related to conservation. Whenever an *ex situ* conservation role involves a conservation translocation, the *IUCN SSC Guidelines for Reintroductions and other Conservation Translocations* also apply.

In essence, *ex situ* management can support species conservation and prevent extinction by:

a) counteracting the impacts (such as reduced survival, poor reproduction and genetic isolation) of primary or stochastic threats on the population;
b) addressing the causes of primary threats;
c) gaining time in situations where threats are not under control or mitigation is not successful (enough); and
d) by using *ex situ* populations for population restoration or conservation introduction.

COMMON *EX SITU* CONSERVATION ROLES

Descriptions of these roles are based on a combination of the role descriptions in the IUCN SSC Guidelines on the Use of Ex Situ Management for Species Conservation and those in Appendix I of the Amphibian Ark Conservation Needs Assessment Process.

Ark

Maintenance of a long-term *ex situ* population after extinction of all known wild populations and as a preparation for reintroduction or assisted colonization if and when feasible.

Rescue (temporary or long term)

A species that is in imminent danger of extinction (locally or globally) and requires *ex situ* management, as part of an integrated program, to ensure its survival. The species may be in imminent danger because the threats cannot/will not be reversed in time to prevent likely species extinction, or the threats have no current remedy. The rescue may need to be long term or temporary (for example, to protect from catastrophes or predicted imminent threats that are limited in time, e.g. extreme weather, disease, oil spill).

Demographic manipulation

Improving a demographic rate (survival or reproduction) or status (e.g. skewed sex ratio), often of a particular age, sex, or life stage. For example, head-start programs that remove individuals from the wild to reduce high mortality during a specific life stage and then subsequently return them to the wild.

Population restoration

Source for population restoration, either to re-establish the species to part of its former range from which it has been extirpated, or to reinforce/supplement an existing population (e.g. for demographic, behavioral or genetic purposes).

Ecological replacement

Re-establish a lost ecological function and/or modify habitats. This may involve species that are not themselves threatened but that contribute to the conservation of other taxa through their ecological role.

Assisted colonization

Introduce the species outside of its indigenous range to avoid extinction.

Insurance population

Maintaining a long-term viable *ex situ* population of the species to prevent predicted local, regional or global species extinction and preserve options for future conservation strategies. These are typically species that are threatened and for which it is unsure whether *in situ* threat mitigation will have the sufficient effect in a sufficient timeframe to prevent the extinction of the species or to prevent a dramatic decline in the numbers, populations and/or genetic diversity of the species. An *ex situ* population may be desired as an insurance population from which individuals can be extracted for genetic and/or demographic supplementation or other conservation translocations as required, but these are not yet actively planned the foreseeable future.

Ex situ research and/or training

Ex situ populations that are used for research and/or training that will directly benefit conservation of the species, or a similar species, in the wild (e.g. monitoring methods, life history information, nutritional requirements, disease transmission/ treatment). The research/training addresses specific questions essential for success of the overall conservation strategy for the species. This can include non-threatened species serving as a model for more threatened species, or establishing *ex situ* populations of a threatened species to gain important species-specific husbandry and breeding expertise that is likely to be needed in the future to conserve the species.

Conservation Education

The *ex situ* management forms the basis for an education and awareness program that addresses specific threats or constraints to the conservation of the species or its habitat. The education addresses specific human behavioral changes that are essential for the success, and an integral part of, the overall conservation strategy for the species. This primarily involves *ex situ* locations visited by the intended human audience.

Others?

If you see a need for an *ex situ* management role that is not covered by the role descriptions provided above, please specify in your reply to the survey.

II. Indirect Conservation Roles for *ex situ* management

These are situations in which the zoo community can contribute to conservation by:

- **making available its expertise, knowledge, materials, staff, fund raising, etc. to help implement *in situ* conservation actions, and/or**
- **carrying out general awareness and conservation education activities aimed at the zoo visiting public**

Indirect conservation contributions can be made for a species regardless of whether or not it is held in captivity.

Examples of indirect conservation roles include:

- Providing knowledge, experience or training to build capacity for veterinary care or handling of individuals in the field (e.g. radio collar application, transport, etc.) or in the context of law enforcement (rescue centers, human wildlife conflicts etc.)
- Making available existing zoo education materials or education/behavior change expertise to teams developing awareness programs for local communities *in situ*.
- Carry out education and awareness about the status of and threats to the species. Increase interest in the species and its habitat/ecosystem.
- Networking and lobbying to influence opinions, legislation processes, etc.
- Small scale fundraising to contribute to high priority *in situ* projects or IUCN SSC Specialist Group activities
- And others …

III. Non-Conservation roles for *ex situ* management

Zoos also have other roles in addition to conservation and may therefore select to maintain certain species for non-conservation reasons such as general biological education, addressing a particular cultural/socio-economic interest or significance, building attractive exhibits, or for use in non-conservation related research. While this will be addressed during the workshop, it is not the focus of this survey and does not require your response.

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APPENDIX III

Workshop Manual

Integrated Collection Assessment and Planning (ICAP) Workshop for Canids and Hyaenids

Omaha, 19-20 March 2016

WORKSHOP MANUAL

ONE PLAN APPROACH

A 'One Plan' approach (OPA) to species conservation promotes the joint development of management strategies and conservation actions for all populations of a species by all responsible parties to produce one comprehensive conservation plan for the species, with the ultimate goal of supporting the species' conservation in the wild (Byers *et al.* 2013)[1].

IUCN SSC GUIDELINES ON THE USE OF *EX SITU* MANAGEMENT FOR SPECIES CONSERVATION[2]

Five-step decision making process to decide when *ex situ* management is an appropriate conservation tool within the overall conservation strategy for a taxon:

STEP 1. **Compile a status review of the species, including a threat analysis.**

STEP 2. **Define the role(s) that *ex situ* management will play in the overall conservation of the species.**

STEP 3. **Determine the characteristics and dimensions of the *ex situ* population needed to fulfil the identified conservation role(s).**

STEP 4. **Define the resources and expertise needed for the *ex situ* management program to meet its role(s) and appraise the feasibility and risks.**

STEP 5. **Make a decision that is informed (i.e. uses the information gathered above) and transparent (i.e. demonstrates how and why the decision was taken).**

[1] Byers, O., C. Lees, J. Wilcken, and C. Schwitzer. 2013. The "One Plan Approach": The philosophy and implementation of CBSG's approach to integrated species conservation planning. *WAZA Magazine* 14: 2-5.

[2] IUCN SSC. 2014. Guidelines on the Use of Ex Situ Management for Species Conservation. Version 2.0. Gland, Switzerland: IUCN Species Survival Commission.

INVESTIGATING POTENTIAL *EX SITU* CONSERVATION ROLES

FOR THREATENED SPECIES (for this project defined as EW, CR, EN, VU, NT on the IUCN Red List)

DIRECT CONSERVATION (i.e. the individuals in the *ex situ* population play a conservation role – see page 3)

1. **Is there an existing conservation strategy/action plan for this species that calls for some form of *ex situ* management in support of conservation?**

2. **Do you feel (and/or does an existing strategy/plan state) that *ex situ* management with one or more direct conservation roles would be required for this species – and if so, which roles? *(One* ex situ *program may serve several conservation roles – either simultaneously or consecutively)***
   a. **If yes, do you feel that the zoo community should help with:**
      i. Implementing an *ex situ* program located elsewhere than on zoo grounds (e.g. in a range country facility or another non-zoo environment)
   b. **And/or:**
      i. Implementing an *ex situ* program in professionally managed zoos (this can range from one, to a few zoos, to a large cooperative program regionally or globally)

INDIRECT CONSERVATION (i.e. ways in which the expertise, knowledge, materials, staff, fund raising etc. present in the zoo community can contribute to *in situ* conservation activities – see page 4). Please note that a threatened species may be eligible for indirect conservation support from the zoo community even if it is currently not held by zoos.

3. **Do you see a specific need for expertise, knowledge, materials, staff or other in-kind support from the zoo community to help implement a particular *in situ* conservation action, or address a particular *in situ* problem?**

4. **Is there a high priority *in situ* project for which small scale funding from the zoo community could make a lot of difference for the conservation of the species (that might perhaps have difficulty attracting funds from other sources?)?**

5. **Are there particular messages that you feel would be good for zoos to include in general conservation educational activities for the zoo visitors?**

NON-CONSERVATION ROLES

6. **Do you see any important non-conservation roles for this species (see page 4)**

PLEASE RATE the conservation benefits of any conservation roles chosen as well as the benefit to the zoo community of any non-conservation roles chosen (see page 4)

FOR NON-THREATENED SPECIES

7. **Do you have reason to believe that this taxon, which is currently not listed as either EW, CR, EN, VU or NT, might recently have run into significant trouble, such that its current threat status might be more severe than is evident from its current IUCN Red List category?** If yes, please specify and answer questions 1-5 above

8. **Do you think feel there is a need for this non-threatened species to function as a model, through *ex situ* activities, for a threatened species, for example to gain husbandry experience, for conservation-targeted research, conservation-targeted education, or "ecological replacement"?**

9. **Do you see any important non-conservation roles for this species (see page 4)**

PLEASE RATE the conservation benefits of any conservation roles chosen as well as the benefit to the zoo community of any non-conservation roles chosen (see page 4)

COMMON DIRECT CONSERVATION ROLES FOR *EX SITU* MANAGMENT

Descriptions of these roles are based on a combination of the role descriptions in the IUCN SSC Guidelines on the Use of Ex situ Management for Species Conservation and those in Appendix I of the Amphibian Ark Conservation Needs Assessment Process.

Ark
Maintenance of a long-term *ex situ* population after extinction of all known wild populations and as a preparation for reintroduction or assisted colonization if and when feasible.

Rescue (temporary or long term)
A species that is in imminent danger of extinction (locally or globally) and requires *ex situ* management, as part of an integrated program, to ensure its survival. The species may be in imminent danger because the threats cannot/will not be reversed in time to prevent likely species extinction, or the threats have no current remedy. The rescue may need to be long term or temporary (for example, to protect from catastrophes or predicted imminent threats that are limited in time, e.g. extreme weather, disease, oil spill).

Demographic manipulation
Improving a demographic rate (survival or reproduction) or status (e.g. skewed sex ratio), often of a particular age, sex, or life stage. For example, head-start programs that remove individuals from the wild to reduce high mortality during a specific life stage and then subsequently return them to the wild.

Population restoration
Source for population restoration, either to re-establish the species to part of its former range from which it has been extirpated, or to reinforce/supplement an existing population (e.g. for demographic, behavioral or genetic purposes).

Ecological replacement
Re-establish a lost ecological function and/or modify habitats. This may involve species that are not themselves threatened but that contribute to the conservation of other taxa through their ecological role.

Assisted colonization
Introduce the species outside of its indigenous range to avoid extinction.

Insurance population
Maintaining a long-term viable *ex situ* population of the species to prevent predicted local, regional or global species extinction and preserve options for future conservation strategies. These are typically species that are threatened and for which it is unsure whether *in situ* threat mitigation will have the sufficient effect in a sufficient timeframe to prevent the extinction of the species or to prevent a dramatic decline in the numbers, populations and/or genetic diversity of the species. An *ex situ* population may be desired as an insurance population from which individuals can be extracted for genetic and/or demographic supplementation or other conservation translocations as required, but these are not yet actively planned the foreseeable future.

***Ex situ* research and/or training**
Ex situ populations that are used for research and/or training that will directly benefit conservation of the species, or a similar species, in the wild (e.g. monitoring methods, life history information, nutritional requirements, disease transmission/ treatment). The research/training addresses specific questions essential for success of the overall conservation strategy for the species. This can include non-threatened species serving as a model for more threatened species, or establishing *ex situ* populations of a threatened species to gain important species-specific husbandry and breeding expertise that is likely to be needed in the future to conserve the species.

Conservation Education
The *ex situ* management forms the basis for an education and awareness program that addresses specific threats or constraints to the conservation of the species or its habitat. The education addresses specific human behavioral changes that are essential for the success, and an integral part of, the overall conservation strategy for the species. This primarily involves *ex situ* locations visited by the intended human audience.

INDIRECT CONSERVATION ROLES FOR *EX SITU* MANAGMENT

These are situations in which the zoo community can contribute to conservation by:

- **making available its expertise, knowledge, materials, staff, fund raising, etc. to help implement *in situ* conservation actions, and/or**
- **carrying out general awareness and conservation education activities aimed at the zoo visiting public**

Indirect conservation contributions can be made for a species regardless of whether or not it is held in captivity.

Examples of indirect conservation roles include:

- Providing knowledge, experience or training to build capacity for veterinary care or handling of individuals in the field (e.g. radio collar application, transport, etc.) or in the context of law enforcement (rescue centers, human wildlife conflicts etc.)
- Making available existing zoo education materials or education/behavior change expertise to teams developing awareness programs for local communities *in situ*.
- Carry out education and awareness about the status of and threats to the species. Increase interest in the species and its habitat/ecosystem.
- Networking and lobbying to influence opinions, legislation processes, etc.
- Small scale fundraising to contribute to high priority *in situ* projects or IUCN SSC Specialist Group activities
- And others …

NON-CONSERVATION ROLES FOR *EX SITU* MANAGMENT

Questions that can be asked to investigate non-conservation roles for *ex situ* management in zoos and aquaria:

- Is this species required/suited to let holders gain experience in canid/hyaenid husbandry before taking on more difficult species? Specify which type of experience.
- Is the species important for research that is not conservation related (basic and applied research)? Specify the research fields.
- Is the species particularly valuable for non-conservation education (specific aspects of canid/hyaenid biology)? Specify the education topics.
- Does the species have an above average evolutionary distinctiveness score (see page 7 and 8)?
- Is the species colorful/distinctive/diurnal/active and particularly attractive as a zoo exhibit?
- Does the taxon have a special human cultural value (e.g. as a national or regional symbol, in a historic context, featuring in traditional stories, etc.) or economic value (e.g. traditional medicine, tourism, hunting) within its natural range or in a wider global context, and does this give the species a particular value for education or exhibit?

RATING OF ROLES

Conservation benefit of any direct conservation roles chosen (as a group): High/Medium/Low

Conservation benefit of any indirect conservation roles chosen (as a group): High/Medium/Low

Importance of the species to the zoo community, unrelated to conservation: High/Medium/Low

DETERMINING CHARACTERISTICS AND RESOURCES OF THE *EX SITU* POPULATION NEEDED TO FULFIL THE IDENTIFIED ROLE(S)

1. **General characteristics**
   - Does the program likely need to be long, medium or short term?
   - Is a release phase already planned for the foreseeable future?
   - Is proximity to the natural habitat crucial or beneficial?
   - Do the *ex situ* activities involve whole living organisms and/or live bio-samples?
   - What level of human proximity or interaction is desirable?

2. **Founders and population size**
   - Is the founder base of the current *ex situ* population likely already sufficient or are more founders required?
   - Can additional founders or unrelated individuals be (legally and logistically) obtained? From wild? Other zoo regions? Other *ex situ* collections?
   - Can the population be kept at, or grown to, the required population size?

3. **Genetic and demographic management**
   - Is the taxonomy clear *in situ* and *ex situ*? What is the taxonomic scope of the *ex situ* program?
   - Will reproduction be required in the *ex situ* program?
   - Is retention of a high proportion of gene diversity of high, medium or low importance?
   - Is control over the population size/growth and age/sex structure of high, medium or low importance?
   - Is the species best managed at individual or group level?
   - Will breeding and transfer recommendations be necessary? If yes, how important is it that these are mandatory?
   - How likely are ownership and access issues likely to impede success of the program?

4. **Location and scale**
   - Geographic location and scale? Range country involvement?
   - Do (some) non-zoo association members or non-zoo institutions play a role? If yes, what level of commitment is required from them?
   - If work required across regions, is there a need for a formal framework for this or is more informal collaboration sufficient?

5. **Catastrophes**
   - Biosecurity needs?
   - Specific requirements to reduce impact of other potential catastrophes?

6. **Research** or **Training** setup/equipment needed?

7. Particular **welfare** issues to be addressed?

Feasibility: High / Medium / Low
(existing ex situ population, husbandry challenges, technical or logistical challenges, availability of skilled staff, availability of sufficient financial and other resources, …)

Risks: High / Medium / Low
(sensitivity to catastrophes, consequences for wild population, occupying ex situ space for other species that need it more, human health and safety risks, political risks, risks for social or public conflicts …)

SUGGESTED RECOMMENDATION CATEGORIES

a) Reaching consensus whether or not to go ahead with *ex situ* activities with these roles:

- **For conservation roles**: Considering the relative importance/weight of potential conservation benefit (also compared to alternative conservation actions or inaction) *vs.* likelihood of success, costs and risks, what is the recommendation for *ex situ* management, if any, for conservation? Potential factors that can influence the relative weighting:
  - Severity of threats/risk to the wild population
  - Value of the species (ecological, cultural, sociological, economic, evolutionary distinctiveness, potential as flagship species, etc.)
  - Legal and political mandates,
  - Etc.

- **For non-conservation roles**: Considering the relative importance/weight of the benefit of the species to the zoo community (unrelated to conservation) *vs.* likelihood of success, costs and risks – ESPECIALLY the cost of occupying enclosure space for canids/hyaenids, or for other taxa with similar requirements, what is the recommendation for *ex situ* management, if any, for non-conservation reasons?

➔ **Final roles selected (if any) are**: ……………………………………………………………………………………..

b) In order to fulfil the roles selected under a (if any) and build an *ex situ* program with the characteristics defined earlier, which of the actions below is recommended for this species (more than one may apply)? These are non-binding recommendations to be discussed within relevant regional association collection planning and program management structures.

- **Do Not Obtain Globally**
- **Do Not Obtain Regionally** (specify which region(s))
- **Phase out Globally**
- **Phase out Regionally** (specify which region(s))
- **Develop/continue regional studbook** (temporary – for further research – then phase into one of other categories)
- **Develop/continue international studbook** (temporary – for further research – then phase into one of other categories)
- **Develop/continue regional high intensity program** with characteristics defined during workshop process. (In as much as this is possible within regional association *ex situ* program structures and rules.)
- **Develop/continue regional low intensity program** with characteristics defined during workshop process. (In as much as this is possible within regional association *ex situ* program structures and rules.)
- **Develop/continue informal multi-regional program** with characteristics defined during workshop process. (In as much as this is possible within regional association *ex situ* program structures and rules.)
- **Potential candidate for development of formal multi-regional program (e.g. GSMP, RSMP)**

Evolutionary Distinctiveness scores (from ZSL http://www.edgeofexistence.org/)

CANID Species	Common names	GE Score	ED Score
Otocyon megalotis	Bat-eared Fox	LC	8,846867958
Nyctereutes procyonoides	Racoon Dog	LC	7,872139452
Urocyon littoralis	California Channel Island Fox, Channel Islands Fox, Island Fox, Island Gray Fox, Island Grey Fox	CR	6,471532391
Urocyon cinereoargenteus	Grey Fox, Gray Fox, Tree Fox	LC	6,471532391
Vulpes chama	Cape Fox, Silver Fox, Silver Jackal	LC	5,454765503
Vulpes bengalensis	Bengal Fox, Indian Fox	LC	5,405492285
Vulpes cana	Blanford's Fox, Afghan Fox, Corsac, Dog Fox, Hoary Fox, Steppe Fox	LC	4,590209815
Vulpes zerda	Fennec Fox	LC	4,590209815
Lycaon pictus	African Wild Dog, Cape Hunting Dog, Painted Hunting Dog, Wild Dog	EN	4,221528043
Cerdocyon thous	Crab-eating Fox, Common Fox, Common Zorro, Crab-eating Zorro, Forest Fox, Savannah Fox	LC	4,174530331
Speothos venaticus	Bush Dog, Savannah Dog, Vinegar Dog	NT	4,154607202
Chrysocyon brachyurus	Maned Wolf	NT	4,13820942
Atelocynus microtis	Short-eared Dog, Short-eared Fox, Small-eared Dog, Small-eared Zorro	NT	4,084189876
Cuon alpinus	Dhole, Asiatic Wild Dog, Indian Wild Dog, Red Dog	EN	4,001419045
Alopex lagopus	Arctic Fox, Polar Fox	LC	3,911300991
Canis mesomelas	Black-backed Jackal, Chacal À Chabraque, Silver-backed Jackal	LC	3,663512913
Vulpes macrotis	Kit Fox, Desert Fox	LC	3,568916036
Vulpes velox	Swift Fox	LC	3,568916036
Canis aureus	Golden Jackal, Asiatic Jackal, Common Jackal	LC	3,568733385
Canis adustus	Side-striped Jackal	LC	3,568733385
Vulpes vulpes	Red Fox, Cross Fox, Silver Fox	LC	3,560572771
Vulpes rueppellii	Rüppell's Fox, Rueppell's Fox, Rüeppell's Fox, Rüppel's Fox, Rüppell's Sand Fox, Rüppell's Sand Fox, Sand Fox	LC	3,560572771
Vulpes corsac	Corsac Fox, Corsac	LC	3,557949386
Vulpes ferrilata	Tibetan Fox, Sand Fox, Tibetan Sand Fox	LC	3,557949386
Pseudalopex vetulus	Hoary Fox, Hoary Zorro, Small-toothed Dog	LC	3,338245655
Canis simensis	Ethiopian Wolf, Simien Fox, Simien Jackal	EN	3,323787763
Canis latrans	Coyote, American Jackal, Brush Wolf, Prairie Wolf	LC	3,309152245
Canis lupus	Grey Wolf, Arctic Wolf, Common Wolf, Gray Wolf, Mexican Wolf, Plains Wolf, Timber Wolf, Tundra Wolf	LC	3,295050397
Pseudalopex griseus	Argentine Gray Fox, Grey Zorro, South American Grey Fox	LC	2,936270142
Pseudalopex fulvipes	Darwin's Fox	CR	2,936270142
Pseudalopex gymnocercus	Pampas Fox, Azara's Fox, Azara's Zorro, Azara's Fox	LC	2,856731824
Pseudalopex sechurae	Sechura Fox, Peruvian Desert Fox, Sechura Desert Fox	NT	2,85047486
Pseudalopex culpaeus	Culpeo, Andean Fox	LC	2,844044765
		Average:	**4,18952783**

HYAENID Species	Common names	GE Score	ED Score
Proteles cristata	Aardwolf	LC	29,11644048
Crocuta crocuta	Spotted Hyaena	LC	20,6948818
Hyaena hyaena	Striped Hyaena	NT	20,52750819
Hyaena brunnea	Brown Hyaena	NT	20,52362391
		Average	**22,7156136**

CANID AND HYAENID SPECIES ORDERED BY THREAT CATEGORY AND SIZE OF POPULATION IN ZOOS

	***Ex Situ* Status (global pop size)**				
Status	**Large Pop (>100)**	**Small Pop (~50-100)**	**Very Small (<40)**	**Not in captivity**	**Total Taxa**
Threatened	**8**	**0**	**3**	**3**	**14**
Non-Threatened	**9**	**5**	**12**	**3**	**29**
Total Taxa	**17**	**5**	**15**	**6**	**43**

	***Ex Situ* Status (global pop size)**			
Status	**Large Pop (>100)**	**Small Pop (~50-100)**	**Very Small (<40)**	**Not in captivity**
Threatened	African wild dog (696) Bush dog (200) Dhole (363) *Dingo (163)* Maned wolf (371) Mexican gray wolf (243) Red wolf (202) Striped hyena (243)		Brown hyena (13) Island fox (5) Sechura fox (13)	Darwin's fox Ethiopian wolf Short-eared dog
Non-Threatened (Least Concern)	Arctic fox (155) Bat-eared fox (165) Coyote (127) Fennec fox (356) Golden jackal (200) Gray wolf (1172) Raccoon dog (300) Red fox (389) Spotted hyena (265)	Corsac fox (65) Grey fox (48) Iberian wolf (50) Sand fox (49) Swift fox (65)	Aardwolf (6) Bengal fox (7) Black-backed jackal (33) Blanford's fox (28) Cape fox (6) Chilla (6) Crab-eating fox (26) Culpeo fox (22) Kit fox (15) Pampas fox (3) Side-striped jackal (1) Singing dog (37)	Hoary fox Pale fox Tibetan fox

Underlined = non-threatened species with above average Evolutionary Distinctiveness score (from ZSL http://www.edgeofexistence.org/)
Canid and Hyaenid averages calculated separately within these groups – see page 7

CPSG Development and Fundraising: Continuing to support the implementation of CPSG's strategic plan

Convenors: Jo Gipps and Brad Andrews

Aim:

To consider ways in which the wider CPSG community can continue to support the implementation of CPSG's Strategic Plan 2018-2020, *particularly through securing additional funding*.

Background:

The core of CPSG's Strategic Plan (the five Strategic Goals) was drafted by CPSG staff, and was discussed at the CPSG Annual Meeting 2018 in Bangkok. Other sections of the Plan (Mission, Approach and Challenge; Introduction and Context; Governance; Finance; Fundraising) have been added subsequently.

Process:

We shall start by reminding ourselves (very briefly) of The Strategic Plan and the associated fundraising background information, taking close account of last year's discussion.

Then we shall focus on some important questions:

- What potential partnerships exist for CPSG to strengthen its 'case for support'?
- How can CPSG best target its existing donors to increase their support?
- How can CPSG encourage zoos and aquariums, who do not currently support us, to do so?
- How can we attract support from outside the zoo and aquarium community?
    - Trusts and Foundations (any suggestions?).
    - Rich individuals (ditto?).
    - Corporates (ditto?).
- Are there institutions out there that would commit significant and consistent staff time to help CPSG scale up its capacity building?

Outcomes:

- Concrete ideas for fundraising initiatives.
- Volunteering from people prepared to help us with specific initiatives.
- Improvements in structure, reach and utility of all the work needed to deliver the Strategic Plan successfully.

Materials:

Please review the Strategic Plan and the list of background fundraising support material.

IUCN SSC
Conservation Planning Specialist Group

Strategic Plan
2018-2020

IUCN SSC Species Survival Commission

CONSERVATION PLANNING SPECIALIST GROUP

Changing the Future for Wildlife

IUCN SSC
Conservation Planning Specialist Group

CPSG Strategic Plan 2018-2020

<u>Table of Contents</u>

1. Executive Summary

Our Mission is to save threatened species by increasing the effectiveness of conservation efforts worldwide.

We approach this by leading workshops, using science-based tools, and through extensive training programmes.

The challenge we face is to scale up the global conservation community's capacity to ensure that every species that needs a conservation plan is covered by an effective plan.

The Conservation Planning Specialist Group (CPSG) is a member of the largest conservation organization in the world, the International Union for Conservation of Nature (IUCN): Species Survival Commission (SSC).

We have five overarching Strategic Goals:

1. ***Target species are prioritized, and conservation needs assessed, for conservation plan development, and conservation planning efforts are expanded.***
2. ***Context-specific, best practice planning methods are applied based on a One Plan Approach.***
3. ***Species conservation planning capacity is increased across SSC Specialist Groups and IUCN members.***
4. ***The ability of governments to meet international biodiversity targets is improved.***
5. ***Species conservation planning methods are evaluated for impact and effectiveness, leading to continual improvement.***

CPSG's staff, based in Minneapolis, support 11 Regional Resource Centres around the world.

Around 300 volunteers (conservationists, scientists, government and NGO personnel) are Members of CPSG.

Around 200+ Donor Institutions (mostly zoos and aquariums, zoo associations, individuals) support CPSG financially.

The twelve international Trustees of a 501c3 charity (called the Global Conservation Network) oversee the financial and governance matters of CPSG.

The CPSG Strategic Committee, composed of 40+ CPSG Members, discusses and advises the CPSG Chair (Chief Executive) on matters other that governance and finance.

A small Fundraising Committee works actively to secure funds for all CPSG activities (delivered to CPSG via GCN), and is in the process of ramping up its size and capabilities to meet the challenges described in the document.

The costs of all the new activity, described here, and intended to deliver the 5 Goals, is calculated to be $1.3 over the next three years.

2. Our Mission, Approach, and Challenge

Our Mission

CPSG's Mission is to save threatened species by increasing the effectiveness of conservation efforts worldwide. For over 30 years, we have accomplished this by using scientifically sound, collaborative processes, bringing together people with diverse perspectives and knowledge to catalyze positive conservation change.

We provide species conservation planning expertise and training to governments, SSC Specialist Groups, zoos and aquariums, and other wildlife organizations.

Our Approach

Workshop Processes

Our workshops provide an objective environment, expert knowledge, and thoughtful group facilitation. They are designed systematically to address problems and develop focused solutions using sound science.

Science-Based Tools

CPSG develops and employs a wide variety of tools to assist conservation professionals in developing effective strategies for averting extinction of endangered species.

Training

Training lies at the heart of CPSG's work; by training a large group of facilitators, modellers and others from within the IUCN/SSC Specialist Groups, we shall be able to scale up the amount of conservation planning that will be needed in future.

Our collaborative, inclusive, and science-based approach to conservation ***planning*** ensures delivery of the most effective conservation ***action*** to protect future generations of threatened species.

Our Challenge

Over the next three years we intend to take a lead role in scaling up the global conservation community's capacity to ensure that *every species that needs a plan is covered by an effective plan.* By 2020, the Species Survival Commission (SSC) has committed to make significant impacts on the status of threatened species worldwide and, as central pillar of this plan, asked CPSG to lead on the up-scaling of species conservation planning, so that we measurably increase the number of threatened species supported by an effective plan

CPSG's own Strategic Plan 2018-2020 has been developed to meet this challenge. It consists of five goals that involve:

- Developing more efficient processes to move species from threat assessment, through conservation planning to action;
- More effectively including all individuals of a species in our decision-making processes - whether *in situ* or *ex situ* – so that we most effectively plan for the recovery of species;
- Increasing institutional and individual capacity for species conservation planning across IUCN SSC Specialist Groups, national authorities and other IUCN member organizations globally
- Enabling governments to meet their commitments to relevant Convention on Biological Diversity's (CBD) Aichi Targets and United Nations Sustainable Development Goals
- Evaluating the impacts of species conservation planning on the recovery of threatened species to ensure continued learning and improvement.

3. Introduction

We have lost more than 50% of wildlife in the last 40 years[1]. With more than seven billion people on the planet and between 50 to 70% of the Earth's land surface already modified for human activities, this loss is likely to increase. Unless, that is, **we can develop strategies which recognize human needs** alongside those of the biodiversity on which all life depends.

Success is possible. Where conservation actions have been implemented through a **collaborative planning process that is stakeholder-inclusive**, recognizing the multiple needs of diverse interest groups, significant species recovery can be achieved. In 1990, approximately 450 golden lion tamarins remained in scattered fragments across Brazil's Atlantic forest. Multiple conservation projects were undertaken, and, with careful conservation planning and facilitation, these various projects became unified around concrete goals that dramatically reversed the species' decline. The population now stands at around 3000, and work continues to connect and conserve the species' fragmented habitat.

The **Conservation Planning Specialist Group** (CPSG) is a member of the largest conservation organization in the world, the **International Union for Conservation of Nature** (IUCN): **Species Survival Commission** (SSC). CPSG has been working for more than 30 years "to save threatened species by increasing the effectiveness of conservation efforts worldwide." Through the development of collaborative planning processes, we bring together people with diverse perspectives and knowledge to catalyze positive conservation change. We have facilitated more than 600 workshops in 71 countries that have often acted as 'pivot points' in the conservation of over 250 species with which we have worked to date.

Context

Given the escalating deterioration in the overall state of nature, the need for the IUCN SSC to substantially increase the scale and effectiveness of its conservation planning for species is clear. In recognition, the SSC in 2016 committed to working towards a world in which the status of species is improved through conservation planning to support governments and wider society in achieving United Nations Sustainable Development Goal-Target 15.5 "to take urgent and significant action to reduce degradation of natural habitat, halt the loss of biodiversity, and by 2020 protect and prevent the extinction of threatened species". This commitment is reflected in the equally ambitious goal: Every species that needs a conservation plan will be covered by an effective plan and in the fact that, for the first time, the 2017-2020 SSC Strategic Plan includes a species conservation planning objective.

Since 1979, the IUCN SSC Conservation Breeding Specialist Group (CBSG) has been helping to guide the conservation of the world's threatened and endangered species. Originally called the Captive

[1] McRae L, Freeman R & Marconi V (2016) 'The Living Planet Index' in: Living Planet Report 2016: Risk and resilience in a new era (ed. Oerlemans N). WWF International, Gland, Switzerland

Breeding Specialist Group, our network of members and partners helped zoos and aquariums link their *ex situ* activities with *in situ* activities for conservation and provided tools to help them maintain genetically and demographically healthy populations. In 1994, CBSG's mandate expanded to include providing expertise on management of small, *in situ* populations. To better reflect this evolution, we changed our name from 'Captive' to 'Conservation', while remaining focused on integrated species conservation planning for both *ex situ* and *in situ* populations.

In November 2016, the SSC Chair formally requested the Conservation Breeding Specialist Group (CBSG) to take the lead in delivering the SSC species conservation planning objective, in collaboration with other Specialist Groups. CBSG has consequently been renamed the IUCN SSC Conservation Planning Specialist Group (CPSG) in recognition of this expanded mandate. CPSG's challenge is to facilitate an increase in the SSC's involvement in planning, with a focus on responding to the needs of governments to conserve and protect their biodiversity.

The CPSG network brings a great deal of expertise and resources to the table and the SSC, as a whole, has a long history spanning more than three decades of planning for species conservation designed to be responsive to the needs of the time. This includes the IUCN 'black book' Action Plans of the 1980s and 1990s, the Strategic Planning guidance of the 2000s, and a host of tailored activities by SSC Specialist Groups. CPSG will catalyze and coordinate these resources in an effort to maximize our collective contributions to conservation planning, make progress on the SSC Strategic Plan and, in turn, towards the international biodiversity targets to reduce the risk of extinction of the species with which we share this planet.

This IUCN SSC CPSG Strategic Plan is designed to provide a shape and direction to our response to the SSC's challenge, laying out how the CPSG network, with colleagues across the SSC, the Global Species Program and IUCN more broadly, and with the support of the Global Conservation Network (GCN), plan to deliver on our responsibility, contribute to achieving the relevant Key Species Results (KSRs) of the 2017-2020 IUCN SSC Strategic Plan, and increase substantially the effectiveness of the SSC's leadership in planning to avoid species extinctions.

In late February 2017, we convened a creative thinking meeting to gather advice and guidance from across the CPSG network, from other SSC Specialist Group Chairs, the Global Species Program, GCN and other partners. We also conducted an SSC-wide species conservation planning survey to identify planning priorities, technical and training needs, and expertise available in the Commission that can be brought together to meet those needs.

It is within this framework that the IUCN SSC CPSG Strategic Plan was crafted.
The Plan consists of 5 high level goals, with associated objectives and actions, which map directly to SSC Strategic Plan KSRs 15-18, 21 and 25. (see Diagram, page 7, below)

THE CONTEXT

The SSC Species Conservation Planning Vision

The status of species is improved through conservation planning to support governments and wider society in achieving United Nations Sustainable Development Goal-Target 15.5 *"to take urgent and significant action to reduce degradation of natural habitat, halt the loss of biodiversity, and by 2020 protect and prevent the extinction of threatened species"*.

The SSC Species Conservation Planning Goal

Every species that needs a conservation plan will be covered by an effective plan.

The SSC Species Conservation Planning Objective (Objective D, 2017-2020 SSC Strategic Plan)

To provide leadership in scaling up multi-stakeholder species conservation planning and priority setting in order to: i) support efforts to conserve and restore populations of species under threat; and ii) to halt species extinctions by 2020.

2017-2020 SSC Strategic Plan Key Species Results

KSR 15.
IUCN SSC species conservation planning efforts are significantly expanded, especially for priority species. A method for prioritization of species planning is developed and more conservation action planning is undertaken to halt the loss of biodiversity, and protect and prevent the extinction of threatened species.

KSR 16.
IUCN SSC species conservation planning efforts are monitored for impact and effectiveness. Evaluation approaches are developed and implemented to measure, improve and report on the impact and effectiveness of IUCN SSC's species conservation planning efforts.

KSR 17.
Species conservation planning capacity is built through expanded training programs. Capacity is developed to expand effective species conservation planning efforts throughout the SSC network and beyond, and ensure that these efforts are considered valuable and accessible to all relevant parties.

KSR 18.
IUCN SSC provides rigorous guidance for species conservation planning through the continued development and application of cutting-edge, science-based tools and processes. IUCN SSC Species Conservation Planning features best practices using an adaptive, evidence-based approach, with application of tools and processes that contribute to, and are informed by, emerging scientific and technological advances in conservation biology and related fields.

KSR 19.
IUCN SSC species conservation planning is sufficiently and sustainably resourced. Funding and human resources are secured to ensure the growth and sustainability of IUCN SSC's species conservation planning.

KSR 20.
The discipline of "Species Conservation Planning" is formally embedded in SSC's organizational framework in a way that reflects its increasing importance to SSC's work. A Species Conservation Planning structure is put in place, catalysing and guiding the governance and implementation of species conservation planning in SSC.

KSR 21.
IUCN SSC is recognized as a leader in species conservation action planning. IUCN SSC Species Conservation Planning processes are increasingly adopted or built upon, and evidently guide conservation actions and influence policy.

KSR 25.
Conservation Breeding, and links to the ex situ *community.* Advice and facilitation is in place to support *ex situ* species recovery programs.

4. Goals, Objectives, and Actions

These five goals, when taken together, will guide achievement of the SSC Key Species Results and, ultimately, the fulfillment of our shared vision.

Goal 1. ***Target species are prioritized, and conservation needs assessed, for conservation plan development, and conservation planning efforts are expanded (KSR15, 21)***

Goal 2. ***Context-specific, best practice planning methods are applied based on a One Plan Approach (KSR18, 25)***

Goal 3. ***Species conservation planning capacity is increased across SSC Specialist Groups and IUCN members (KSR17, 21)***

Goal 4. ***The ability of governments to meet international biodiversity targets is improved (KSR21)***

Goal 5. ***Species conservation planning methods are evaluated for impact and effectiveness, leading to continual improvement (KSR16)***

Two additional KSRs (19 and 20) for which CPSG is responsible do not have corresponding goals in this plan.

KSR 19 is around financing for species conservation planning: *IUCN SSC species conservation planning is sufficiently and sustainably resourced*. The resources, human and financial, needed to implement the CPSG Strategic Plan are still being determined. Human resource needs are, in part, addressed in Goal 3 around capacity building. Once there is a clearer idea of the scale of the financial support required to sustainably resource species conservation planning within the SSC, a finance plan will be developed under the guidence of the Global Conservation Network (GCN), an independent charity incorporated to support the work of CPSG. The SSC Chair's Office and the GCN Board will work together to raise the necessary funds.

KSR 20 calls for the discipline of "Species Conservation Planning" to be formally embedded in SSC's organizational framework in a way that reflects its increasing importance to SSC's work. By expanding the mandate of CBSG, and changing the name to CPSG, the SSC Chair has clearly taken initial steps to meet this KSR. Through the application of Version 2.0 of the SSC Strategic Planning for Species Conservation guidance, and CPSG's successful implementation of the strategic goals around development of capacity and dissemination of a shared set of planning tools, species conservation planning will be firmly rooted in the SSC.

It is our intention to convene a strategic planning meeting in 2019 to review progress, adjust the plan as necessary and begin preparations for the 2021-2024 quadrennium.

Goal 1: Target species are prioritized, and conservation needs assessed, for conservation plan development, and conservation planning efforts are expanded (KSR 15, 21)

Through our Regional Resource Centers, SSC Specialist Groups, governments and non-governmental organizations (NGOs), we will assist in identification of those species for which the development of conservation plans would provide greatest net return (in terms of species conservation). We will respond (with the same commitment and enhanced capacity) to requests for assistance with urgent and/or high conservation value projects that come to us via traditional channels and from Specialist Groups. In collaboration with relevant stakeholders, efforts will be made to increase the number of species covered by effective plans.

CPSG Leads: Caroline Lees, Phil Miller

Introduction

Conservation planning identifies the conservation needs of species and connects them to those with the capacity and will to provide for them. Species conservation planning may be undertaken in a range of contexts and may be focused on a single species, on all members of a taxonomic group, or on multiple taxa residing in a particular ecosystem, area or country. Though it is the central focus of our work, we recognize that conservation planning is only one part of a sequence of steps involved in ensuring that all species receive the conservation attention they need (see Figure 2). The first step in this sequence is to understand what species there are (Inventory); next is to understand which are likely to need conservation support (Risk Assessment); conservation planning then helps us to understand what kind of conservation support is needed (Conservation Needs Assessment); and how we might best connect those needs to the will and capacity to act through evaluation of benefits, costs and feasibility of potential options (Species Conservation Action Planning); the implementation of resulting plans must be monitored (Implementation Monitoring); and finally, we need to review the effectiveness of all of the steps in delivering results for species, to see where improvements can be made (System-wide Review and Revision). We recognize that we need to expand significantly our capacity to produce a wider range of species conservation plans on behalf of the SSC and that this will mean moving more species, more rapidly, through this planning cycle. To help with this we will develop or employ additional tools and resources, find ways to make better and more efficient use of existing ones, and work to make smarter decisions about where to target our expanding capacity.

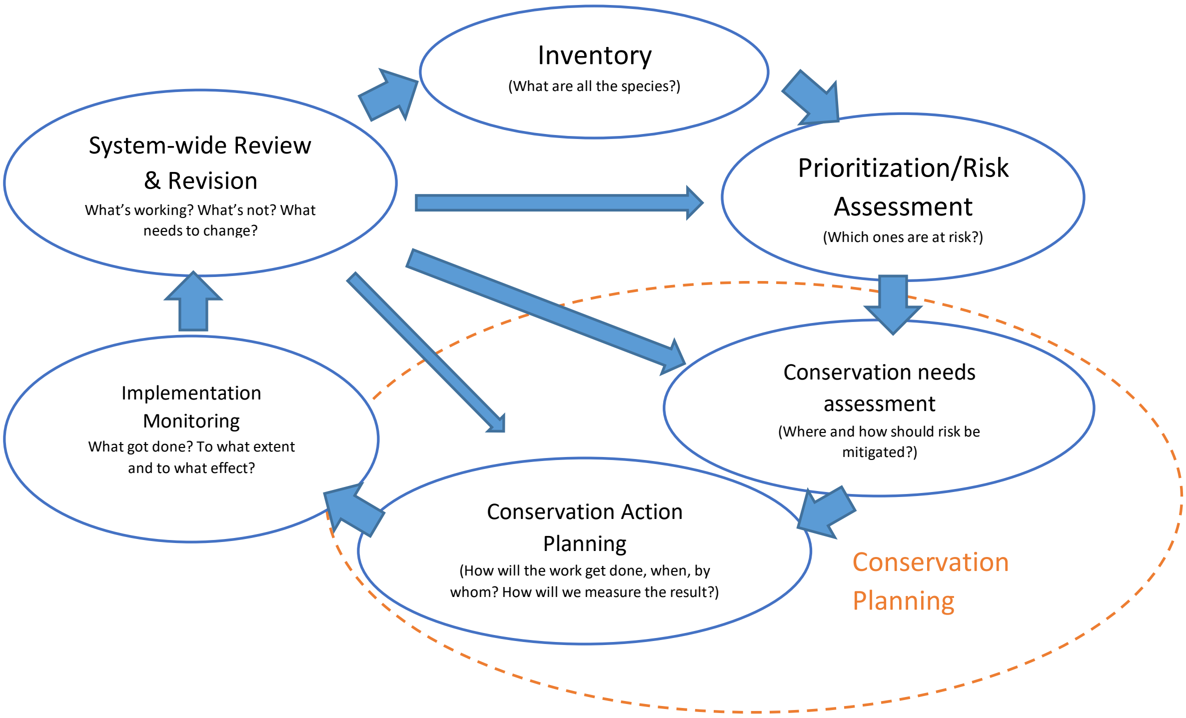


Figure 2. A generalized sequence of steps for providing species with the conservation attention they need (the broken orange line delineates the conservation planning steps).

Objectives

<u>Objective 1.1</u>

Explore deployment of a more rapid risk assessment tool for Specialist Group-driven risk assessments, particularly for species-rich taxonomic groups, to accelerate the diagnosis of taxa for which planning might be needed.

Red Listing, assessing conservation needs and action planning should be complementary rather than competing activities. In reality, at present, resources are such that prioritizing formal red-listing as the first step in the SSC's approach to species conservation planning can mean delaying planning for some years, particularly where groups are dealing with large numbers of taxa. We will explore tools for rapidly diagnosing species potentially in need of planning and, where useful, enable broader access to them. We aim to do this in a way that complements rather than competes with, Red List resources.

<u>Objective 1.2</u>

Deploy a universally applicable conservation needs assessment tool.

The knowledge and experience of SSC Specialist Groups makes them the ideal not only for conducting risk assessments but also for taking the next step and identifying conservation needs in a systematic and transparent way. There is currently no specific SSC tool or process designed to elicit this additional layer of information and, if collected, no easily searchable place in which to store it (the Red List 'conservation actions needed' field is not mandatory, not systematically used, and not searchable). Part of the role of a universal conservation needs assessment tool would be to identify whether the species should be the subject of conservation planning and if so, what kind of planning attention would be most appropriate (e.g. range-wide single or multi-species, or planning targeted at a specific threat, area or ecosystem). The IUCN's Key Biodiversity Areas tool will be relevant here.

Objective 1.3

Improve complementarity between Red Listing, conservation needs assessments, and conservation planning.

There are areas of overlap among these activities and, therefore, opportunities to create efficiencies and synergies.

Objective 1.4

Provide a generic process for species prioritization for planning, adaptable to a range of relevant situations.

Over one third of Specialist Groups responding to the recent SSC species conservation planning survey have no method by which to prioritize species for planning. In addition, respondents identified Red List categories as the most commonly employed factor in use by SSC Specialist Groups to identify species priorities for planning. Using this as a single criterion immediately excludes all taxa not yet assessed. Further, with limited conservation resources and more than 23,000 species identified as threatened, Red List category alone will not provide sufficient direction for the SSC on which species they should pursue planning for, or which they should pursue planning for first. Further, other conservation actors (governments, NGOs, community groups) will have viewpoints, values, and constraints that differ from those of Specialist Groups such that no single set of prioritization criteria will suit all circumstances. Though priorities are needed, it is important that they are generated transparently and are not divisive.

Objective 1.5

Increase the rate of conservation planning (number of species with identified conservation needs and actions).

By developing and implementing multi-taxa rapid assessment tools (Goal 2), and complemented by increased capacity for conservation planning (Goal 3), a larger number of species will be assessed more effectively and conservation actions identified.

Actions

Action	Output	Outcome	Timeline	Resources
Objective 1.1. Explore deployment of a more rapid risk assessment tool for Specialist Group-driven risk assessments, particularly for species-rich taxonomic groups, to progress faster the diagnosis of taxa for which planning might be needed.				
1.1.1 Work with Specialist Groups to explore current status and potential utility of the assessment tool RAMAS RapidList.	RapidList is readily accessible to Specialist Groups.	Faster diagnosis of those taxa that are likely to be threatened and in need of planning support.	End of 2018	Est. USD 3000 if reinstatement on Red List site needed
1.1.2. If RapidList is found unsuitable, identify, or if necessary develop, a system similar to those used by Amphibian Ark (AArk), New Zealand Department of Conservation (NZDoc), or automated plant red listing process used in Brazil*.	A rapid risk assessment tool is readily accessible to Specialist Groups.	Faster diagnosis of those taxa that are likely to be threatened and in need of planning support.	End of 2019	
Objective 1.2. Deploy a universally applicable conservation needs assessment tool.				
1.2.1. Identify, assess and compare relevant systems and resources (e.g. systems used by AArk and NZDoc, CAMP Section 2, relevant Red List classification standards). **1.2.2.** Use this analysis to develop a universal conservation needs assessment tool for broad application.	Universal Conservation Needs Assessment (UCNA) tool developed and widely deployed, with adequate provision for both *in situ* and *ex situ* management needs, and for threat mitigation needs arising from the human dimension (e.g. climate change impacts, unsustainable development, displacement and migration of people; laws, enforcement, policy and practice; demand for wildlife products etc.)	Specialist Groups are supported to complete and report centrally on standardized conservation needs assessments for taxa.	End of 2019	To be determined

Action	Output	Outcome	Timeline	Resources
1.2.3. Ensure appropriate consideration of potential *ex situ* conservation options in the UCNA.	UCNA includes assessment of ex situ management options in accordance with IUCN *ex situ* guidelines	Universal Conservation Needs Assessment incorporates *ex situ* management options	End of 2019	
1.2.4. Promote and support the use of the UCNA tool by SSC SGs.	SSC SGs are aware of, and actively conducting, UCNAs.	Universal Conservation Needs Assessment is seen as an essential element of every taxonomic Specialist Group's remit.	By 2020	
Objective 1.3. Improve complementarity between Red Listing, conservation needs assessments, and conservation planning.				
1.3.1. Support SGs to assess conservation needs in conjunction with Red List assessments, using the new tool (see above).	Methodology tested and deployed for including UCNAs in conjunction with Red List assessments.	Greater complementarity between Red Listing and UCNAs. More UCNAs conducted.	Ongoing – report annually on progress	CPSG staff time. SGs will need resources to do this – proceed opportunist ically
1.3.2. Work with SGs to ensure that outputs from at least all SSC facilitated or enabled planning projects, and ideally from any existing planning projects, are incorporated into the Red List database.	Red List includes data from at least all SSC facilitated or enabled planning projects.	Greater complementarity between Red List data and conservation planning outputs.	Ongoing – report annually on progress	CPSG staff time. RL office needs resources to make this possible – proceed opportunist ically
Objective 1.4. Provide a generic process for species prioritization for planning, adaptable to a range of relevant situations.				
1.4.1. Based on a review of the literature, develop guidelines for prioritization approaches likely to be of value in typical planning prioritization scenarios.	Guidelines for species conservation planning prioritization	Relevant stakeholders have access to guidance on prioritization for planning – duplication in this area is reduced.	2019	No special funding needed. However, staff and volunteer time will need to be committed to it.

Action	Output	Outcome	Timeline	Resources
1.4.2. Explore potential for an expert system that allows users to build their own prioritization tool using criteria developed and tested by others (e.g. IUCN Critically Endangered & Endangered; Evolutionarily Distinct and Globally Endangered (*EDGE*), Alliance for Zero Extinction (AZE), etc.).	Expert system for prioritizing species for planning attention	Specialist Groups, in-country wildlife departments, ex situ facilities, etc., can rapidly prioritize species for planning and action using widely recognized, well tested prioritization criteria, freely accessible to them through an expert system.	Report on feasibility and utility – mid-2018	No special funding needed. However, resources will need to be committed to it, in terms of both staff and volunteer time – amount dependent on design
Objective 1.5. Increase the rate of conservation planning (number of species with identified conservation needs and actions).				
1.5.1. Apply the developed rapid assessment tools above, and multi-species planning tools (Goal 2) in CPSG-led or CPSG-inspired conservation planning activities to increase the number of species receiving conservation planning attention.	Rapid assessments, and single and multi-species planning projects are conducted.	Conservation needs and actions will be identified for species at a faster rate.	Dependent upon tool development and capacity building; increased rate starting in 2019	Staff time and funding to conduct assessments

** Application of such a tool would not replace a more detailed assessment, but would instead be an interim measure. Additional data required for a more thorough assessment could be gathered as part of the needs assessment and planning processes; thus these steps could feed back into red listing rather than wait for its completion.*

Goal 2: Context-specific, best practice planning methods are applied based on a One Plan Approach (KSR18, 25).

We will ensure that IUCN SSC Species Conservation Planning efforts feature the proper application of best practices using an adaptive, evidence-based approach. Planning activities will be increased and enhanced through the use of tools and processes that contribute to, and are informed by, emerging scientific and technological advances in conservation biology and related fields.

CPSG Leads: Phil Miller, Caroline Lees and Kathy Traylor-Holzer

Introduction

The Conservation Breeding Specialist Group has always been recognized as a leader in the development and application of rigorous, science-based tools and processes for the purposes of strategic conservation planning for endangered species. As we evolve as an organization through our expanded role as the Conservation Planning Specialist Group, it is vital for us to retain this critical leadership role. As the science of conservation biology continues to evolve, and the theory of structured decision analysis for biodiversity conservation becomes more refined, we must continue to scan the horizon for cutting-edge tools that will help us produce more meaningful conservation plans for a wider range of threatened taxa than we have considered in our history. We firmly believe that developing and implementing a comprehensive “toolkit” of conservation planning elements – including both science-based analytical tools and process-based facilitative techniques – allows for the creation of a broader array of more effective plans that are responsive to the conservation needs and specific contexts of the many taxa requiring dedicated conservation planning activity.

In addition, we will promote, enhance and implement the One Plan Approach (OPA) to species conservation planning, facilitating further linkages between the global *ex situ* community and *in situ* management stakeholders; enhancing cross-fertilization of expertise between both communities; ensuring that intensively managed populations are as useful as possible to species conservation; accelerating the evolution of species conservation planning tools; and ultimately leading to a decline in the loss of biodiversity.

The One Plan Approach (OPA) to species conservation promotes the joint development of management strategies and conservation actions for all populations of a species by all responsible parties to produce a single comprehensive conservation plan for the species. This includes recognition, by both *in situ* and *ex situ* communities, of the diverse potential conservation roles of *ex situ* activities; systematic evaluation of benefits, costs, risks and feasibility of potential *ex situ* options for the species; and incorporation of *ex situ* activities, when and as appropriate, into species conservation plans. This approach results in comprehensive plans that can drive both *in situ* and *ex situ* activities to support species conservation and enables *ex situ* facilities to serve as true conservation partners. Field conservationists benefit by gaining additional tools, expertise and resources for addressing both short-term and long-term threats to species in the wild, and *ex situ* partners receive guidance and form partnerships that result in appropriately structured *ex situ* activities to support conservation. By including all stakeholders and evaluating all possible management options and populations, the One Plan Approach ensures that all potential conservation efforts are being used to save a species from extinction.

The current IUCN Guidelines on the Use of Ex Situ Management for Species Conservation outline an informed and transparent decision process that defines potential conservation roles and evaluates their feasibility, risks, and likelihood of success. This decision process is flexible and can form the basis of tools to support ex situ conservation (KSR25) and thereby the OPA.

In collaboration with other SSC members and partners, we will make freely available to all that require them a spectrum of conservation planning tools that harness the diverse approaches adopted across the IUCN and meet the needs of Specialist Groups, NGOs, governments and civil society groups engaged in planning for species.

Objectives

Objective 2.1

Explore opportunities to strengthen the tools and processes used for single-species conservation planning activities.

We will continue to use our traditional PHVA-based conservation planning process for intensive conservation planning of individual species or populations. This process must continue to evolve through the incorporation of components of other planning processes and through the assimilation of relevant new tools and technologies as these emerge.

Objective 2.2

Develop a suite of planning tools and templates that can be applied to planning activities for multiple species on a landscape.

Species conservation planning tools currently in use by CPSG and the wider SSC typically focus on one or a few species at a time. Though better plans may result from this more thorough but time-intensive approach, the time and costs involved restrict the rate of progress and place dedicated planning out of reach for most species. For many taxa, even a relatively simple approach to planning will likely be better than no planning at all. We will evaluate a number of existing strategies for multi-species planning for their applicability to our own expanding scope of work. For example, the IUCN's Key Biodiversity Areas (KBAs) initiative, which helps to identify areas that support high concentrations of threatened species, can provide an important framework for this activity.

Objective 2.3

Contribute to enhancing the SSC Species Conservation Planning Guidelines.

A new Version 2.0 of the IUCN SSC Species Conservation Planning Guidelines has been approved by the SSC Steering Committee. Key elements of CPSG's toolkit are a valuable addition. The new Guidelines are lengthy and attempt to cover a significant breadth of diverse topics; a more focused "Practitioner's Guide" aimed at planning facilitators could further improve the utility of this document.

Objective 2.4 (see Objective 3.2)

Increase the value to SSC planning of the IUCN SSC Species Conservation Planning Tools Library.

The IUCN SSC Species Conservation Planning Tools Library provides a central location for information about an array of tools of value to species conservation planning. For each tool, it identifies the step or steps in the planning process to which it is most relevant and provides details of its strengths and weaknesses for different planning situations.

Objective 2.5

Increase awareness and consideration of potential *ex situ* conservation roles and activities where appropriate among all species conservation planners and population managers.

Many wildlife managers and *ex situ* population managers are unaware of the potential direct conservation benefits of *ex situ* activities or do not consider the diversity of *ex situ* activities that can address primary threats, buy time in emergency situations, offset population instability, and/or restore wild populations. Raising awareness of these conservation options, and providing training in the decision process to evaluate them in the IUCN SSC Guidelines on the Use of *Ex Situ* Management for Species Conservation, promotes their appropriate consideration in the species conservation planning process and in *ex situ* collection planning.

Objective 2.6

Provide tools and processes for evaluating and incorporating *ex situ* options into species conservation and collection planning.

Historically, conservation planning efforts for *in situ* and *ex situ* populations of a species have been initially developed separately rather than as a collaborative and interactive exercise to most effectively address the conservation needs of a species. This is due in part to a lack of tools and processes to facilitate such integration. New tools will be explored and developed to facilitate application of the IUCN *ex situ* guidelines and its decision process into single and multi-species conservation planning and *ex situ* collection planning, including both process and modeling tools.

Objective 2.7

Promote integrated species conservation planning by involving both *in situ* and *ex situ* communities in OPA species conservation and collection planning processes.

It is important that species experts and managers from both communities are involved in planning for both *in situ* and *ex situ* populations. This is necessary for integrated planning under the One Plan Approach and builds relationships to facilitate future conservation collaborations. Access to data on both *in situ* and *ex situ* species status facilitates this integration.

Actions

Action	Output	Outcome	Timeline	Resources
Objective 2.1 Explore opportunities to strengthen the tools and processes used for single-species conservation planning activities.				
2.1.1 Assemble and evaluate existing processes (Open Standards, Conservation Action Planning, Priority Threat Management, Human-Wildlife Conflict Analysis, etc.) for the applicability of selected components to PHVA-based planning methodology	Revised PHVA Handbook with expanded suite of appropriate tools for analysis and process facilitation, incorporated into *Practitioner's Guide* (see Action 2.3.2)	Continued improvements to CPSG's "trademark" planning process	Ongoing – report annually	None from CPSG budget initially, but will require staff time and perhaps funding for a dedicated workshop or two.
2.1.2 Continue collaboration with and support for the Species Conservation Toolkit Initiative	An evolving toolkit that continues to meet the planning needs of the SSC	Planning for species is well-supported by SCTI tools	Ongoing	CPSG will need to commit time and energy to this and our partner, SCTI, will need to commit significant resources, both financial and human.
Objective 2.2 Develop a suite of planning tools and templates that can be applied to simplified planning activities for multiple species.				
2.2.1 Review existing approaches to multi-species conservation planning and adopt or adapt for general use.	Expanded suite of planning tools and templates drawing from multi-species conservation planning approaches	Ability to apply CPSG planning principles across a broader spectrum of situations (single/few/many taxa, simple to complex planning needs, etc.)	Ongoing – report annually	Will require staff time and funding for a dedicated meeting.

Action	Output	Outcome	Timeline	Resources
2.2.2. Explore the strengths and weaknesses of the theory and application of systematic conservation planning as a multi-species conservation planning process for potential use by CPSG	Internal document reviewing the use of systematic conservation planning and its potential for application within CPSG planning projects	Enhanced ability to decide if, when, and how to incorporate area-based conservation planning approaches into our work	End 2018	Coordinate with WCPA/SSC Joint Task Force on Biodiversit y and Protected Areas
2.2.3. Explore utility and feasibility of developing a "project implementation tracking" tool to assist collaborators in assessing the extent of action plan implementation	A tool (likely MS Excel?) is created and available for tracking implementation of actions within species conservation planning documents	Enhanced follow-up information available to CPSG on the extent of action plan implementation and factors influencing implementation	End 2018	Staff time initially
Objective 2.3 Contribute to enhancing the SSC Species Conservation Planning Guidelines.				
2.3.1 Contribute to the enhancement of version 2.0 of the IUCN SSC planning guidelines through incorporation of quantitative risk assessment, disease risk analysis, the One Plan Approach, and application of the ***IUCN SSC Guidelines on the Use of*** Ex Situ ***Management for Species Conservation***.	Enhanced SSC Species Conservation Planning Guidelines document.	New SSC Species Conservation Planning Guidelines reflect CPSG's philosophy and toolkit.	2017	None - completed
2.3.2 Develop an SSC Species Conservation Planning "*Practitioners Guide*" (see Action 3.2.2)	A "*Practitioner's Guide*" for species planners.	A "*Practitioner's Guide*" supports capacity building and is in regular use by SSC species conservation planning facilitators. The SSC approach to species conservation planning is clear, recognized and available to SSC SGs, governments, and the broader conservation community.	End of 2018	A significant contributio n of staff and volunteer time required as well as funding for a writing workshop.

Action	Output	Outcome	Timeline	Resources
Objective 2.4 Increase the value to SSC planning of the IUCN SSC Species Conservation Planning Tools Library				
2.4.1 Invite submissions from SSC conservation planners and the wider species conservation planning community. **2.4.2** Add revised PHVA Handbook (see Action 2.1.1), "Practitioner's Guide" (see Action 2.3.2), Conservation Facilitator's Handbook (see Action 3.2.2) and OPA implementation resources (see Objectives 2.6 & 2.7) to the Tools Library.	Enhanced and well-used Species Conservation Planning Tools Library	Tools Library is a key resource for the growing network of SSC CPSG planning facilitators and other practitioners. Specifically: • number of tools increases annually; • diversity of tools increases; • tools are rated by users; feedback received and acted upon.	Ongoing. Review by mid-2018	Minimal staff time initially. Estimated cost of upgrade (if needed) = USD 5,000-6,000
2.4.3 Add a user-driven "Rate Tool" facility to the Tools Library and invite SSC planners and networks to view, use and provide feedback on the Library's strengths and weaknesses.	Library rating tool created and made available to conservation community	Improved Tools Library	Mid-2018	Some staff time required initially. Estimated cost of upgrade (if needed) = USD 5,000-6,000
Objective 2.5. Increase awareness and consideration of potential ***ex situ*** conservation roles and activities where appropriate among species conservation planners and population managers.				
2.5.1. Produce publications describing the use of ***ex situ*** options for species conservation, targeting both ***in situ*** and ***ex situ*** communities.	Publication of articles, book chapters, and similar documents in different conservation fora.	Wildlife managers, field conservationists, and others involved in conservation planning for wild populations are aware of the diverse *ex situ* management tools that may support species conservation.	At least two publications in 2018.	Some staff time. Potential publication fees.

Action	Output	Outcome	Timeline	Resources
2.5.2. Give presentations at scientific and zoological conferences on the above topics. Consider convening a dedicated OPA conference.	Ensure that relevant OPA and *ex situ* conservation concepts have been presented to all relevant scientific and zoo association conferences or joint conferences.	*In situ* and *ex situ* communities are each aware of the power and diversity of roles the other plays in support of species conservation.	By 2019	Potential staff time. USD 5000 to attend 2-3 conferences. A dedicated OPA conference could incur significant costs in time and funds
2.5.3. Engage with the botanic garden community in population management and species conservation planning.	Work with botanic gardens to identify appropriate application of the IUCN *ex situ* guidelines to botanical collections (may include publications and/or presentations at meetings)	Improved contributions of botanic gardens to plant species conservation	End 2018	Potential staff time. USD 2000 to attend conference?
2.5.4. Provide online materials on the CPSG website regarding an overview of the OPA and application of the IUCN ***ex situ*** guidelines in species conservation or collection planning.	Provide relevant materials (documents and presentations) on CPSG website.	Species conservation planners are aware of and incorporate consideration of *ex situ* conservation tools into planning activities, as appropriate.	Mid-2018	CPSG staff time
2.5.5. Incorporate an overview of these topics, at the appropriate level, in all CPSG-led training courses. (see Obj 3.1)	Include OPA and *ex situ* conservation tools into training materials	CPSG-trained facilitators understand the process of evaluating *ex situ* conservation tools and incorporate the OPA into future planning activities.	Mid-2018	CPSG staff time

Action	Output	Outcome	Timeline	Resources
2.5.6. Incorporate identification and evaluation of ***ex situ*** options, at the appropriate scale, as a component in all species conservation planning workshops such as PHVAs.	Provide guidance on how to incorporate these concepts and considerations, as appropriate, into all CPSG-led training courses and conservation planning workshops.	CPSG-led conservation planning workshops will incorporate evaluation of *ex situ* tools, as appropriate	End 2018	
Objective 2.6. Provide tools and processes for evaluating and incorporating ***ex situ*** options into species conservation and collection planning.				
2.6.1. Finalize development of the Integrated Collection Assessment and Planning (ICAP) tool to guide Taxon Advisory Groups or similar groups with a multi-species focus in strategic ***ex situ*** collection planning to support conservation.	Provide resources (documents and/or online materials) regarding ICAP process.	Conservation roles will be considered and evaluated by a joint in situ/ex situ team during *ex situ* collection planning, leading to the development of *ex situ* activities that are better designed to address species conservation needs and make better use of *ex situ* resources and expertise.	End 2018	CPSG staff time
2.6.2. Finalize and document the suggested workshop process for detailed evaluation of ***ex situ*** options for a single species ***as a separate but supportive component*** of a broader, integrated conservation planning initiative (i.e., separate workshop or process).	Provide resources (documents and/or online materials) regarding detailed evaluation of *ex situ* conservation options and feasibility.	*Ex situ* conservation options will be considered and evaluated as part of species conservation planning, leading to the development and implementation of *ex situ* activities that are better designed to address species conservation needs.	Mid-2018	CPSG staff time

Action	Output	Outcome	Timeline	Resources
2.6.3. Finalize and document the suggested workshop process for evaluation of ***ex situ*** options ***within*** an integrated species conservation planning workshop (e.g., within a working group).	Provide resources (documents and/or online materials) on how to incorporate evaluation of *ex situ* options into species conservation planning (e.g. PHVA). Incorporate this process into CPSG *Practitioner's Guide*.	*Ex situ* conservation options will be considered and evaluated during species conservation planning, leading to the development and implementation of *ex situ* activities that are better designed to address species conservation needs.	Mid-2018	CPSG staff time

2.6.4. Assist Species Conservation Toolkit Initiative (SCTI) in enhancing population software tools (e.g. Vortex, PMx) for assessing ***ex situ*** management strategies as part of species conservation.	**Enhanced options are available and documented for stochastic modeling of *ex situ* populations and for modeling species meta-populations across the management continuum, including genome banks. This may include a Vortex 'sub-manual' for modelling *ex situ* populations.**	***Ex situ* management options can be evaluated and developed, as appropriate, to support species conservation planning.**	**Initial documentation for Vortex by mid-2018Draft Vortex sub-manual developed in concert with SCTI in 2018; ongoing**	**CPSG and SCTI staff time**
2.6.5. In collaboration with SCTI, consider any tool modifications needed to adapt existing and new tools for plant species conservation planning.	Tools and processes available to assist botanic gardens and other plant *ex situ* facilities in contributing to species conservation planning	*Ex situ* plant collections (botanic gardens, seed banks, etc.) are designed to best contribute to species conservation.	Ongoing	
Objective 2.7. Promote integrated species conservation planning by involving both ***in situ*** and ***ex situ*** communities in OPA species conservation and collection planning processes.				
2.7.1. Involve stakeholders from both communities in all CPSG-led conservation planning workshops (e.g., PHVAs, ICAPs) as well as in SSC facilitated or enabled projects where applicable.	There will be *in situ* and *ex situ* stakeholder involvement in all CPSG-led conservation planning activities.	Better integration of conservation planning and management for all populations of a species	By 2018 and ongoing	
2.7.2. Explore the development or linking of databases that integrate ***in situ*** and ***ex situ*** data for species (e.g., Species360 ZIMS and Red List database).	Information on *in situ* or *ex situ* species status is more accessible	Improved communication and collaboration among all stakeholders managing populations of a species	By 2018	

Goal 3: Species conservation planning capacity is increased across SSC Specialist Groups and IUCN members (KSR 17)

We will develop and implement CPSG's strategic approach for increasing capacity for species conservation planning across SSC Specialist Groups, governments, and the wider conservation community. Through the development and delivery of face-to-face and online training courses and workshops, we will ensure that CPSG through its Regional Resource Centers has a cadre of conservation planners sufficient to respond to global conservation planning needs, and that all SSC Specialist Groups that desire them have sufficient members in place who are equipped with the confidence and competence required to lead species conservation planning processes for their constituents.

CPSG Lead: Jamie Copsey

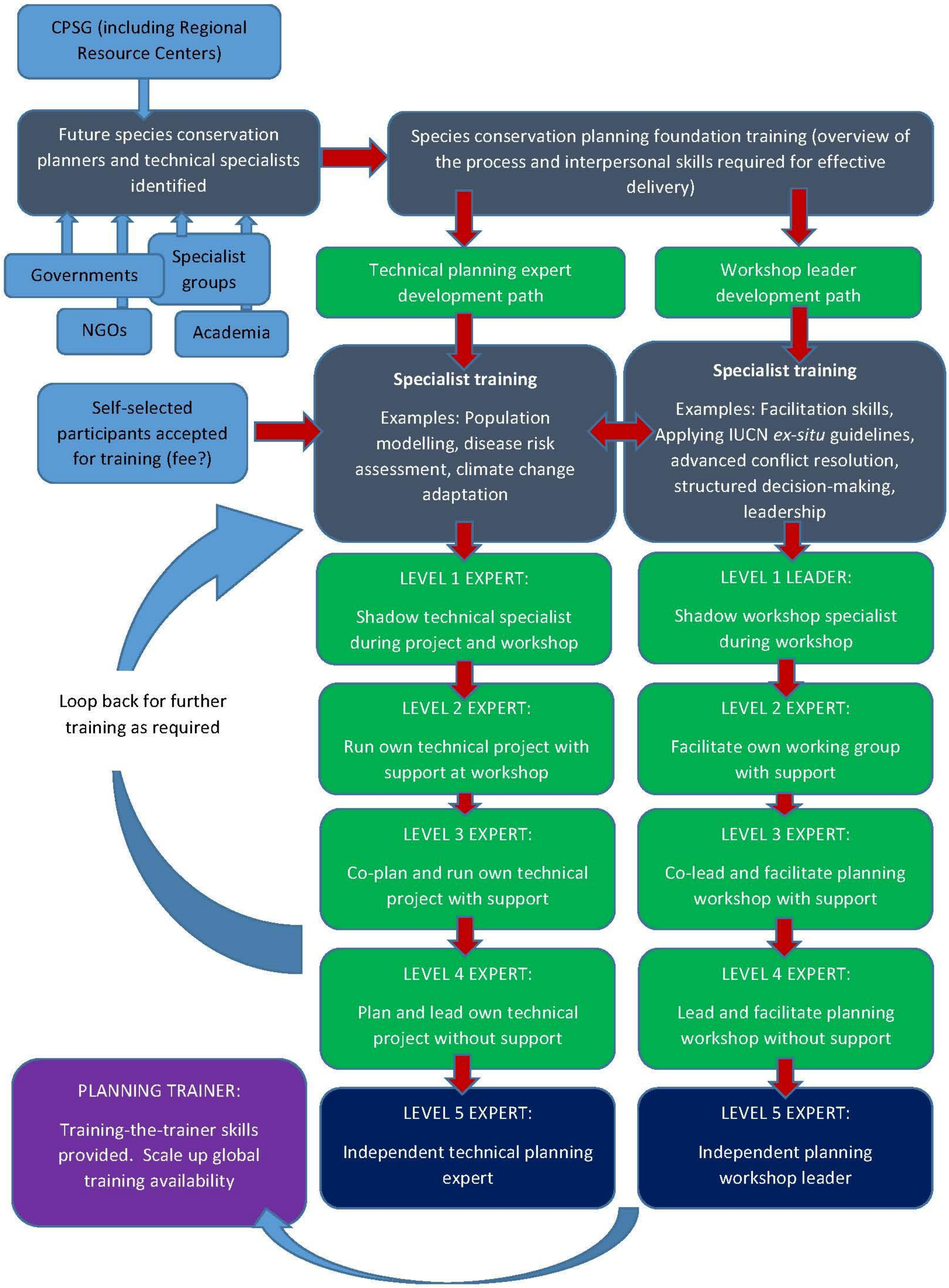
Introduction

With several thousand species currently requiring conservation plans there is a global need for more competent and confident conservation planners. Ninety-three percent of respondents to a recent SSC Specialist Group survey confirmed that there were species or species groups for which conservation planning would be helpful, providing examples ranging from plants, through invertebrates to mega vertebrates. Seventy-eight percent of respondents expressed a desire for more technical assistance in species conservation planning, with 72% expressing an interest in training in the area. If we can meet this need for capacity building within the SSC, then we can make a significant contribution to the conservation community's ability to plan more effectively for threatened species recovery.

The up-scaling of global capacity for species conservation planning (KSR17) will utilize and contribute to the innovation in conservation planning tools (KSR18), as the cadre of trained 'species conservation planners' grows, applies existing tools, learns, and informs the development of new tools. This expanding pool of trained conservation planners will facilitate the creation of new conservation plans for priority species and the refinement of existing plans, including those for *ex situ* management for species recovery (KSR15, KSR25). Monitoring and evaluation of key indicators of success for capacity building for species conservation planning (KSR16) will enable us to demonstrate the outcomes of our work and improve on our capacity building practice.

The following flow of logic (Figure 3) summarizes how we envisage the capacity building work stream to proceed. Our strategic focus is on the development of teams of experienced conservation planners able to proactively facilitate the development and delivery of a suite of conservation planning processes. Through them, the IUCN will be in a position to meet the growing need for species conservation planning support, contributing to the improved management of threatened species globally.

Figure 3. Conservation planner development path



Objectives

Objective 3.1

Establish and implement CPSG's Species Conservation Planning Training Program.

Training in species conservation planning does occur across the SSC but has to date not been coordinated in a systematic and comprehensive manner. This is important if we are to scale up capacity for species conservation planning to the level required to meet the global need. By 2020 we will have developed a suite of training courses delivered in a 'blended' way (online + face-to-face) to all SSC Specialist Groups and governments that require them to ensure they can meet their species conservation planning needs.

Objective 3.2

Create facilitation skill sub-section of the species conservation planning processes tools library.

With the development of the new SSC species conservation planning guidelines, there is now a body of literature that captures the steps involved in the process. To provide species conservation planners with support to turn these principles into practice, we need to complement these guidelines with a suite of tools to support the process. A process tools library has already been established by CPSG. We now see a role for a suite of facilitation skills resources to guide conservationists through the practicalities of making plans within cross-disciplinary stakeholder groups. By 2020 we will have created a suite of online and downloadable tools to support facilitators of species conservation planning processes in the design, delivery, and monitoring of workshop processes. This virtual library will support conservation planners in tailoring planning processes, resolving inter-stakeholder conflict and guiding species conservation planning initiatives that result in the creation of effective species conservation plans.

Objective 3.3

Launch Species Conservation Planners Development Path program.

While experienced facilitators and technical specialists of species conservation planning processes do exist across the SSC, our collective need is greater than the supply. To build this capacity we need to combine access to high quality training, with opportunities for one-to-one coaching, and on-the-job experience. By 2020 we will have a well-established Species Conservation Planner Development Path program (Figure 3) guiding future species conservation planners and technical experts along a professional development path to the point of expertise sufficient to lead their own technical working groups and multi-stakeholder planning processes. With this enhanced capacity we can contribute to meeting the needs of SSC Specialist Groups, CPSG Regional Resource Centers, zoos and aquariums and specific governments and NGOs to deliver on species conservation planning priorities.

Objective 3.4

Establish CPSG Species Conservation Planning Learning Network (sPLAN).

Facilitating species conservation planning processes can be complex and, as such, requires honing of skills, sharing of experiences, and the development of innovative ways to navigate the path through to completion of effective plans that are then put into practice. Learning networks are now well-established as means by which practitioners can receive constructive criticism and support from their peers (e.g. the Conservation Measures Partnership CCNET). By 2020 we will have established a global online learning network of species conservation planners exchanging tools, lessons-learned and to ensure that SSC Specialist Groups, CPSG Regional Resource Centers, zoos and aquariums and specific governments and NGOs are able to develop and deliver context-specific planning processes that lead to the implementation of conservation action and improved species status.

Actions

Action	Output	Outcome	Timeline	Resources
Objective 3.1. Establish and implement CPSG's Species Conservation Planning Training Program.				
3.1.1. Develop training course program designed to meet the needs of target audiences (in particular the SSC Specialist Groups and governments).	SSC training needs assessment completed, online learning management system in place, training course program with materials produced, including face-to-face and online provision. By 2020 we are training more than 100 conservation planners per annum and will have helped establish teams of experienced species conservation planners in all SSC Specialist Groups and governments that require them to deliver on their planning needs globally.	SSC-wide training program in action, meeting the capacity needs of the SSC and governments and contributing to the development of species conservation plans for priority taxa.	SSC-wide training needs assessment completed October 2017; Review of most appropriate Learning Management System (LMS) completed end September 2017 and in place by December 2017; Initial trial online courses (2?) in place and launched by end January 2018; First face-to-face course delivered in partnership with RSG (Nov 2017); Facilitation skills course launched at Smithsonian Q1 2018.	Work with SCTI to identify most appropriate LMS. All courses have own financial plans including possible fee-paying option to cover costs. Online courses to draw on existing expertise across SSC where possible with the aim of minimizing costs. May be annual fee for management of LMS (<USD 5000?).
3.1.2. Develop the financial plan to ensure the financial viability of the program.	Financial projections produced to demonstrate long-term sustainability of the program.	Financially-viable training program established meeting its costs and laying the foundations for long-term growth and development	Financial plan developed in line with CPSG annual budgeting procedures.	Staff time to develop plan.

Action	Output	Outcome	Timeline	Resources
3.1.3. Establish monitoring and evaluation systems for program refinement and communication of outcomes.	Monitoring and evaluation (M&E) system established for objectives 3.1-3.4.	System of data flow established to monitor effectiveness of training program in building individual, organizational, and systemic capacity for species conservation planning and informing the development of future programs.	Initial review of M&E system during October 2017 Annual Meeting workshop. M&E system draft completed by mid-November 2017 for sign-off mid-December 2017. At least one paper summarizing program impacts by year-end 2018.	Ideally contract an intern to help with this process for 4 months. Total cost USD 6000. Alternatively use MSc student (Colby College? Imperial College?, etc.?)
Objective 3.2. Create facilitation skill subs-section of the species conservation planning processes tools library.				
3.2.1. Produce initial suite of online support tools to complement existing CPSG tools library, focusing on the facilitation skills development.	Searchable and interactive facilitation skills resources developed and launched on CPSG website, including downloadable support documents, pre-recorded 'how to' sessions and examples, and instructions for further reading.	Greater support in place through SSC for species conservation planners looking to apply the IUCN species conservation planning guidelines.	Review of existing online facilitation tools relevant to species conservation planning processes completed end January 2018; Launch of initial suite of facilitation tools within existing tools library end of Q2 2018	Minimal cost assuming we can develop the tools in-house. Potential cost of equipment to record 'how to' sessions. Resources could be housed on the Learning Management System selected as additional resources for training program support

Action	Output	Outcome	Timeline	Resources
3.2.2. Write Conservation Facilitators Handbook as a compendium to the Practitioner's Guide to Species Conservation Planning. (see Obj 2.4)	Production of Conservation Facilitators Handbook (downloadable for possible hard copy publication).	The SSC Community has the guidence needed to conduct effective species conservation planning.	Review of existing species conservation planning facilitation tools available online and gap analysis for development completed by end of 2017; Conservation Facilitators Handbook outline drafted by mid 2018 with contributors/editorial team identified (including production costs); Handbook drafted and out for review end Q3 2018 with final publication end Q4 2018	Costs mainly restricted to staff time to produce the handbook. More detailed cost analysis being conducted to go into the budget that will follow this plan
Objective 3.3. Launch Species Conservation Planners Development Path Program.				
3.3.1. Develop Species Conservation Planning Development Path Program.	Selected cohorts passing through the program and achieving independent planner status. By 2020, a minimum of 50 participants will have passed through the development path and be leading their own species conservation planning processes, to meet the needs of SSC Specialist Groups and governments.	Iterative program of competency development and planning specialisms in place, sustaining capacity for the leadership of species conservation planning processes across the SSC and governments states. This will lead to more plans being developed more effectively to save more priority species.	Finalized conceptual map of the Species Conservation Planner Development Path, including details of agreed specialisms (end October 2017); M&E programme in place to track participants' success and obstacles encountered in developing and delivering on more conservation plants (end January 2018); first cohort of planners through programme by year-end 2018	Costs to be determined. Will be based in part on number of individuals we would like to put through the development process in 2018 and the extent to which we can absorb costs within existing CPSG species conservation planning workshops for 2018.

Action	Output	Outcome	Timeline	Resources
3.3.2. Identify and develop program of competency specialisms (e.g. advanced conflict resolution, applying disease risk assessment guidelines, Data Science) to follow core competency development around facilitation.	Individual planner specialisms achieved and utilized to support species conservation planning processes		Planning competency specialisms identified mid-November 2017; Subject specialism experts identified and confirmed end Q1 2018; First round of specialism training for 2018 cohort achieved and evaluated by year-end 2018	Plan to identify subject specialists willing to give time at cost. Could involve travel and subsistence costs for individuals following the specialisms. Note: program could be opened to fee-paying individuals too. Draft budget developed to follow this plan
Objective 3.4. Establish CPSG Species Conservation Planning Learning Network (sPLAN).				
3.4.1. Develop a Species Conservation Planner directory	Directory of existing, experienced species conservation planners developed	Core group of network members developed to form the hub for future growth	Online directory of existing planners completed by end of September 2017; Survey to ensure interest in forming network (end November 2017); Group established as core for network Q1 2018	No cost

Action	Output	Outcome	Timeline	Resources
3.4.2. Develop strategic plan for the learning network recognizing its purpose to sit between that of informal learning and a community of practice networks.	Strategic plan for learning network produced. By 2020, the network will consist of a minimum of 300 species conservation planners, from across all SSC Specialist Groups and governments that require support in delivering on their species conservation planning needs for priority taxa.	Active learning network established with regular exchanges of good planning practice between members and feedback generated on the strengths and weaknesses of existing planning tools to help with their ongoing refinement.	Concept reviewed October 2017, finalized mid-December 2017; Launch of network in Q1 2018, with first cohorts of CPSG alumni. Additional participation encouraged from participants of past CPSG courses and from target audiences (e.g. SSC Specialist Groups)	Based on feedback from other network managers, we would need to recruit a dedicated individual to run the network. Additional resources minimal, unless we build in face-to-face Learning Network meetings.

Goal 4: The ability of governments to achieve international biodiversity targets is improved (KSR21)

We will, in collaboration with the SSC's Post 2020 Task Force, assist governments in using the SSC species conservation planning process to help them meet their obligations under international biodiversity conventions (e.g. Aichi Target 12 of the Convention on Biological Diversity's Strategic Plan for Biodiversity 2011-2020 and United Nations Sustainable Development Goal-Target 15.5).

CPSG Leads: Phil McGowan, Louise Mair, Onnie Byers, Caroline Lees

Introduction

Conservation planning is an integral process in preventing species extinctions and improving species' conservation status. CPSG therefore has a vital role to play in assisting countries to make progress towards Target 12 and other biodiversity targets by providing frameworks, tools and approaches, and by building national-level capacity for conservation planning. CPSG seeks to work with colleagues throughout SSC, and IUCN more broadly, to increase substantially the effectiveness of SSC's leadership in planning to avoid species extinctions.

Progress has been limited on the achievement of Target 12: *By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.* The reasons for this are undoubtedly complex and varied, but the continued deterioration of species makes clear the urgent need for intensified effort on behalf of species conservation. Therefore, a strategic, systematic, and sustainable approach to achieving international biodiversity targets is urgently needed.

In order for CPSG to effectively assist countries, it is necessary to develop an understanding of why progress towards Target 12 has been limited. We therefore need to identify the current constraints faced by countries. We then need to analyse the availability of tools and approaches that could assist countries in overcoming these constraints, and identify and where possible fill any potential gaps. The fundamental aim of this process is to increase implementation. Tools and approaches should therefore be disseminated to the appropriate bodies, and training given, to improve national capacity and increase the uptake of conservation planning tools.

CPSG also seeks to look beyond the 2020 reporting date to consider and agree what species planning-related targets should be after 2020, both for the CBD and for various targets in the UN Sustainable Development Goals. We intend to take the opportunity to influence these discussions and place species conservation at the heart of future global biodiversity targets.

Objectives

Objective 4.1

Within our area of influence, develop a clear and practical response to the challenges facing countries in achieving Biodiversity Target 12 of the CBD 2020 Strategic Plan.

Objective 4.2

Assist governments to use the SSC species conservation planning process to help them meet their obligations under Target 12 of the CBD 2020 Strategic Plan.

Objective 4.3

Play a meaningful role in influencing the next iteration of biodiversity targets, post 2020, ensuring that species conservation planning is included in the next set of internationally agreed biodiversity conservation targets.

Actions

Action	Output	Outcome	Timeline	Resources
Objective 4.1. Within our area of influence, develop a clear and practical response to the challenges facing countries in achieving Biodiversity Target 12 of the CBD 2020 Strategic Plan.				
4.1.1. Review the conservation planning literature with regard to obstacles to governmental implementation of relevant biodiversity convention targets	Professional publication	Identification of where CPSG (and other SSC entities) can have the greatest impact	Within six months	Newcastle University/CPSG postdoc plus support from CPSG staff as needed.
4.1.2. Analyze the efforts and progress made by countries towards Aichi Target 12, and identify the main obstacles and challenges that limit progress.	Scientific publication (& potentially a CBD report on effort and progress made by countries towards Target 12.	Improved understanding of progress by countries towards halting extinctions informing the response of CPSG	Within a year	Newcastle University – CPSG postdoc position plus support from CPSG and other contacts within SSC, IUCN and CBD
4.1.3. Using interviews and workshops, develop case studies that give a deeper understanding of obstacles, and identify existing approaches and mechanisms that could be used to overcome these.	Scientific publication reports	Understanding of obstacles and challenges to specific countries in meeting Target 12 and how SSC species conservation planning tools could assist. Identification of opportunities, including strategic alliances (NGOs and others) able to contribute to tool and guideline development, and also parties willing to be advocates for ambitious post-2020 targets	Over the next 2 years	Newcastle University/CPSG postdoc with support from CPSG and other contacts within SSC, IUCN and CBD, and financial support to host workshops

Action	Output	Outcome	Timeline	Resources
4.1.4. Identify gaps in the process where they exist and, where feasible, develop tools and processes to fill the gaps.	A database/online resource collating available tools and processes; gap analysis and, where necessary and feasible, new tools to fill those gaps	Improved access to and uptake of available tools, and increased range of tools available	End of 2019	Newcastle University/CPSG postdoc plus support from CPSG as needed
4.1.5. Test, and revise as needed, the generalized process to produce a scalable decision-support tool or guidance materials that will allow national level policy officials and planners to understand how to make the most progress towards Target 12.	Strategic guidelines document presenting the generalized process and associated tools to assist governments to overcome obstacles to fighting extinction.	Nations develop strategic plans that efficiently and effectively result in progress towards Target 12 (while considering other Aichi targets and international commitments) and ultimately progress on halting extinctions.	End of 2020	Newcastle University/CPSG postdoc plus support from CPSG staff as needed; Financial support to host workshops and other testing and development opportunities
Objective 4.2. Assist governments to use the SSC process to help them meet their obligations under Target 12 of the CBD 2020 Strategic Plan.				
4.2.1. Provide materials and training to interested governments to enable them to use the decision-support tool or guidance materials to develop their own Target 12 strategies.	In-country workshops and side events at international meetings (e.g. the Convention on Biological Diversity's (CBD) Subsidiary Body on Scientific, Technical and Technological Advice, *SBSTTA*); Trained staff, in-country.	Increased national capacity through training in, and uptake of, the decision-support tool. In-country government departments have staff trained in the application of SSC decision-support tools for species conservation planning.	End of 2020 (and beyond)	Regional contacts to assist with delivery, financial support for workshops

Action	Output	Outcome	Timeline	Resources
4.2.2. Develop, and make available to relevant government CBD contacts, a database of SSC-assisted species conservation needs assessments and conservation planning initiatives.	An evolving, searchable database, to which nations are encouraged to contribute, to guide in-country planning	Increased information sharing resulting in improved implementation of the planning process through shared experience; Some information-related barriers to in-country planning are removed	End of 2020	Technical support and regional contacts to collate database
4.2.3. Include, at the outset of each species conservation planning initiative, consideration of the role of the initiative in contributing to delivery of Target 12 within the nation(s) of interest, and build this element into the next generation of SSC planning guidelines.	National-level assessment of how each planning initiative contributes to progress towards Target 12. Appropriate integration of SSC species conservation planning with in-country CBD (esp. Target 12-related) initiatives.	Improved understanding of progress towards Target 12. Where in-country government-led species conservation frameworks exist, SSC species conservation planning initiatives support and are supported by them.	End of 2020 (and beyond)	No additional resources.
Objective 4.3. Play a meaningful role in influencing the next iteration of biodiversity targets, post 2020, ensuring that species conservation planning is included in the next set of internationally agreed biodiversity conservation targets.				
4.3.1. In collaboration with the CBD Secretariat, present the decision support tool or guidance materials in relevant fora.	Presentations/workshops at CoP, SBSTTA and other relevant fora as opportunities arise	Increased awareness of the value of SSC conservation planning approaches and increased uptake by parties	Over the next three years	Colleagues at the CDB Secretariat
4.3.2. Collaborate with other IUCN and SSC entities on opportunities to influence policy, legislation and conventions on species conservation planning	Evidence-based policy, legislation and convention recommendations for species conservation	The value of conservation planning is recognized in policy, legislations and conventions	Over the next three years	Colleagues across IUCN and SSC entities

Action	Output	Outcome	Timeline	Resources
4.3.3. Contribute to SSC's post-2020 taskforce that will work where appropriate alongside the WCPA post-2020 taskforce, and involve relevant partners.	Evidence-based recommendations of post-2020 targets for species conservation	Conservation planning is placed at the heart of internationally agreed biodiversity targets	Over the next three years	Colleagues across SSC and WCPA

Goal 5: Species conservation planning methods are evaluated for impact and effectiveness, leading to continual improvement (KSR16)

We will develop and implement evaluation approaches to measure, improve, and report on the impact and effectiveness of IUCN SSC species conservation planning efforts.

CPSG Lead: Caroline Lees

Introduction

The following logic model (Figure 4) describes very broadly our current understanding of the route through which SSC planning will impact the status of species. In addition to a long-term study of the impact of SSC planning on species status, our evaluation approach will focus on intermediate steps in the process: the quality of the planning process, the planning outputs, and plan implementation. Evaluation data will be reviewed annually and new insights fed back into planning methods and tool development. This work will be done in collaboration with key partners, integrating the SSC's "Green List" approach as this becomes available.

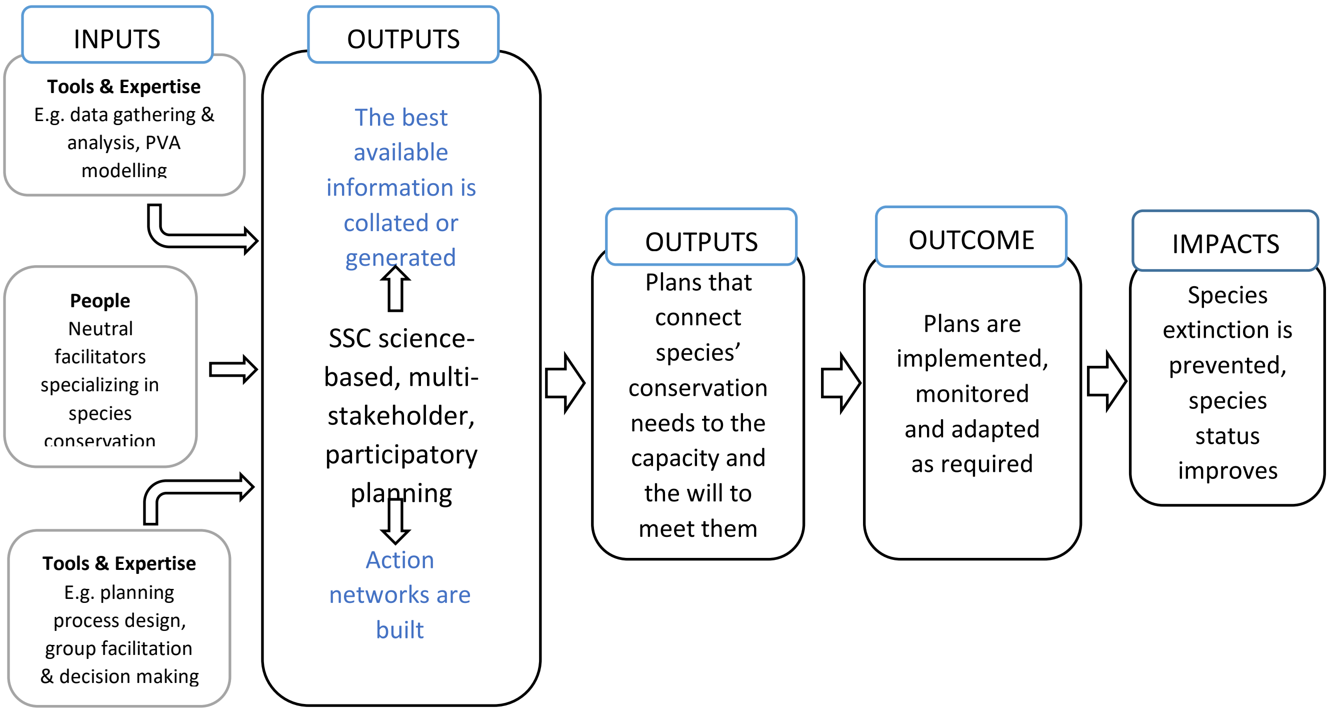


Figure 4. Logic model for species conservation planning activities in the SSC, as guided by CPSG.
(Modified from Westley & Miller, 2003)

Objectives

Objective 5.1

Develop and test new mechanism(s) for evaluating the impact of conservation plans and enhancing the SSC's species conservation planning process to increase probability of implementation and facilitate future evaluation.

An SSC framework will be developed to monitor, evaluate, and report on the conservation impact of SSC-facilitated species conservation plans. Results will be used to refine planning process design and delivery. The framework will cover the following stages in the IUCN SSC CPSG logic model (illustrated above):

Quality of planning process and outputs: surveys will be used to examine the extent to which the SSC planning approach promotes the conditions for successful conservation action (as they are currently understood and described in the logic model above). The results of these surveys will be used to refine planning tools and approaches.

Plan implementation: we will not be responsible for monitoring the implementation and outcomes of planned actions within projects but will encourage this practice through the planning process and through our capacity-building arm. We will evaluate the extent to which plans are implemented, and the outcomes of implementation, through an agreed contact point designated for each planning project.

Impact on species status: multi-stakeholder, participatory planning is a relatively new approach to building conservation strategies for many organizations. CPSG has been using this approach for 30 years and is in a unique position to examine the long-term impact of this style of intervention and to use the insights gained to update its tools and approach. To progress this we will build on past CPSG evaluation studies and on the IUCN SSC's "Green List" approach as this becomes available.

Objective 5.2

Implement and manage the SSC monitoring and evaluation mechanism.

A body of information will be built that will allow the SSC to manage adaptively the evaluation of planning impact. Ready access to evaluation-related statistics will be key to ongoing assessments of effectiveness. Much of the relevant data are not currently collected routinely, are held in user-unfriendly formats, or are only partially collated. Centralized, standardized collection and curation will be key to a successful long-term program of evidence-led adaptation.

Actions

	Output	Outcome	Timeline	Resources
Objective 5.1 Develop and test new mechanism(s) for evaluating the impact of conservation plans and facilitate future evaluation.				
5.1.1 Refresh and re-instate post-planning surveys to evaluate success. Repeat surveys at 1 and 3 years and report results annually. Refine understanding of conditions for success as new information becomes available.	Annual reports supporting ongoing, evidence-based understanding of the relationship between how participants view and experience the planning process, and downstream outcomes for species.	Ongoing, evidence-based refinements to planning processes towards improved outcomes for species and to facilitate future evaluation.	New evaluation scheme in place by early 2018.	Possible subscription to online survey application (TBD).
5.1.2 Require, as a condition of SSC involvement in planning, a commitment from organizers to ongoing reporting on plan implementation and impact. Collate and disseminate a summary of project implementation results.	A standard form for organizer commitment is developed, and a publication produced summarizing extent and outcomes of implementation of SSC facilitated or enabled plans.	Ability to evaluate the extent and outcomes of plan implementation.	Pilot publication by mid-2018, then, if found to be useful, produced on a regular basis (bi-annually?)	None for the pilot.
5.1.3 Evaluate and report the long-term impact on species status of CPSG-facilitated planning events. Use the new SSC "Green List" method and Durrell’s work as a framework.	Report on the long-term impact on species status, of CPSG’s planning approach.	Evidence base 1) for predicting the long-term impact on species, of CPSG's planning approach, and 2) for modifying approach to enhance positive impact.	Report by end of 2019.	Significant staff and volunteer time required.

Objective 5.2 Implement and manage the SSC monitoring and evaluation mechanism.				
5.2.1. Set up and maintain a database of recent SSC facilitated or enabled conservation plans and associated details.	System for accessing relevant data relating to global species conservation planning needs and progress towards meeting them.	Ability to characterize the magnitude of the task ahead and to evaluate progress in the short, medium and long-term.	Specifications agreed mid-2018.	Staff time required. Additional resource needs to be reassessed once specifications agreed.

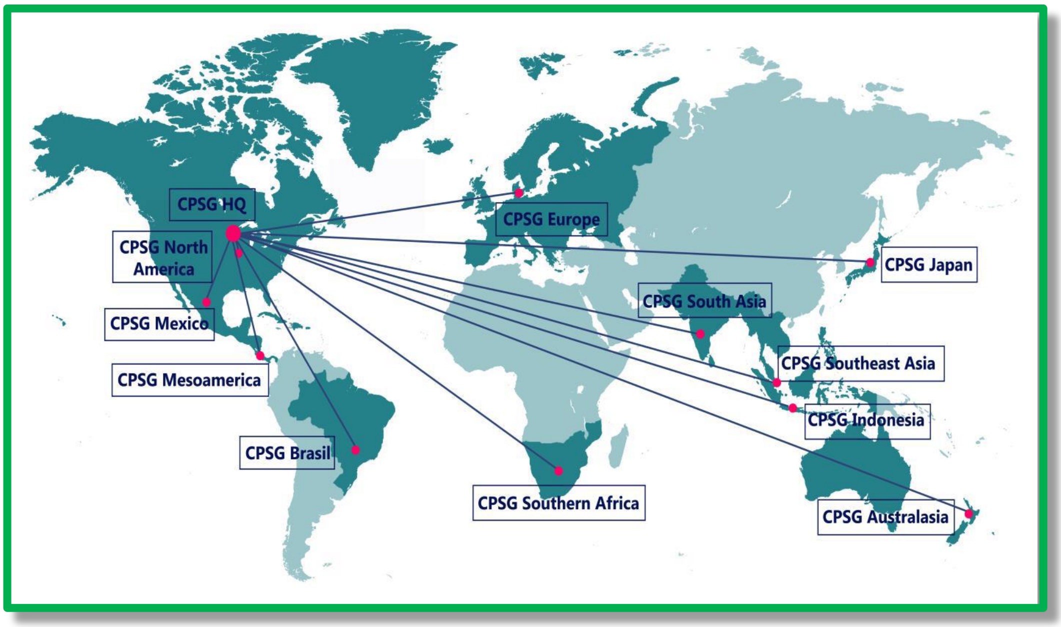
5. CPSG Structure and Governance

CPSG Staff

CPSG is led by its Chair, Dr Onnie Byers, with a Headquarters staff (6) in Minneapolis and other staff in UK, Australia and Denmark. Responsibility for coordinating and managing the delivery each of the Goals 1 – 5 above has been allocated to one or more specific members of staff.

Regional Resource Centers

A network of 11 Regional Resource Centers takes CPSG tools and principles into the local institutions of a region or country, allowing stakeholders to adapt our proven conservation techniques to meet their own unique needs. http://www.cpsg.org/about-cpsg/cpsg-regional-resource-centers



CPSG Members

CPSG is supported by a global volunteer network of 270 professionals, who are invited to be Members by the Chair of CPSG. Most of our members work in conservation, and all are invited because they have unique expertise and knowledge upon which CPSG depends to fulfil our mission.

CPSG Donors

The work of CPSG is made possible by some 200 Institutions (zoos, aquariums, international, regional and national zoo associations, and others) and individuals, contributing sums between less than $100 and more than $25,000 a year. A significant proportion of these donors have made contribution ever since CPSG was founded by Dr Ulie Seal (as CBSG) in 1979. CPSG Donors are not necessarily or usually CPSG Members.
A full list (.pdf) of Donors can be found at: http://www.cpsg.org/support-cpsg

Global Conservation Network

CPSG financial affairs are overseen by the Global Conservation Network's Board of Trustees. GCN is an independent not-for-profit 501c3 Charity, incorporated in the state of Minnesota. It was set up by Ulie Seal in 1979 so that CPSG (then CBSG) would be able (a) to separate its financial management and (b) to fundraise internationally, to support all its activities. CPSG is thus financially independent from IUCN/SSC, of which it is a constituent Specialist Group. GCN has a Board of 12 international Trustees, who oversee all aspects of the financial and risk management of CPSG. The Board meets once a year in person (at the Annual Meeting) and on 3 or 4 further occasions per year via a telephone conference call. The GCN Board adopts the best-practice standards of charity management, as articulated by the US government (where the Headquarters is based) and by the Charity Commission in the UK (where the Chair and several members are based).

CPSG Strategic Committee

The CPSG Strategic Committee is an informal discussion group of some 50 CPSG Members, whose purpose is to discuss, with the Chair and staff, matters of future strategic interest to CPSG. The group meets at least once a year (the day before the Annual Meeting, commonly with around 30+ Members and guests present) to receive reports from staff and to discuss general issues of strategy. It sometimes meets for a second time (usually at the CPSG mid-year business meeting); this usually consists of a smaller assembly.

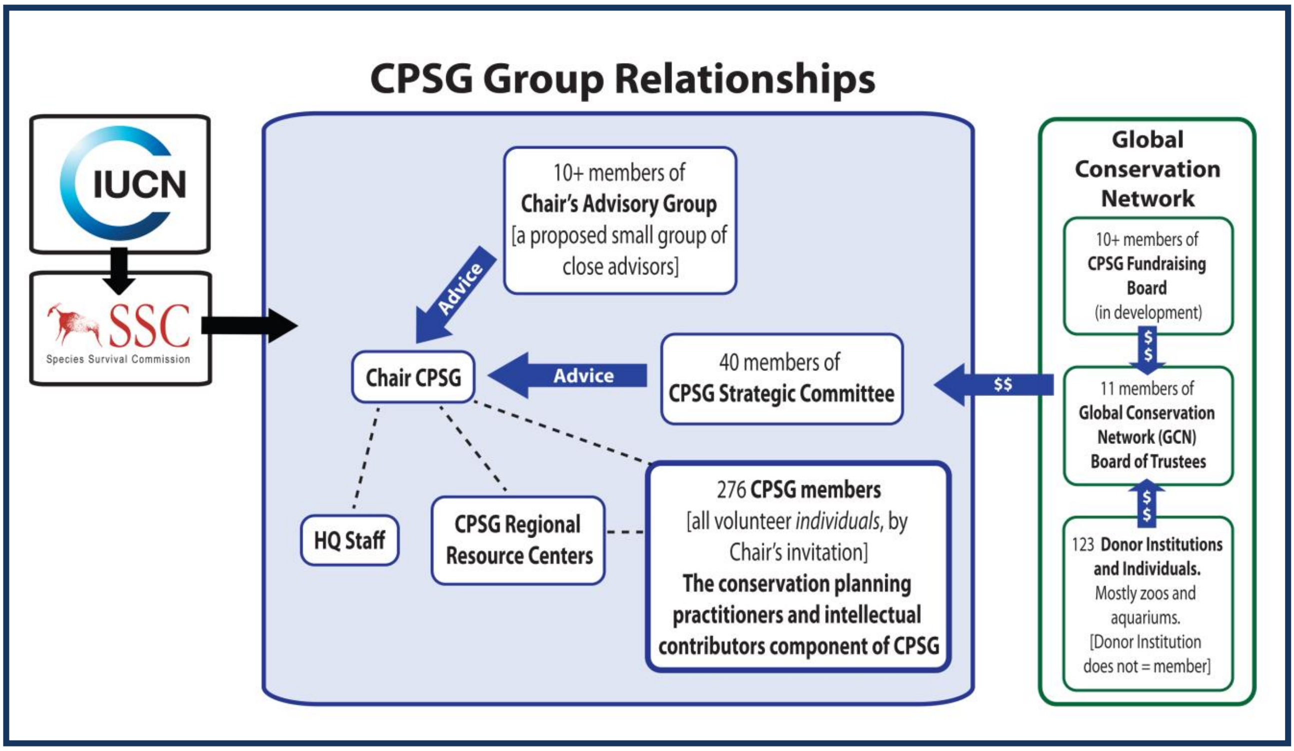
A list of members is here: http://www.cpsg.org/about-cpsg/donors-strategic-committee.

CPSG Fundraising Board

This informal committee is in the process of being formed from the pool of existing donors and members, plus some external support. There are currently two sub-groups, focussing on fundraising in the US and Europe respectively.

Governance Structure

The diagram below shows the relationships between the groups described above. The struture has been carefully planned to maximise the support available to the Chair and staff in their work in Conservation Planning, and to ensure that CPSG works in the most efficient way, both in terms of its Mission-led activities, and financially.



6. Fundraising

We are actively seeking international funding for all the initiatives described in this document.

To this end, we have established a small and growing Fundraising Board (see CPSG Group Relationships diagram in Governance and Management Section, above) to coordinate all fundraising initiatives being undertaken by CPSG staff, GCN members, existing donors, and other CPSG members generally.

We have also created two versions of our **Case for Support** – a single-sheet summary, and a 12-page version with some more detail; both are fully derived from this Strategic Plan document.

- The one-page version is shown below.
- The 12-page version can be found at www.cpsg.orgkădzLJLJƻNJúπŎLJăƎ

CPSG Case for Support – Summary Sheet, front page

Building Global Capacity for Species Conservation Planning

About us

The Conservation Planning Specialist Group (CPSG) is a member of the world's largest global conservation organization, the International Union for Conservation of Nature (IUCN), Species Survival Commission (SSC).

Our Mission & approach

CPSG's Mission is to save threatened species by increasing the effectiveness of conservation efforts worldwide. For nearly 40 years, we have accomplished this by using scientifically sound, collaborative processes that bring together people with diverse perspectives and knowledge to catalyze positive conservation change. We provide species conservation planning expertise to governments, other IUCN SSC Specialist Groups, zoos and aquariums, and other wildlife organizations.

Golden lion tamarins (*Leontopithecus rosalia*)

In 1990, the population of golden lion tamarins was approximately 450. Multiple conservation projects were undertaken and, with careful conservation planning and facilitation by CPSG, these various projects have become unified around concrete goals, and the population now stands at around 3,000.

A need for collaborative conservation action

The average rate of vertebrate extinctions over the last century is around 100 times higher than the background rate, strongly supporting the claim that we are experiencing the Earth's 6th mass extinction event; an event the likes of which have not been seen for at least 65 million years. But the good news is that conservation works.

Wattled crane (*Bugeranus carunculatus*)

CPSG's workshop for wattled cranes facilitated the aggregation of all data and research findings on the species, so that all groups working to conserve the wattled crane could jointly evaluate and plan for its future. The population of wattled cranes in South Africa has increased more than 60%.

There is increasing evidence for the positive impact of conservation funding and conservation action. Conservation actions are having a real impact in reducing biodiversity loss, but are not yet implemented at sufficient scale to stabilize and ultimately reverse current trends. The loss of biodiversity remains one of our planet's most critical problems, threatening valuable ecosystem services and human well-being. But it is clear that with effective, well-funded, and government-supported planning, we can change the trajectory.

We can achieve this through **collaborative conservation planning processes** that are stakeholder-inclusive and take an integrated approach to the conservation of biodiversity. This approach is at the core of CPSG's Mission and philosophy and has proven to catalyze action to save threatened species worldwide.

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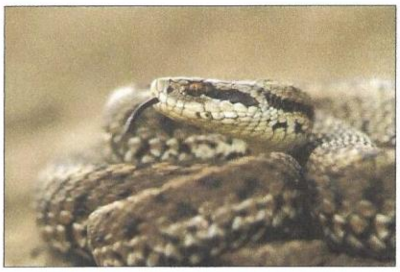
CPSG Case for Support – Summary Sheet, back page

We now need to scale up our efforts substantially to catalyze action for the more than 25,000 species currently threatened with extinction.

CPSG is seeking financial support of **US$ 1.3 million** over the next three years to increase substantially the **global capacity for collaborative conservation planning**, and to make a significant and measurable conservation impact.



Hungarian meadow viper (*Vipera ursinii rakosiensis*)

CPSG's workshop for the Hungarian meadow viper brought stakeholders together to share data and identify assumptions in order to find a common understanding and collaboration. This led to the establishment of a conservation breeding program which has hatched over 2,000 Hungarian meadow vipers, and hundreds have been released into reconstructed grasslands nearby.

Our challenge

Over the next three years, CPSG will take a leading role in significantly building the global conservation community's capacity to ensure that every species that needs a plan is covered by an effective conservation plan.

To achieve this, we will deliver on five strategic goals:

1. Develop more efficient processes to move our work for species from threat assessment, through planning for conservation, to conservation action

2. Ensure that planning efforts follow best practices using an adaptive, evidence-based approach, and integrating input from all conservation allies working for a species, whether inside (*in situ*) or outside (*ex situ*) the species' natural range

3. Increase species conservation planning capacity across SSC Specialist Groups, national authorities, and IUCN members

4. Improve the ability of governments to achieve international biodiversity targets

5. Evaluate species conservation planning methods for impact and effectiveness, leading to continual improvement

In conclusion

The need for effective conservation planning to save species is greater than ever before if we are to turn the tide of extinctions. CPSG's conservation planning tools, processes and trainings have a proven track record of success in saving species.

Your support will allow us to ramp up our activities and to increase substantially the worldwide capacity for species conservation planning. ***Will you please help us?***

American burying beetle (*Nicrophorus americanus*)

Conservation efforts for the American burying beetle were at a standstill due to conflicts among stakeholder groups until a CPSG facilitated workshop showed them all their common ground, allowing them to move into action. Reintroduction efforts are currently making progress in several states.

Photo credits:

Golden lion tamarins © *Florence Perroux, Zoo de la Palmyre*
Wattled crane © *Mehgan Murphy, Smithsonian's National Zoo*
Hungarian meadow viper © *Taviphoto, Dreamstime.com*
American burying beetle © *Ray Meibaum, St. Louis Zoo*

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7. Finance

CPSG already has a substantial and loyal donor base, and its current activities are well funded.

We have carefully evaluated the costs, in $$US and in time, of delivering each of the elements of each of our five Goals. We have also evaluated the extra costs, to the HQ and to the Regional Resource Centers, of delivering and supporting the achievement of the Goals.

Some of the work contained within Goals 1 – 5 can be done by existing staff redirecting some of their efforts, and by Members of CPSG and other SSC Specialist Groups who volunteer their time. However, given the scale of the increase in work required of the organization, we have determined the likely funding gaps.

The result is the table below, which shows the funding gaps for each of the next three years. The total needed, fully to fund our expanded workload, is a little more than US$1.3 million.

CPSG Strategic Plan:
Incomes, Costs and Fundraising Targets: 2018-2020

	Yr 2018	Yr 2019	Yr 2020	3 Yr Total
Core costs (current GCN budget)	$ 700,750	$ 700,750	$ 700,750	$ 2,102,250
Extra Goal-related costs	$ 556,650	$ 478,550	$ 440,950	$ 1,476,150
TOTAL Costs	$ 1,257,400	$ 1,179,300	$ 1,141,700	$ 3,578,400
TOTAL Income	$ 803,750	$ 735,000	$ 735,000	$ 2,273,750
TOTAL Surplus/-Deficit				
= Funding Gap/ Fundraising target	$ (453,650)	$ (444,300)	$ (406,700)	$ (1,304,650)

All these at January 2018 prices (inflation not allowed for)

8. Appendix

- Web Links

CPSG website: www.cpsg.org

- CPSG Annual Report 2017
  - http://www.cpsg.org/latest-news/annual-reports
- CPSG Strategic Plan 2018 – 2020 (this document)
  - Insert web page address
- CPSG Case for support (brief)
  - Insert web page address
- CPSG Case for Support (extended)
  - Insert web page address
- CPSG Donors
  - http://www.cpsg.org/support-cpsg
- CPSG Regional Resource Centers
  - http://www.cpsg.org/about-cpsg/cpsg-regional-resource-centers
- CPSG GCN members
  - Insert web page address
- CPSG Staff members
  - Insert web page address
- CPSG Volunteer members
  - Insert web page address
- CPSG Strategic Committee members
  - http://www.cpsg.org/about-cpsg/donors-strategic-committee.

Conservation Planning Specialist Group.

Hierarchy of Fundraising materials (from simple and direct to fully-detailed)

1. **Core Message (aka 'Elevator Pitch')**
   - What you *say* when you only have 30 seconds to get the message across.
     - Audience: A (busy) potential donor who just *might* be interested.

2. **Promo Video (to be developed)**
   - A short (3-4 mins?) glimpse of CPSG – includes inspirational message from OB
     - Audience: What you show to someone who shows any interest (in 1. Above)

3. **Glossy book – 'Second Nature'**
   - An elegant, pictorial, easily-readable synthesis of CPSG's work and successes.
     - Audiences: Almost anyone who shows an interest in us

4. **Annual Report 2018**
   - A clear summary of the last year's activity
     - Audience: Almost anyone who shows an interest in us, especially those who have been through 1 to 3 above.

5. **One-page Case for Support**
   - A brief but clear explanation of what we propose to do over the next 3 years.
     - Audience: What you show to a potential donor who is interested, ie, someone who has responded positively to the Elevator Pitch and just needs a bit more info.

6. **Extended (12-)page Case for Support**
   - A more detailed exposition of our plans.
     - Audience: What you show to someone who has read and discussed the One-pager; they now want more detailed information, to confirm that the Pitch and Case for Support are valid, thought-through and realistic.

7. **Strategic Plan**
   - A fully-detailed explanation of the three-year strategy, with analysis of implications, resource requirements, risk, governance structure, etc.
   - The core of the CPSG Strategic Plan 2018 -2020 is the working blue-print for the organisation's work, and was developed by CPSG staff, to subdivide, and allocate responsibility for, the many tasks involved in delivering the five Goals.
     - Audiences:
       - A few potential major donors will want the whole works laid out for them (for example, to share with the Board of a major charitable trust, to whom we have applied for a large donation).
       - CPSG staff, existing donors, GCN, CPSG Strategic Committee, SSC.
       - It should be available on the CPSG website, as an indication of the organisation's ethics and philosophy of openness.

Disease Risk Assessment Online Training Course Development

Convenors: Jamie Copsey, Richard Jakob-Hoff and Fabiana Lopes Rocha

Aim:

To build on work to date by incorporating participants' experiences of wildlife-associated disease and best practice teaching and learning approaches to the development of a new Online Training Course in Wildlife Disease Risk Analysis (DRA).

Background:

The global disappearance of amphibians due to chytrid fungus, the death of entire North American bat colonies infected with white nose syndrome, the mass die-offs of saiga antelope and the near extinction of several species of Asian vulture due to diclofenac poisoning are just some example of disease impacts on wildlife. Yet the threat of disease is generally given little attention until an outbreak occurs and poorly informed response – often involving mass slaughter of wildlife - can make matters worse as infected animals escape and spread disease further. Disease is a manifestation of something wrong in the system which is why an understanding of the system is needed to predict what might happen and select the preventative actions with the highest chance of success. This is the role of the DRA planning tool.

Disease Risk Analysis is a systematic, evidence-based process that has been well tested but has yet to be widely adopted on a global scale. Through a partnership between the IUCN-Species Survival Commission and the World Organisation for Animal Health (OIE) the process was published in 2014 as the multi-authored Manual of Procedures for Wildlife Disease Risk Analysis and its companion Guidelines document.

These are now widely cited, and workshops based on them have revealed that additional training in the DRA process markedly improves their use. But face-to-face training is expensive and limited to small numbers of people. If we are to achieve the SSC's aim of significantly increasing global conservation planning capacity, an online course is needed to make this training accessible globally.

A workshop in August 2019 considered the content for the course and developed a draft curriculum a link to which is provided below.

This Working Group will draw on the personal knowledge and experiences of participant to consider potential audiences, DRA applications and case studies and effective distance learning tools and techniques for course delivery.

Process:

This Working Group welcomes everyone with an interest wildlife disease and/or experience in distance education. Following a brief outline of the course aims and content, we will divide into small topic-focused groups to address specific questions around audience, applications/case studies and course delivery.

This will be an opportunity to contribute your experience and areas of expertise to help make this a globally relevant and outstanding learning experience that will equip trainees with knowledge and skills that increase their effectiveness in wildlife conservation.

Richard Jakob-Hoff (CPSG Australasia Co-Convenor), Fabiana Lopes Rocha (CPSG Brasil) and Jamie Copsey (CPSG Director of Training) will co-facilitate the session and representatives of each work stream will meet on Sunday morning to finalize the Working Group report and presentation for the plenary session.

Outcomes:

1. Broader appreciation of the audiences for this course.

2. Insights into current wildlife-associated disease threats in participant's range countries/DRA case studies

3. Recommendations on e-learning tools and functionality to deliver an outstanding learning experience

4. Identification of additional collaborators and next steps to course completion.

Materials:

- Draft DRA online course curriculum
- Manual of Procedures for Wildlife Disease Risk Analysis
- Guidelines for Wildlife Disease Risk Analysis

VISION

The Wildlife Disease Risk Analysis (WDRA) course and associated resource library are easily accessible, free of charge and used globally for the investigation and management of health risks associated with wildlife.

MISSION

To enable all trainees to conduct a robust, evidence-based disease risk analysis for any situation involving disease impacts on wildlife and impacts on people or domestic animals in contact with wildlife.

LEARNING OUTCOMES

After completing this course, you will:

1. Understand the epidemiological basis of WDRA within a One Health framework.
2. Be familiar with the value and range of applications of WDRA.
3. Have drafted a WDRA of relevance to your work.
4. Be aware of potential constraints on conducting a WDRA and how to select an approach suited to a range of situations.
5. Have the opportunity to continue to connect with WDRA practitioners to progress and share your learning.

Course length: 10 weeks (full course) or 2 weeks (contracted course, Modules 1, 9, 10).

Course quota: 15 – 25, dependent on available teaching resources.

Course frequency: Twice yearly?

Description and content

Will describe course structure, time commitment, learning outcomes, navigation, resources (including use of and contribution to online library), software requirements, registration, feedback/evaluation, eligibility, working agreement/online training etiquette.

REGISTRATION AND PRE-COURSE TASKS

- Complete online registration form noting:
    - **Eligibility criteria**: First priority will be given to professionals (i.e. veterinarians, epidemiologists, disease ecologists, One Health practitioners, wildlife managers and other with good familiarity of disease) able, within a six month period, to apply the training. A 3 week contracted course for senior policy and decision makers is offered introducing the IUCN/OIE WDRA Guidelines and describing the process, range of applications and potential environmental, social and economic benefits for consideration when planning projects with environmental and potential human, domestic animals or wildlife health impacts.
- Review web-based course description.
- Link to Survey Monkey baseline DRA competency self-assessment – to be re-visited at end of course. (15 minutes)

- Link to personality preference tool such as https://www.colorcode.com (15 minutes)
- Download and review DRA Worksheet template (Word document) with instructions on use.
- Submit the outline of a personal DRA case study to apply course training outputs for documentation in the DRA Worksheet. Trainer review and feedback.

MODULE 1: INTRODUCTION TO DISEASE RISK ANALYSIS

Learning Outcomes

- Understand and explain core concepts and the role of DRA in conserving wildlife and biodiversity and in improving the health of people, domestic animals and wildlife.
- Explain the steps in a DRA process
- Understand the key expertise required and the key stakeholders who need to be involved in a DRA process.
- Be able to identify situations where a DRA is needed.
- Aware of range of DRA applications (including biodiversity conservation, public health, domestic animal health)
- Be able to discuss pros/cons of DRA vs alternative approaches.
- Understand the difference between qualitative vs quantitative analysis and discuss pros and cons of each
- Aware of DRA tools and resources to help tool selection

Content	Delivery	Resources	To do
• Definitions • Core concepts • DRA steps • Different types/levels of DRA according to the situation at hand • National frameworks and legislation • Resources required for a DRA	• Introductory film/infographic? • Reading materials: IUCN/OIE Guidelines & first section of the Manual • DRA library/examples	IUCN/OIE Guidelines & first section of the Manual Glossary in Manual.	Script for infographic/film – must be engaging and high quality ($$$) - usable for course marketing – check out OIE resources – they have some good videos now. PDF copy of first section of manual for upload. (Guidelines already available as PDF). Design library framework and search capability.

• On-line self-knowledge check on these topics	• Short answer/multiple choice questionnaire		Develop questionnaire

MODULE 2: EPIDEMIOLOGY AND ONE HEALTH

- Explain measures of disease in populations (e.g. incidence versus prevalence);
- Describe and understand the factors that influence disease in individuals and in populations;
- Be able to apply causal models to the system of interest.
- Explain measures of disease in populations (e.g. incidence versus prevalence);
- Describe and understand the factors that influence disease in individuals and in populations;
- Be able to apply causal models to the system of interest.
- Understand drivers of disease emergence and shifting nature of this.
- Recognize and include factors that might influence the system (e.g. climate change, changing land-use, agriculture)
- Describe and understand the concept of ONE HEALTH (human-environment disease interfaces, how each system affects the other, co-dependency of these systems).
- Be able to choose good data sources to provide information for DRA
- Ability to apply epidemiological and One Health principles to the system of interest.

Content	Delivery	Resources	To do
• Measures of disease. • Factors that influence disease. • Diagnostic tests - sensitivity, specificity, validation. • Causal models.	On-line reading materials plus on-line exercises (question answer plus do one causal diagram using e.g. Dagitty – www.dagitty.net)	Powerpoints that cover some of this material from RJH, Steve Unwin, others?	• Identify reading materials and make sure they can be made available • Identify/coerce someone to do an interactive case-study • Flesh out the other learning activities

• Monitoring and surveillance.			• Could use assignment to indicate competency • Could consider a mentoring process – students will be isolated • Consider connecting people to other local participants (national/regional)
Content	Delivery	Resources	To do
• Measures of disease. • Factors that influence disease. • Diagnostic tests - sensitivity, specificity, validation. • Causal models. • Monitoring and surveillance.	On-line reading materials plus on-line exercises (question answer plus do one causal diagram using e.g. Dagitty – www.dagitty.net)	Glossary: DRA Manual, OIE, D.O. Pfeiffer intro to vet. epidemiology; Manual Appendix 3, pp 97-102; existing ppt presentations	Review resources, ID gaps and compile.
• Definition of disease emergence • Drivers	On-line reading materials plus on-line exercises Case study (possibly live and interactive) Discussion boards		Source and compile delivery materials.

Content	Delivery	Resources	To do
Definition of One Health. Interactions and interfaces.	TED talk by Sharon Deem: The ties that bind us: One Health (15.35)	Some FAO/WHO/OIE Barrett & Osofsky One Health book chapter. materials but possible gap is a good basic resource. One Health Commission (distributes a lot of material for free but some has to be paid for).	Source and compile delivery materials. Contact Sharon Deem for permission/input.
Data repositories. Search terms.	Presentation/materials from some of the data sources. Self-directed learning activity.	OIE WAHID; FAO EMPRESS Wildlife Health Australia databases (permission required) Species360 databases	Source and compile delivery materials.
Worked examples	Presentation of individual case studies including the elements learned.	www.CPSG .org documents library US Geological Survey National Wildlife Health Center website Canadian Wildlife Health Cooperative.	Source and compile delivery materials.

MODULE 3: PROBLEM DESCRIPTION

- Describe and apply the different components of the 'Problem description' (identify the goal, scope and focus and questions)
- Able to source and collate relevant background information (citing published and unpublished sources) to provide context and justification for a DRA.
- Understanding the importance of engaging relevant people in the development of the problem description
- Clear understanding of how to formulate assumptions and limitations appropriate to the DRA and the importance of transparency in this
- Understanding the challenge and importance of gaining stakeholder agreement on the level of 'Acceptable risk' from the start
- Defining success criteria to help define acceptable level of risk
- Understanding how the acceptable level of risk feeds into the consequence and hazard assessment for the identified hazards
- Where translocation is involved, how to identify the translocation pathways for this DRA, and understand how these impact on rest of the process (hazard ID, risk assessment and mitigation steps)

Content	Delivery	Resources	To do
• Outline of the steps – eg, from IUCN Manual pg 24 • Definitions/glossary – clearly describes, with examples, the difference between each of these terms • Highlight how important this step is in the overall process, and that it should be undertaken in collaboration • Knowledge of national and international	• Video of a site visit, showing the kinds of discussions, asking questions – showing that its really important to have a practical understanding of what is actually going to happen during the translocation • Prior DRAs – looking at good and poor examples of these components to show the importance of this initial summary, agreement within the stakeholder group and	• IUCN manual/guidelines • All the usual guides/reference papers	Compile a list of questions which need to be answered/considered in order to create a useful problem description e.g. • What is going to affect this DRA? • how do we go about it, and what do we think about at the highest levels? • What is the driver for this DRA? • What is the specific question for this DRA • Which regulations/policy

legislation and how they impact the DRA • Knowledge of the appropriate conservation plans for the species • Recognition that this includes identification of the population(s) of concern (translocated species, sympatric species) • This is the next iteration after the 'causal diagram' considered in earlier section on epi	how poor outcomes here can affect the rest of the process – possibly delivered as a recorded expert interview.		might guide/inform this process? • Video of site visit • Source appropriate case studies. • ID and brief expert and record interview.
Content	**Delivery**	**Resources**	**To do**
• Identifying who is important, and who should be involved at this stage • What are the different methods of engagement and when should they be applied	• Show poor outcomes when effective collaboration hasn't occurred at this stage (could be included in expert interview)	As above	Source relevant case studies.

Content	Delivery	Resources	To do
• Content from current IUCN manual • Case studies of previous DRA	• Case studies • Graphic showing how moving things will result in risk	See Manual pp 24-29	Source and compile delivery materials.
Content	**Delivery**	**Resources**	**To do**
• Defining the acceptable level of risk in the context of your DRA and methods to gain stakeholders agreement.	• Facilitation – eg, creation of a video showing how to gain agreement on this in a meeting space	• Knowledge of conservation status, OIE lists of notifiable disease • Prior DRAs giving examples	Source and compile delivery materials. Video of DRA stakeholder discussion on acceptable risk.
Content	**Delivery**	**Resources**	**To do**
• Description of what a translocation pathway is, and how it affects the DRA • How to draw a translocation pathway graphically	• Provide a case study of a problem description students need to develop translocation pathways for	• Sainsbury and Vaughan-Higgins 2012	• Useful applications/open source software to assist in the graphical representation of translocation pathways
• Open Discussion	Discussion thread topics: 1) Sources of unpublished information 2) Selecting criteria to define acceptable risk 3) Case study issues arising	• Live discussion/Forum	

Knowledge check	On-line knowledge check on this topic	Short answer/multiple choice questionnaire	

MODULE 4: RISK COMMUNICATION

Learning outcomes

- Define and develop a communications plan
- Understand the importance role of a communications plan in a multi-stakeholder environment [within the framework of a DRA]
- Understand how to implement a communications plan and channels/methods of communication
- Understand the challenges/complexities involved in dealing with a diverse audience in terms of language, culture, attitudes and multiple disciplines
- Able to identify and apply appropriate tools for managing risk communication.

Content	Delivery	Resources	To do
Demonstration of the DRA process and where risk communication occurs and its importance (2)	Case study/studies Expert webinar/recorded talk on experiences in risk communication – what worked and what didn't. Personal reading <u>Exercise</u>: Disease outbreak scenario with participants responding from unfamiliar perspectives followed by brainstorm discussion.	DRA manual Existing DRA cases that include communications plan	Source suitable case studies Identify presenter and record talk

Definitions of key DRA terms related to communications (1)	Glossary	DRA manual	Source and compile delivery materials.
Introduction to learning and communication styles and methods, including challenges (3, 4)	Reading pp 112-113 IUCN Manual Personal preference tool giving insight into own learning styles. Context examples of what good and bad communication looks like	Jamie Copsey's videos for role plays (one good and bad) Free online learning styles tests (could also be pre-course and share with mentor) What motivates people	Johari Window model: http:\\kevan\org\Johari.cgi Ask Jamie Copsey, CPSG What motivates people (Youtube: Dan Pink -The surprising truth about what motivates us -see https://ed.ted.com/featured/LT8oQQTo Ben Davidson talking about how this t Also look at Maslow's Hierarchy of needs e.g. https://www.thoughtco.com/maslows-hierarchy-of-needs-4582571
How to develop and implement a communications plan (1, 2, 3)	Elements of an effective communications plan Benefits of identifying stake holders and developing a communications plan and consequences of not doing so. Exercise: Develop a draft DRA communications plan for your case study (to be reviewed at end of process)	DRA manual pp 23-25, 91-92 Course worksheet Examples of resources/components Online examples e.g. https://communitycomms.org.nz/wp-content/uploads/2016/06/Comms-plan-template.pdf	Source and compile delivery materials.
Communication tools (5, 4)	Conflict management examples	Jamie Copsey (CPSG)	In DRA Manual (p53) – table of tools to use at each stage

	Basic facilitation skills Trans-disciplinary and cross-cultural considerations and challenges Using different media (written, multimedia, images, audio etc)	Role play videos Examples of opening lines to substitute for less useful conversations (Ben to share his course) Lecture (new course presentation - To be done)	Source and compile delivery materials.
Knowledge check	Short answer/multiple choice questionnaire	To be developed	
Open Discussion	Discussion thread topic Developing a communications plan for the Case Study and issues arising[1]	Live discussion	SU/Forum[2]

MODULE 5: HAZARD IDENTIFICATION

Learning outcomes

- Be able to clearly define the population(s) of concern within scope and focus of the problem.
- Appreciate what disease is – includes non-infectious disease
- Demonstrate how to conduct a thorough hazard ID for a population of concern
- Know how to establish criteria for ranking the importance of each hazard within the bounds of the DRA goal

[1] Perhaps a panel of experts could be established to review and provide feedback on the case studies as they develop?

[2] An online forum for participants to interact, share information and ideas and support each other. This could form the basis of an on-going DRA support community.

Content	Delivery	Resources	To do
• What is the Population of concern – consider target species, sympatric species, taxonomically related species, share same niche	• Use of case studies, and getting students to identify population(s) of concern	• Previous DRAs	Identify suitable DRAs as exemplars
• Definitions – infection vs disease, non-infectious disease • Factors that can contribute to health concerns – captive, wild, stress of translocation/capture	• Glossary • Lecture based on case studies	DRA Manual pp 145-149	Convert glossary for quick search access within online course.
Content	**Delivery**	**Resources**	**To do**
• Resources to use – literature (published/unpublished), databases, experts in field, medical reports	• Same lecture based on case studies	• ZIMS • eWHIS/national wildlife disease database • Recovery plans/reports • Scientific literature	Source and compile delivery materials.
• Clear explanation of the importance of establishing criteria for ranking each hazard • Explain how to assign likelihood & consequence to hazards – which tools to use to achieve this • Consider the consequence of each hazard to help decide whether a full hazard assessment is required for each hazard • Transmission pathways and how this information can be	• Same lecture with examples of tools/approaches used to assign likelihood/consequences and the tools used to prioritise – eg with and without a matrix.	• Dalziel, A.E., Sainsbury, A.W., McInnes, K., Jakob-Hoff, R. and Ewen, J.G., 2017. A comparison of disease risk analysis tools for conservation translocations. *EcoHealth*, *14*(1), pp.30-41. • pp29-34 and Sainsbury and Vaughan-Higgins (2012)	• Pull together a list of hazards for the personal case study and use two prioritization tools to show how different methods can give different results

used to understand/clarify risk of hazards • Exclusion of hazards – how to achieve this, what it means			
• Knowledge check	• On-line knowledge check on this topic	• Short answer/multiple choice questionnaire	
• Open Discussion	Discussion thread topics 1) Generating hazard list in the absence of species-specific data 2) Case study issues arising	• Live discussion	• TBD/Forum

MODULE 6: RISK ASSESSMENT 1: QUALITATIVE

Learning Outcomes

- Understand and be able to apply the elements of a qualitative risk assessment using appropriate qualitative terminology
- Familiarity with 'rapid' and 'comprehensive' risk assessment methods, the pros and cons of each and the appropriate circumstances for each
- Familiarity with and ability to use a range of qualitative risk assessment tools
- Demonstrated ability to construct a hazard pathway diagram and identify Critical Control Points (CCPs)

Content	Delivery	Resources	To do
• Justifying the selection of hazards for detailed risk assessment. Eg. Risk estimation: Based on the above and (any other considerations), the overall risk of this hazard to (population(s) of interest) is	• Lecture/reading with case study examples	• Existing IUCN manual and guidelines for DRA • OIE - https://www.oie.int/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Training_Manual_Wildlife_3.pdf	Table/flow chart of available tools – eg, includes international border, known disease risks, reintroduction, geographic barrier, resources available (eg time) – which leads you to

ranked as (HIGH/MEDIUM/LOW/NEGLIGIBLE) and risk mitigation actions are/are not recommended. • Ensuring transparency in methodology including level of uncertainty, assumptions and limitations. E.g. Level of Confidence in this Risk Estimation (Rank High, Medium or Low and explain the basis of this ranking) • Documenting knowledge gaps and identifying research to reduce uncertainty		• Best practice guidelines for the re-introduction of great apes - http://www.primate-sg.org/best_practice_reintroduction/ • Suarez, M.B., Ewen, J.G., Groombridge, J.J., Beckmann, K., Shotton, J., Masters, N., Hopkins, T. and Sainsbury, A.W., 2017. Using qualitative disease risk analysis for herpetofauna conservation translocations transgressing ecological and geographical barriers. EcoHealth, 14(1), pp.47-60. https://link.springer.com/article/10.1007/s10393-015-1086-4 • Electronic databases In Australia eWHIS WAHID - https://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/diseasehome Canadian Wildlife Health Cooperative Wildlife Disease Database - http://www.cwhc-rcsf.ca/wildlife_disease_database.php Country specific lists of notifiable diseases	an appropriate method/tool – and THIS is part of the course content ie, students would need to show that they have used each as a case study

Content	Delivery	Resources	To do
• The format and terminology for a qualitative risk assessment	• Lecture/reading with case study examples • Glossary	• Manual glossary	Record lecture; source case studies
• Rapid risk assessment methods and their application; advantages and disadvantages	• Expert interview: Kate McInnes re use of NZ DOC's DRAT tool	• Reading McKenzie and Langstaff report for MAF re RRA to prioritize wildlife surveillance.	Requests to Kate McInnes and Jo McKenzie.
• Tools that can assist qualitative risk assessment.	• Demonstration of tool use for each step in the risk assessment	• DRA Manual Figs 9 & 10 pp 52-53 • Case study exemplars	Access to tools which can be applied at different levels
• Use of graphical models and scenario trees to visualise biological and spatial pathways and factors influencing disease occurrence.	• Reading/case studies • Exercise: Develop graphical models/scenario trees for individual case study	• DRA Manual pp 60-74 • Case study exemplars	Source and compile delivery materials.
• Knowledge check	• On-line knowledge check on this topic	• Short answer/multiple choice questionnaire	
• Open Discussion	Discussion thread topics 1) Transparency in qualitative risk assessment 2) Case study issues arising	•	TBD/Forum

MODULE 7: RISK ASSESSMENT 2: QUANTITATIVE

Need to include (maybe in the overview of qualitative versus quantitative approaches) – thinking up front about what the management options are – fit the level of analysis to the decisions that you need to make.

Learning Outcomes

- Be aware of the main quantitative tools available for the risk assessment component of DRA.

- Understand which tools are most applicable to different situations.
- Understand the role of an expert, where to find one and how to work with them to answer the specific questions posed.
- Have a basic understanding of how to interpret the outputs of quantitative risk assessments.
- Understand when to apply quantitative risk assessment e.g. for sensitivity analysis.
- Open Discussion
- Knowledge check

Content	Delivery	Resources	To do
• Overview of what modelling is used for. • Different types of tools (regression analyses, expert elicitation). • Data availability and sources. • Basic stats integrated into teaching via a case study.	• Written materials • Brief written description of OUTBREAK followed by: • Case study (Bob Lacy video) AND • Interactive OUTBREAK run-through (point and click) • Dolphin network models?	IUCN/OIE DRA Manual (tools section – just the tools relevant to quantitative analysis) OIE Handbook Vol II: Quantitative Risk Assessment. OIE publication - Garner & Hamilton Rev. sci. tech. Off. Int. Epiz. Vol 30(2) (2011) Ward et al., same volume and some other sections on wildlife (link is in my email tray) https://web.oie.int/boutique/index.php?page=ficprod&id_produit=944&fichrech=1&lang=en	Case studies to illustrate the effective application of different kinds of quantitative approaches to different DRA problems – to illustrate the range of things that are done. Ensure a capable facilitator for this session! Access an interactive OUTBREAK presentation/session (work with SCTI) Review of quantitative tools →Update of the manual? OIE Scientific and technical review link
• Case studies of "bookend" examples • Mark Re-capture	Lecture/reading		Source suitable case study
• Case study • OIE Terms of Reference	Lecture/reading		Source suitable case study PDF OIE Terms of reference
• Walk-through of sample outputs	Exercise: interpretation of carefully chosen outputs		Design exercise
• Advantages and disadvantages	Short exercise – examine your own case and discuss		Formulate questions

	the pros and cons of applying a quantitative approach.		
Discussion thread topics 1) Q&A relating to videos. 2) Applicability of OUTRBREAK to participant's selected case studies	Webinar		ID webinar host and describe content requirements
On-line knowledge check on this topic	Short answer/multiple choice questionnaire		

MODULE 8: RISK MANAGEMENT

Learning Outcomes

- For each hazard, be able to identify the range of risk management options
- Understand range of approaches to disease risk management in wildlife and when to seek expert advice. (e.g. an outbreak vs. controlled animal movement)
- Be able to assess the feasibility and effectiveness of risk management options
- Recognize when research is required to support more immediate risk management actions
- Be able to develop a contingency risk management plan
- Open Discussion
- Knowledge check

Content	Delivery	Resources	To do
• Explain approaches to reducing the likelihood of disease risk and what can be done to reduce the implications once a disease occurs.	• Lecture • Personal reading • Case studies for this section • Videos illustration a disease investigation and control methods	DRA Manual pp39-44 Wildlife Health Australia Biosecurity Manual	Source and compile delivery materials.
• Introduce general principles of managing disease risks in the context of epidemiology e.g. isolation, quarantine, vaccine and seeking expert advice.	Lecture		Source and compile delivery materials.
• Explain approaches to ranking risk management options with examples	Lecture/case study examples	Table VIII p 40	Source and compile delivery materials.
• Describe situations in which action needed to be taken while information gaps and research priorities are identified and followed through.	• Examples of case studies such as Bellinger Rive snapping turtle in which this applied. • Corroboree frog where there is no clear exit strategy.	Published case studies	Source and compile delivery materials.

Content	Delivery	Resources	To do
• Explain and show examples of a prioritized contingency plan • Introduce decision trees as a tool for mapping out potential options in the presence of uncertainty. • Explain the adaptive management cycle and its application to DRA	Case study examples	DRA Manual p45 Tools section of Manual re decision trees; p.35 for tools.	Source and compile delivery materials.
Discussion thread topics: 1) What makes a mitigation feasible and effective? 2) Case study issues arising	• Live discussion	• TBD/Forum	•
• On-line knowledge check on this topic	• Short answer/multiple choice questionnaire	•	•

MODULE 9: **IMPLEMENTATION AND REVIEW**

Learning Outcomes

- Be able to develop an implementation action plan
- Design a plan to monitor and evaluate (*review*) the effectiveness of the management actions.

Content	Delivery	Resources	To do
• Identify goals, roles and responsibilities (including the importance of a designated project leader), timeline and resources required. • Providing some case study examples	Lecture/case studies	• DRA Manual Appendix 5 p 112 re group dynamics • DRA Manual example p43-44	Source and compile delivery materials.
• Introduce a program logic approach to planning for	Lecture/case studies	Manual Appendix 6 pp118-119	Source and compile delivery materials

monitoring and evaluation of the plan implementation.			

Content	Delivery	Resources	To do
Open discussion: possible topics: 1) Considerations from differing perspectives e.g. landowner, ecologist, conservation manager, wildlife vets etc. 2) Case study issues arising	• Live discussion	• TBD/Forum	
• On-line knowledge check on this topic	• Short answer/multiple choice questionnaire		

MODULE 10: WORKSHOP PLANNING AND REPORTING

Learning Outcomes

- Able to develop a facilitation plan for a multi-stakeholder DRA
- Understand how to integrate DRA into a broader species conservation plan.
- Know when to seek help of an expert facilitator
- Considerations in constructing and finalising the DRA report
- On-line knowledge check on this topic

Content	Delivery	Resources	To do
Exercise: draft plan for selected DRA case study.	Lecture/+personal reading pp 112-117	Under development	Record lecture
Exercise: Complete and submit final case study DRA report.	Webinar + review of submitted case studies	Example case study reports Completed worksheet exemplar	Identify webinar host

Content	Delivery	Resources	To do
Live discussion: Possible topics • Facilitator's role and responsibilities • Challenges of multi-stakeholder engagement • Issues relating to case study	TBD/Forum		
Short answer/multiple choice questionnaire		To be developed	

TRAINING APPLICATION PLAN AND COURSE ASSESSMENT

Description and content	Format	Lead	Progress
Course review: What have we learnt, what did we not understand and what would we like to discuss further?	Online survey	MJH/JC	To be developed
Now at the end of the course we ask individuals to submit their Personal Development Plan detailing how you intend to apply course learning. The plan should include the scope, focus, justification and plan for the next DRA you will conduct and what tools and processes you intend to use at each step in the process and why.	Personal Development Plan submission	JC/RJH	TBD

Submission for a Certificate of Reflective Practice to include: Reflection on progress made against baseline self-assessment and how you think the course went, what went well and what could have gone better. What you would do differently next time to improve the DRA course outcomes for others.	Written submission	JC/RJH	To be adapted from Facilitation course with help from Jamie Copsey
Course End			

IUCN

SSC
Species Survival Commission

Manual
of Procedures for Wildlife Disease Risk Analysis

Richard M. Jakob-Hoff
Stuart C. MacDiarmid
Caroline Lees
Philip S. Miller
Dominic Travis
Richard Kock

OIE
WORLD ORGANISATION FOR ANIMAL HEALTH
Protecting animals, preserving our future

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1. Bushmeat hunters returning to their village on the boundary of Odzala National Park, Republic of Congo, with a variety of duiker species harvested from the forest. Photo courtesy: Michael Kock
2. Oriental white-rumped vultures, Gyps bengalensis, feeding on a domestic water buffalo, Bubalus bubalis, in India. This species is now critically endangered as a result of ingesting the veterinary drug diclofenac used to treat buffalo and cattle for lameness and other conditions but highly toxic to vultures. Photo courtesy: Munir Virani – The Peregrine Fund
3. A Tasmanian devil, *Sarcophilus harrisii* with the cancerous growths typical of Devil Facial Tumour Disease which has decimated populations of this top predator on the Australian island state of Tasmania. Photo courtesy: Sarah Doornbusch
4. Zebra and domestic animals share a grazing area near a local village in the buffer zone of Limpopo National Park, Mozambique. Photo courtesy: Michael Kock

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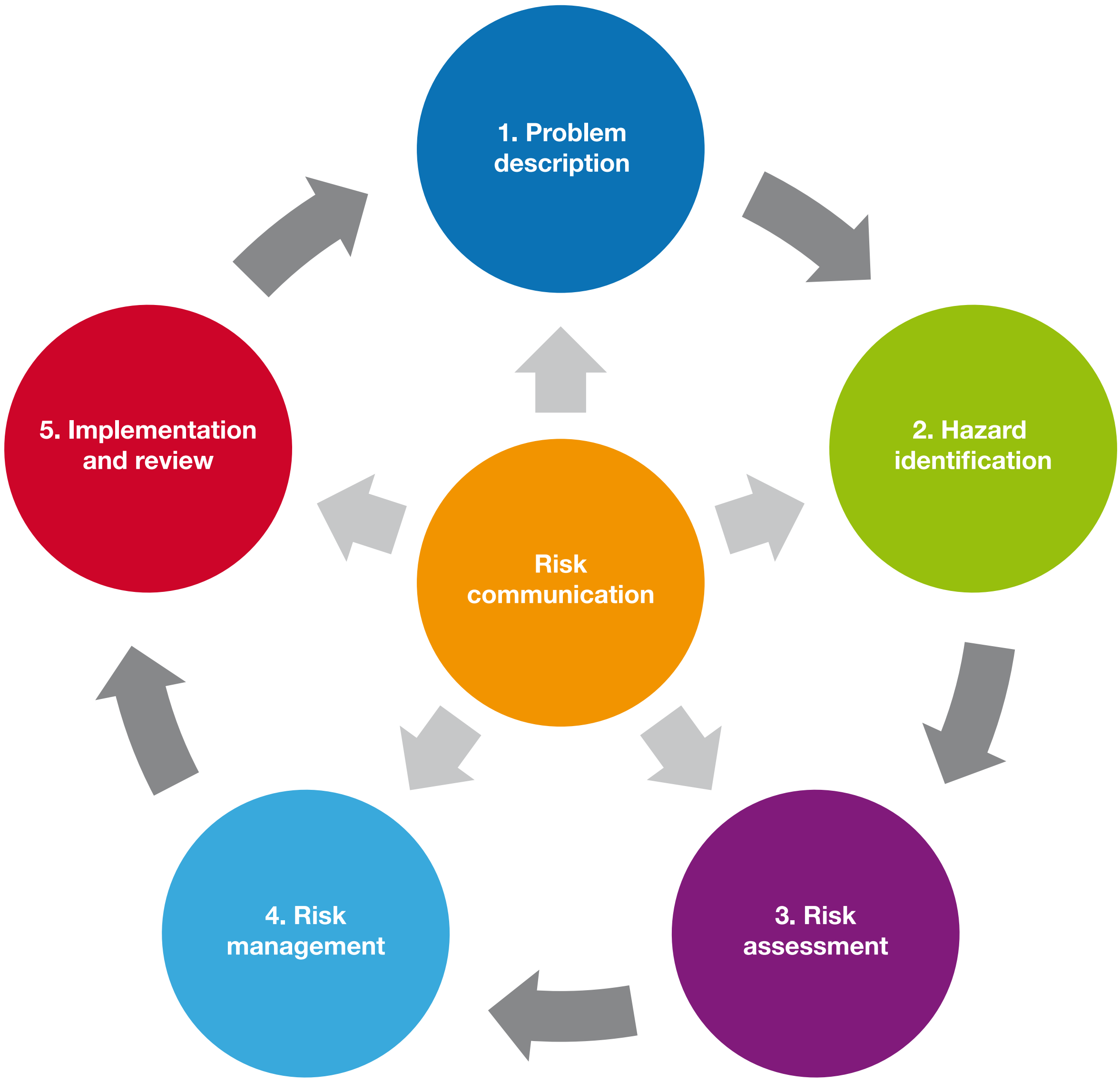
Co-published by OIE and IUCN

Disease risk analysis (DRA) process steps



Steps in the disease risk analysis (DRA) process

Risk communication (applies throughout all DRA steps)

Purpose: Engage with relevant experts and stakeholders in a way that will maximise the quality of analysis and the probability that the recommendations arising will be implemented.

Questions: 'Who has an interest, who has knowledge or expertise to contribute, and who can influence the implementation of recommendations arising from the DRA?'

❶ Problem description

Purpose: Outline the background and context of the problem, identify the goal, scope and focus of the DRA, formulate the DRA question(s), state assumptions and limitations and specify the acceptable level of risk.

Questions: 'What is the specific question for this DRA? What kind of *risk analysis* is needed?'

❷ Hazard identification

Purpose: Identify all possible health *hazards* of concern and categorise into 'infectious' and 'non-infectious' *hazards*. Establish criteria for ranking the importance of each *hazard* within the bounds of the defined problem. Exclude *hazards* with zero or negligible probability of release or exposure, and construct a scenario tree for the remaining, higher priority, *hazards* of concern, which must be more fully assessed (Step 3).

Questions: 'What can cause *disease* in the population of concern?', 'How can this happen?' and 'What is the potential range of consequences?'

❸ Risk assessment

Purpose: To assess for each *hazard* of concern:

a) the likelihood of release (introduction) into the area of concern;

b) the likelihood that the species of interest will be exposed to the *hazard* once released;

c) the consequences of exposure. On this basis the *hazards* can be prioritised in descending order of importance.

Questions: 'What is the likelihood and what are the consequences of an identified hazard occurring within an identified pathway or event?'

❹ Risk management

Purpose: Review potential risk reduction or management options and evaluate their likely outcomes. On this basis decisions and recommendations can be made to mitigate the risks associated with the identified *hazards*.

Questions: 'What can be done to decrease the likelihood of a hazardous event?' and 'What can be done to reduce the implications once a hazardous event has happened?'

❺ Implementation and review

Purpose: To formulate an action and contingency plan and establish a process and timeline for monitoring, evaluation and review of *risk management* actions. The review may result in a clearer understanding of the problem and enable refinement of the DRA. (See 'Adaptive management' on p. 45.)

Questions: 'How will the selected *risk management* options be implemented?' and, once implemented, 'Are the *risk management* actions having the desired effect?' and, if not, 'How can they be improved?'

How to use this *Manual*

Users of this *Manual* will vary considerably in their level of knowledge and experience of *risk analysis* and the resources available to them. As such, the subject matter has been organised to enable users to work through it in a logical sequence or, for more experienced users, to rapidly find and turn to their specific items of interest.

Front and back

Two quick references have been incorporated into the layout:

– The process diagram inside the cover of this *Manual* is positioned for ease of reference to the stages of the DRA process, regardless of which part of the *Manual* is being used. Next to this is a succinct description of the purpose of each step and the questions they are designed to answer. The main steps in the DRA process are colour coded throughout the book.

– The glossary is located at the back of the book for quick reference. In addition, all terms used in the glossary are italicised in the text.

Overall design

Following a brief history of *disease risk analysis* (p. 15), this *Manual* is divided into five major sections:

1. **Key concepts for wildlife *disease risk analysis*** (pp. 17–20):

An outline of fundamental concepts that should be considered when analysing wildlife disease risks.

2. **Planning and conducting a wildlife *disease risk analysis*** (pp. 21–49):

A detailed description of each step in the DRA process with examples taken from published and unpublished sources. This section also includes guidelines for successful interdisciplinary collaboration, technical, social and political considerations and some of the associated challenges.

3. **Tools for wildlife *disease risk analysis*** (pp. 51–92):

Each of the DRA process step descriptions in the previous chapter is accompanied by a box listing the tools that may be useful in completing that step. This chapter provides detailed information on a representative array of the tools available to assist practitioners in working through a DRA. The tools included range from relatively simple drawing tools that help illustrate the disease system of interest and the main influences on it, to more complex, probability-based disease and population modelling programmes that can help with more detailed quantitative analyses. For ease of access, tools are categorised according to the step(s) in the DRA process to which they apply, and also according to their utility in situations in which resources, data or access to specialists, may be constrained.

4. **Appendices** (pp. 93–136):

The appendices include additional information, examples and references relevant to the topics covered in this *Manual*.

Appendix 1 provides a guide to further sources of information of value to *wildlife disease risk analysis*. Appendices 2, 3 and 4 provide information on disease surveillance, screening for pathogens and Monte Carlo modelling. These are large topics which are dealt with comprehensively in other texts. The purpose of the brief introductions included here is to help the broader audience of wildlife managers, policy makers and field biologists, who may be less familiar with these topics, to access a basic understanding and vocabulary in these areas.

Also included are guidelines for planning a DRA workshop (Appendix 5) and a DRA evaluation (Appendix 6). Three wildlife DRA case summaries that illustrate the application of the process to a range of scenarios are contained in Appendix 7, while Appendix 8 provides an example of a more comprehensive DRA utilising some of the tools featured in this *Manual*.

5. **References and Glossary**

A reference section on pages 137–143 is followed by a glossary of the technical terms used in this *Manual*. As the meaning of some of these words or phrases can vary between different disciplines (e.g. veterinary science vs ecology), it is advisable to check the meaning attributed to them by the authors of this publication. As noted above, to assist this, each of the terms featured in the glossary is italicised in the text.

Acknowledgements

The topic and practical nature of this *Manual* mean that it could only have been written through *transdisciplinary* collaboration. The editors are profoundly grateful and humbled by the generosity of the many individuals listed below who contributed their knowledge, skills and time to its development. This included some or all of the following: discussion and development of the vision, mission, overall structure and content through participation in a number of online meetings and, for some, participation in a face to face workshop in Auckland, New Zealand; following up on tasks assigned at, or after, the workshop; providing feedback on, and assistance with, the format, style and content of several drafts of the document over a two-year period; contributions of case studies and bibliographic materials; and assistance with enlisting contributors and supporters by 'spreading the word' through their personal and professional networks.

We thank you and hope you feel the resulting work is worthy of your efforts.

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Dedication

This work is dedicated, with great respect, to the late Ulysses S. Seal (Conservation Breeding Specialist Group Chairman 1979–2003) and to Doug Armstrong (Director of Animal Health, Henry Doorly Zoo) whose combined vision and work inspired its contributors and established the foundation on which this volume was built.

Workshop sponsors

We are deeply grateful to our sponsors: Auckland Zoo, New Zealand Department of Conservation, Landcare Research and the IUCN Species Survival Commission Conservation Breeding Specialist Group, who made the face-to-face workshop in Auckland, New Zealand, possible. This was a pivotal event in the development of this resource, enabling many of the contributors to cement their collaborative relationships, share perspectives and experiences and debate many of the issues relevant to the application of disease *risk analysis* to wildlife.

International Union for the Conservation of Nature (IUCN)

We also pay tribute to the following IUCN Species Survival Commission specialist group Chairs who gave their support to this project from the outset and facilitated the distribution of information regarding it through their networks:

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William Karesh and Richard Kock, Wildlife Health Specialist Group;

Frederic Launay, Reintroduction Specialist Group;

Piero Genovesi, Invasive Species Specialist Group.

The World Organisation for Animal Health (OIE)

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The Members of the OIE Working Group on Wildlife Diseases.

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OIE Preface

World Organisation for Animal Health
12, Rue de Prony - 75017 Paris, France

The need to fight animal diseases at the global level led to the creation of the Office International des Epizooties (OIE) through the signing of an international agreement on 25 January 1924. In May 2003 the Office became the World Organisation for Animal Health but kept its historical acronym, OIE.

The OIE is the intergovernmental organisation responsible for improving animal health worldwide and has 178 Member Countries (as at 2013). The OIE maintains permanent relations with 45 other international and regional organisations and has regional and sub-regional offices on every continent. The OIE is recognised as the international standard-setting organisation for animal health and zoonoses, under the World Trade Organization (WTO) Sanitary and Phytosanitary Agreement (SPS Agreement).

The complexity of disease emergencies in a globalised world calls for the identification of effective strategies, based on both science and proven practical experience, to reduce future threats. The H5N1 avian influenza crisis demonstrated how crucial it is to address persistent global threats at the interface among humans, animals and ecosystems. Moreover, it has shown how a concrete, transparent and consistent approach, based on high-quality scientific advice and practical experience, is vital for the management of these threats and for political credibility, at national, regional and international level. This *Manual of Procedures for Wildlife Disease Risk Analysis* provides a new resource that will be of great value to all those concerned with wildlife-related diseases.

In areas related to the animal–human–ecosystem interface, collaboration and cooperation among the various sectors is critical to ensure that efforts are efficient and effective. The OIE has been working to assist Member Countries with how they can best work at this interface. The OIE strongly supports the publication of this *Manual*, which will help to expand the scientific basis for effective intersectoral collaboration and identify ways to operationalise this interface in policy and in practice.

In recognition of the important role of wildlife as a reservoir of diseases of significance to domestic animals and human health, the OIE established a Working Group on Wildlife Diseases in 1994. The role of this body of international experts is to inform and advise the OIE on all health issues relating to wild animals, whether in the wild or in captivity.

Publications of relevance to this topic include the OIE *Terrestrial Animal Health Code*. Chapter 2.1, Import Risk Analysis, provides OIE Member Countries with recommendations and principles for conducting transparent, objective and defensible risk analysis for international trade in animals and animal products. In addition, two earlier OIE publications, produced in collaboration with the Canadian Cooperative Wildlife Health Centre (CCWHC), are worthy of mention. *Health Risks Analysis in Wildlife Translocations*, published in 2004, provided step-by-step guidelines for health risk analysis for the movement of wildlife across or within national borders. In 2010 a practical *Training Manual on Wildlife Diseases and Surveillance*, authored by CCWHC Director, Dr F.A. Leighton, was published by the OIE and is used by the OIE within its capacity-building global programme of national focal points for wildlife. This was developed for use in training workshops, with a view to providing practical advice on wildlife diseases and surveillance and facilitating an interactive working session for participants.

Another OIE publication of relevance is the *Guidelines for Assessing the Risk of Non-native Animals Becoming Invasive*, published in 2011. This provides an objective and defensible method of determining whether imported animal species are likely to become harmful to the environment, animal or human health or the economy.

This IUCN/OIE *Manual of Procedures for Wildlife Disease Risk Analysis* adds another important resource by extending the application of the standardised OIE risk analysis methodology to the analysis of disease threats to biodiversity conservation. In the spirit of the cross-sectoral collaboration noted above, this document has been jointly developed by the OIE and the International Union for the Conservation of Nature (IUCN). The IUCN has also produced a complementary summary publication, the IUCN/OIE *Guidelines for Wildlife Disease Risk Analysis*, for use by policy and decision makers.

We are extremely grateful to Dr Richard Jakob-Hoff, his editorial committee and the contributing authors for sharing their specialist expertise in the compilation of this *Manual*.

December 2013
Bernard Vallat
Director-General OIE

IUCN Preface

International Union for the Conservation of Nature
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Founded in 1948, the International Union for Conservation of Nature (IUCN) is the world's oldest and largest global environmental organisation. Its membership comprises 12,000 voluntary scientists and experts representing over 200 government and 900 non-government organisations in some 160 countries.

The IUCN Species Survival Commission (SSC) is a science-based network of more than 8,000 volunteer experts from almost every country of the world, all working together towards achieving the vision of: 'A world that values and conserves present levels of biodiversity.' Most members are deployed in more than 130 specialist groups, Red List Authorities, sub-Committees, working groups and task forces.

The technical guidelines produced by the SSC provide guidance to specialised conservation projects and initiatives, such as reintroducing animals into their former ranges, handling confiscated specimens and halting the spread of invasive species. The development of this IUCN/OIE *Manual of Procedures for Wildlife Disease Risk Analysis* and its companion, the IUCN/OIE *Guidelines for Wildlife Disease Risk Analysis*, are fine examples of the benefits of collaboration among the global SSC voluntary network of experts. As outlined in the introduction, this work is the culmination of the collaborative effort of four of the SSC's disciplinary groups with a common interest in pathogenic organisms and their impacts on biodiversity conservation:

The Conservation Breeding Specialist Group (CBSG) aims to save threatened species by increasing the effectiveness of conservation efforts worldwide by:

- developing and disseminating innovative and interdisciplinary science-based tools and methodologies
- providing culturally sensitive and respectful facilitation that results in conservation action plans
- promoting global partnerships and collaborations, and
- fostering contributions from the conservation breeding community to species conservation.

The Wildlife Health Specialist Group (WHSG) serves as a first response for wildlife health concerns around the world and aims to enhance understanding of wildlife disease and its role in multispecies infections or other disease syndromes. It comprises a network of regional experts primarily conducting wildlife health work in the areas of health surveillance, reporting and response, wildlife disease management, disease ecology, diagnostics, epidemiology, pathology, toxicology, health policy and related health disciplines.

The Reintroduction Specialist Group (RSG) aims to combat the ongoing loss of biodiversity by using reintroductions as a responsible tool for the management and restoration of biodiversity through actively developing and promoting sound interdisciplinary scientific information, policy and practice to establish viable wild populations in their natural habitats. Recent RSG publications complimentary to the current volume include the fully revised *IUCN Guidelines for Reintroductions* and Ewen *et al.* (2012) *Reintroduction Biology: Integrating Science and Management* (Wiley-Blackwell).

The Invasive Species Specialist Group (ISSG) aims to reduce threats to natural ecosystems and the native species they contain by increasing awareness of invasive alien species and of ways of preventing, controlling or eradicating them. The ISSG promotes and facilitates the exchange of invasive species information and knowledge across the globe and ensures the linkage between knowledge, practice and policy so that decision making is informed. The two core activity areas of the ISSG are policy and technical advice, and, information exchange through networking and its online resources and tools, including the Global Invasive Species Database, which includes data on the distribution and biodiversity impacts of pathogenic organisms.

The present volume is the first formal collaboration among these four specialist groups on a topic of mutual interest and value. The increasing incidence of emerging and re-emerging disease threats to biodiversity conservation are a symptom of our species' increasing imbalance with our natural environment. In order to redress this imbalance, fundamental shifts in thinking and behaviour will need to be made. These include discarding disciplinary silos in favour of the transdisciplinary collaborations advocated in this *Manual* and modelled in its development.

The Species Survival Commission is grateful for the work of the authors and editors of this excellent volume and, in partnership with the World Organisation for Animal Health (OIE), proud to endorse it as a further, valuable resource for the global conservation community.

December 2013
Simon N. Stuart
Chair, IUCN Species Survival Commission

Introduction

R.M. Jakob-Hoff, S.C. MacDiarmid, C. Lees, P.S. Miller,
D. Travis & R. Kock

Disease risk analysis (DRA) is a structured, evidence-based process that can help decision making in the face of *uncertainty* and determine the potential impact of infectious and non-infectious diseases on *ecosystems*, wildlife, domestic animals and people. Results from the DRA can help decision makers to consider an evidence-based range of options for the prevention and mitigation of disease risks to the population(s) under consideration.

● 'One Health' and another shift in focus

This *Manual of Procedures for Wildlife Disease Risk Analysis* (this '*Manual*') builds on a large body of work on DRA in particular that of the World Organisation for Animal Health (OIE), and extends this to apply existing methodologies to the issues concerned with biodiversity conservation.

Thomas Kuhn, in his seminal 1962 work, *The Structure of Scientific Revolutions* (Kuhn 1962), described the stages through which our understanding of the world and how it works changes over time. Using examples such as the Copernican revolution that changed the dominant Western belief of the 15th Century from an Earth-centric universe to one in which the Earth orbits the Sun, Kuhn identified a consistent sequence of stages in which the prevailing world view or 'paradigm' is replaced by a new one. He found that such 'revolutions' happen over a considerable time period and are driven by a growing body of 'anomalies' that cannot be explained or understood within the framework of the current world view. In Kuhn's analysis, there are long periods of 'normal science' in which research questions are pursued based on the existing paradigm. Observations that cannot be explained within this framework gradually accumulate until another, often radically different, world view is proposed that accounts for existing knowledge as well as these 'anomalies'. A period of crisis follows in which there is strong resistance by the current 'establishment', (often accompanied by the ridicule of proponents of alternative paradigms) as the new thinking challenges prevailing beliefs and the social hierarchies and distribution of resources that have grown alongside them.

Such a 'thought revolution' is currently in progress as we are confronted with the realities of living in a world that is considerably more complex and integrated than suggested by the Newtonian *model* that has dominated Western thinking for the past 300 years. Through this world view natural phenomena are studied by reducing them to their component parts. This mechanistic paradigm has enabled (and continues to enable) extraordinary advances in medicine, technology and many other areas of human endeavour over the last three centuries. However, its limitations are becoming increasingly evident as we face a world dominated by the combined activities of 7 billion of our species. Human-induced or 'anthropogenic' effects on the planet are now radically changing *ecosystems* and the regulatory mechanisms (such as climate and the carbon cycle) that have become closely integrated over millions of years and provide the environmental conditions necessary to support the diversity of life we know today. If we are to understand (and manage) the drivers of wildlife disease in the dynamic, interdependent living systems of which we humans are a part, it is necessary to re-focus our view on the 'big picture' provided by the relatively modern science of ecology (the study of relationships between organisms and the environment) and epidemiology (the study of disease dynamics in populations).

The emergence of new diseases in people (e.g. bovine spongiform encephalitis or 'mad cow disease', human immunodeficiency virus/acquired immune deficiency syndrome, Severe acute respiratory syndrome,) and the re-emergence of diseases once thought to be controlled (e.g. tuberculosis) have prompted the re-establishment of the concept of 'One Health' and the development of associated disciplines such as 'Ecosystem Health' and 'Conservation Medicine' (Aguirre *et al.* 2002; Friend 2006, Rabinowitz and Conti 2010).

One Health is a comprehensive approach to health that focuses on:

1. improving health and well-being through the prevention of risks and the mitigation of the effects of crises (emerging diseases) that originate at the interface among people, animals and their various environments

2. promoting cross-sectoral collaborations and a 'whole of society' treatment of health *hazards*, as a systemic change of perspective in the management of risk.

This world view was encapsulated in the 'Manhattan Principles' at a 2004 conference at The Rockefeller University, New York, entitled 'One World, One Health: Building Interdisciplinary Bridges to Health in a Globalized World'. The Wildlife Conservation Society's Robert Cook, William Karesh and Steven Osofsky summarised these principles, now supported by many national and international bodies (e.g. see www.onehealthinitiative.com/supporters.php), in the closing statement of the conference report:

> *It is clear that no one discipline or sector of society has enough knowledge and resources to prevent the emergence or resurgence of diseases in today's globalized world. No one nation can reverse the patterns of habitat loss and extinction that can and do undermine the health of people and animals. Only by breaking down the barriers among agencies, individuals, specialties, and sectors can we unleash the innovation and expertise needed to meet the many serious challenges to the health of people, domestic animals, and wildlife and to the integrity of ecosystems. Solving today's threats and tomorrow's problems cannot be accomplished with yesterday's approaches. We are in an era of 'One World, One Health' and we must devise adaptive, forward-looking and multidisciplinary solutions to the challenges that undoubtedly lie ahead.*

The authors of this *Manual* have endeavoured to provide a practical resource that will enable wildlife conservation professionals and those who work within the health sciences – human, animal and environmental – to apply these principles to their analysis of disease risk. In so doing, we hope that they may be able to advance the inter-related causes of biodiversity conservation, biosecurity and domestic animal and public health through informed decision making when addressing the many situations in which wildlife disease is a critical factor.

The history and need for this *Manual*

Since 1992 the Conservation Breeding Specialist Group (CBSG) of the IUCN Species Survival Commission (IUCN SSC) has been facilitating collaboration between experts in zoo and wildlife veterinary medicine, disease ecology and population management to develop a set of tools for realistic and rigorous analysis of wildlife disease risks. This culminated in the publication of a workbook focused on disease risks associated with animal translocations (Armstrong *et al.* 2002) and available through the CBSG website (www.cbsg.org). In 2010, recognising that the range of concerns in relation to wildlife disease had broadened well beyond those associated with animal movements, CBSG, in partnership with three other IUCN SSC specialist groups (Wildlife Health, Reintroduction and Invasive Species), undertook a global needs analysis survey. The 290 responses from 40 countries represented 26 different occupation categories with an interest in wildlife disease (Box 1). As illustrated in Figure 1, human–wildlife interaction was the main issue of concern to the largest proportion of survey respondents, followed by domestic animal–wildlife interactions, management of wildlife in nature (in situ), wildlife translocations and management of wildlife in captivity (ex situ).

Box 1:
Occupations of respondents to the disease risk analysis needs analysis survey, 2010

Biologist
Biosecurity advisor
Captive breeding practitioner
Ecologist
Entomologist
Environmental toxicologist
Field manager
Herpetologist
Information management specialist
Marine biologist
Microbiologist
Nurse
Ornithologist
Pathologist
Planner/Manager
Policy officer
Public health physician
Research permit processing administrator
Researcher
Statistician
Student
Veterinary epidemiologist
Virologist
Volunteer
Wildlife ranger
Wildlife veterinarian

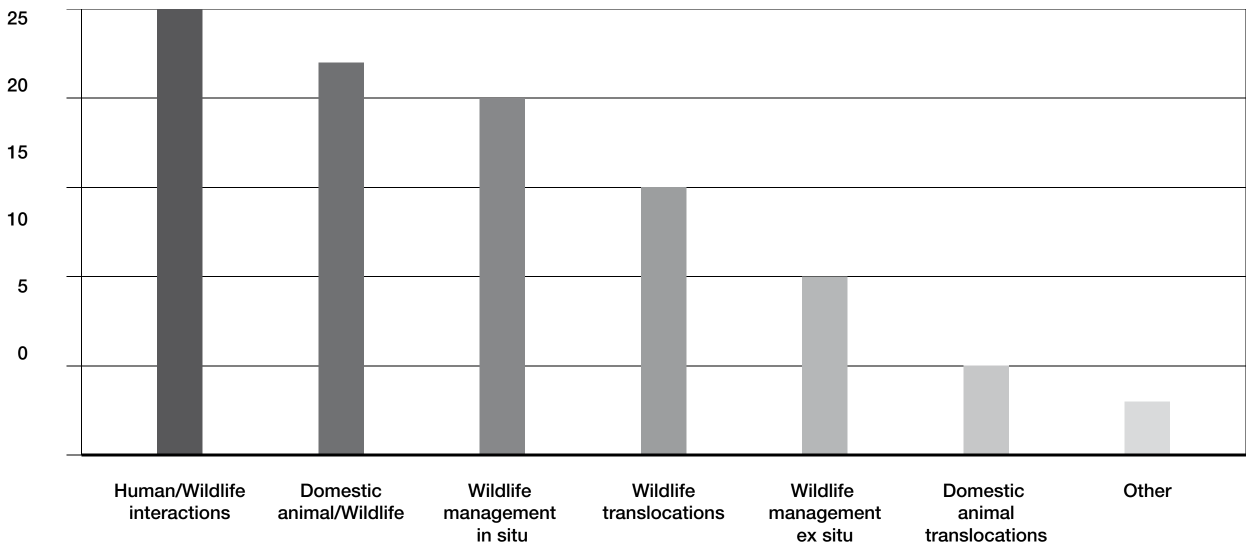


Fig. 1
Needs analysis survey respondents' main areas of wildlife disease concern (*n* = 290)

These results demonstrate that wildlife disease concerns are global, broad in scope and involve a wide diversity of people from multiple disciplines. This *Manual* was conceived and developed in response to this demand.

Prevention and collaboration

Fundamental to the understanding and management of wildlife disease risk are the concepts of 'prevention' and 'collaboration'.

The adage 'an ounce of prevention is worth a pound of cure' is nowhere more relevant than in addressing the impacts and management of wildlife disease. As outlined in this *Manual*, there are numerous examples in which infectious disease agents have inadvertently been transferred with the intentional and unintentional movement of wild and domestic animals, as well as people and animal products (Woodford and Rositer 1994; Wobeser 2006; Travis *et al.* 2011) . Examples include:

– the introduction of bovine tuberculosis into South Africa's Kruger National Park by domestic cattle, resulting in the rapid spread of infection through the park's African buffalo population, which now spreads the disease to other wildlife (Bengis *et al.* 1996; Michel *et al.* 2009)

– the introduction of invasive Australian brush-tailed possums, *Trichosurus vulpecula*, into New Zealand where they have become the major *reservoir* of tuberculosis for the cattle industry (Hickling 1991), and

– the spread of amphibian chytrid fungus, *Batrachochytrium dendrobatidis*, (now linked to mass amphibian extinctions), through legal and illegal trade (Travis *et al.* 2011).

As described in detail by Wobeser (2006), once the conditions needed for a *pathogen* to be released are established, (e.g. owing to changing populations, landscapes or ecological conditions) its control is invariably challenging and extremely expensive and eradication virtually impossible. For example:

– Despite over 40 years of efforts to eradicate bovine tuberculosis in possums in New Zealand, localised pockets of infected animals remain as *reservoirs* for cattle, and country-wide freedom, as at 2013, had not been achieved (Porphyre *et al.* 2008).

– The culling of 20,000 badgers, *Meles meles*, in England to control the spread of tuberculosis to cattle has resulted, in some cases, in the disruption of the social systems of these animals causing some infected badgers to disperse over greater distances (Donnelly *et al.* 2003).

Consequently there are major financial benefits in investing in the preventive strategy of conducting a DRA wherever wildlife is concerned – whether the object of concern be potential impact on wildlife conservation or the impact of wildlife as *reservoirs* or *vectors* of disease to people or domestic animals.

Transdisciplinary communication

Given the complexity of wildlife disease ecology, the relative scarcity of relevant published information and the involvement of multiple stakeholders, a major emphasis of this *Manual* is on *transdisciplinary collaboration*.

To make this resource as useful and accessible as possible to such a broad potential audience, an experienced multidisciplinary team, situated in many parts of the world, have freely and collaboratively contributed their knowledge and experience to the writing of this *Manual*. Through this collaboration it became evident that different disciplines sometimes use the same term but apply different meanings. This can present a language barrier when working in *transdisciplinary* groups. Consequently, there has been an effort to keep the language in this text plain and, where technical terms are necessary, to define each term in a glossary. The glossary of terms included herein has been developed and agreed upon by authors representing a range of disciplines in an effort to ensure consistent usage and interpretation by all users of this *Manual*. It is our hope that, over time, this publication will be translated into languages other than English so that this barrier to communication may also be overcome.

Disease risk analysis in the context of structured decision making

Analysing and managing disease risk in the context of animal population management involves many different decision points: What are the diseases of concern to my system of interest? How in particular do the species within that system – including humans – respond to the offending pathogenic agent? What are the best forms of treatment for the disease? What are the biological consequences of moving different species or populations of animals into or through the system of interest? This simple subset of questions helps to define the biological parameters of the larger problem, and the tools and processes described in this *Manual* are focused on analysing these in detail.

It is critical to realise, however, that species biology and disease epidemiology is only one of potentially many axes of information to consider when working to make the best decision to minimise the risk of disease introduction or transmission. Reducing financial cost, maximizing the extent of public support for a given management decision, or enhancing opportunities for gaining additional scientific knowledge of the system of interest can all be additional axes that might require consideration through the decision-making process. In fact, it is often necessary to make difficult trade-offs between the biologically optimal management decision and the allowable financial cost. How does the relevant decision-making authority balance these sometimes competing factors when trying to identify the best management decision?

The general field of structured decision making (SDM), sometimes referred to more specifically as multi-criteria decision analysis (MCDA), is ideally suited to address these types of complex, multidimensional problems. Structured decision making provides an organised approach to analysing the problem at hand, clarifies trade-offs between alternative potential courses of action and helps to communicate how people view these various options. Using a set of diverse tools and processes, SDM can integrate rigorous analysis and thoughtful deliberation in a fully transparent and accountable way. The process deals very explicitly with uncertainty, and can build significant capacity among included stakeholder domains for future decision-making abilities. For more information on SDM, see Clemen (1997), Gregory *et al.* (2012) and references therein.

Our goal with this *Manual* is not to provide the full breadth of information on the mechanics of putting DRA in the larger context of structured decision making. However, we recognise the potential value of incorporating elements of SDM when required for the specific decision at hand. If an expanded analysis becomes the desired approach, we recommend thoughtful consideration and application of the available SDM resources as an extension of the DRA analyses discussed here.

Wildlife DRA into the future

This *Manual* is a work in progress. We trust that managers and decision makers involved in land use planning that impacts wildlife, protected area managers, conservationists and those concerned with health in the broadest sense will see the benefits of this approach. Many of the examples used to illustrate the processes and tools described in the following pages are previously unpublished and are derived from the personal experiences of the authors. This exemplifies the current status of wildlife DRA with its considerable reliance on unpublished sources of information. However, there is a rapidly growing body of publications on the topics covered in this *Manual* and it is our hope that this resource will stimulate and encourage many more people to undertake wildlife DRAs and to publish and share their experiences. Only in this way will we broaden and refine our understanding of the complex systems of which wildlife disease is a manifestation and be able, collectively, to make decisions that benefit the health of all those who live on planet Earth.

December 2013

A brief history of disease risk analysis

D. Travis, S.C. MacDiarmid & R. Kock

The process of analysing risk has been a part of the human condition throughout history; every day, each of us assesses risk in the course of normal activities. However, it was not until 1654 when the French and Italian mathematicians Blaise Pascal and Luca Paccioli, exploring the issues of chance and *uncertainty* in gambling, developed what is now called the theory of probability, combining for the first time mathematics and rudimentary elements of today's concept of risk. In time, the theory of probability mathematics was further developed and refined by those in other disciplines attempting to assess risks and forecast the future (Berstein, 1996).

Veterinarians and veterinary services have traditionally based decisions regarding disease risks on experience and qualitative assessment.

In the late 20th Century, mathematicians, engineers, economists and health care professionals began to standardise techniques for qualitatively or quantitatively assessing and predicting measures of *risk* in their respective fields. As a result, a collection of methods known as *risk analysis* has emerged to support rational decision-making in the face of *uncertainty*. *Risk analysis* is not science *per se*, but is, instead an evidence-based process that is an organised and logical approach to identifying and using scientific information to support policy-making in the real world.

Numerous health-related organisations have published *risk analysis* frameworks for diseases caused by microbial organisms; most follow the generic *risk analysis* process but have differing *risk assessment* formats. A comparison of the intricacies of the formats can be found in the *ILSI Revised Framework for Microbial Risk Assessment* (International Life Sciences Institute 2000). A close inspection of the comparison provided by the International Life Sciences Institute (q.v.) shows that many *risk assessment models*, although evolving separately, converge into a similar format.

Box 2:
Recent landmarks in the development of disease risk analysis

In 1969, *quantitative risk assessment* methodology was advanced by Chauncey Starr who outlined a standardised format for the quantitative assessment of risk (Starr 1969).

In 1980, William W. Lowrance suggested that *quantitative risk assessment* methods should be applied to evaluate risks associated with infectious disease (Lowrance 1980).

In 1981, signs that *risk analysis* was becoming a formal discipline were evident as the journal *Risk Analysis* was created.

In 1983 the United States National Research Council of the National Academy of Sciences (NRC-NAS) standardised the format for the assessment of the effects of hazardous chemicals on human health in what is referred to as the Red Book. *Risk assessment* methodologies commonly used in animal and human health fields today can be traced back to this.

The World Organisation for Animal Health *risk analysis model* (Brückner *et al.* 2010) was developed from the environmental *risk assessment* methodology of Covello and Merkhofer (1993). Although developed primarily as a tool for import *risk analysis*, it has proven to be versatile in a number of diverse situations (Bartholomew *et al.* 2005). In this *Manual* we have adapted this globally used *model* to encompass the special features associated with *disease risk analysis* as it is applied to *wildlife* and biodiversity conservation.

Key concepts for wildlife disease risk analysis

D. Travis, S.C. MacDiarmid, K. Warren, C. Holyoake, R. Kock, R.M. Jakob-Hoff, I. Langstaff & L. Skerratt

People with a range of backgrounds and perspectives may apply *disease risk analysis* (DRA) to a broad spectrum of situations. To be successful, this *Manual* must communicate its contents effectively and consistently to all of these groups. In pursuit of this goal, we begin by describing a number of key concepts. Gaining an understanding of these is an important precursor to understanding the science and practice of DRA.

Risk

Risk is usually defined as the chance of encountering some form of harm, loss or damage. For this reason it has two components:

1. the likelihood[1], or probability, of something happening and, if it does happen,
2. the consequences of the deleterious activity.

Because of the element of chance, we can never predict exactly what will happen but, through an appropriate process, we can estimate the probability of any particular outcome occurring (Brückner *et al.* 2010).

Risk analysis

'*Risk analysis* is a formal procedure for estimating the likelihood and consequences of adverse effects occurring in a specific population, taking into consideration exposure to potential *hazards* and the nature of their effects' (Thrusfield 2007). It is a tool to enable decision makers to insert science into policy.

Disease

At the most basic level, disease is defined as any impairment of the normal structural or physiological state of an organism. The manifestation of disease is often complex and may include responses to environmental factors such as food availability, exposure to toxins, climate change, infectious agents, inherent or congenital defects, or a combination of these factors (Wobeser 1997).

Three important epidemiological concepts of disease to keep in mind are:

1. Disease never occurs randomly.
2. All diseases are multifactorial.
3. Disease is always a result of an interaction among three main factors: pathogenic agent, host and environment (Fig. 2).

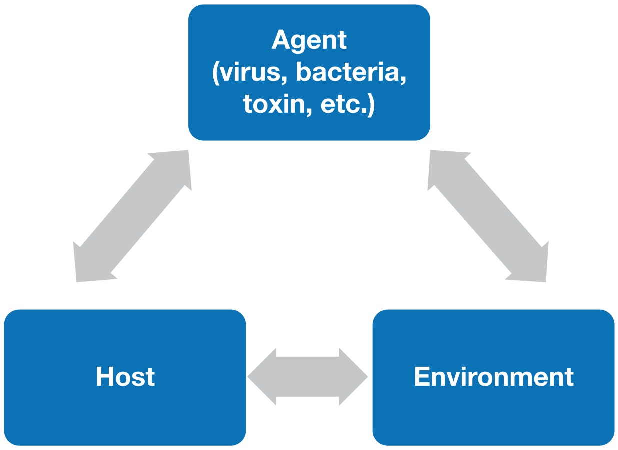


Fig. 2
Interaction among pathogenic agent, host and environment

Infectious microbes are a normal part of the *ecosystem* and thus disease plays an important role in maintaining the genetic health of populations and in regulating population numbers (Smith *et al.* 2009). However, in a highly disturbed environment, where significant and relatively permanent changes from earlier ecological states have occurred, disease may threaten the survival of an entire population.

Disease causes and impacts

Given that infectious microbes ('agents') occur normally in the environment, severe environmental events (natural or human induced) that alter the balance among agent, host and environment may result in the introduction, spread or manifestation of disease in a specific population. Some examples are given below.

1 The terms 'likelihood' and 'probability' may be used interchangeably. There is a tendency to use the term 'probability' when referring to quantified risk, and 'likelihood' when risk has been assessed qualitatively. However, both terms are correct

1. Human–wildlife interactions

Human–*wildlife* interactions can occur through hunting or harvesting, construction of roads, habitat modification, ecotourism, animal movement including global trade of animals and animal parts, pollution (e.g. organic contaminants, heavy metals, toxins, pharmaceutical drugs, sewage, oil spills, etc.). See Box 3 for an example.

> Box 3:
> How human pregnancy testing may have contributed to global amphibian decline
>
> In 1934 urine from pregnant women, injected into African clawed frogs, *Xenopus laevis*, was found to stimulate ovulation and became the basis of a human pregnancy test.
>
> Subsequently large numbers of this frog species were shipped to diagnostic and research laboratories worldwide.
>
> African clawed frogs have since been found to be carriers of the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* but usually remain disease free.
>
> Mass extinction of amphibians in multiple geographic regions has subsequently been associated with the spread of the disease chytridiomycosis caused by this fungus.
>
> The accidental or deliberate release of infected *Xenopus* frogs is one mechanism proposed for the dissemination of this pathogen. One retrospective study demonstrated that the fungus was introduced to Mallorca through the release of captive-bred Mallorcan midwife toads, *Alytes muletensis*, which had been in contact with chytrid-infected Cape platanna, *Xenopus gilli*, an endangered frog native to Western Cape, South Africa.
>
> *References: Weldon* et al. *2004; Skerratt 2007; Walker* et al. *2008*

2. Livestock–wildlife interactions

Interactions between *wildlife* and domestic livestock (cattle, sheep, pigs, etc.) can occur, for example, through direct or indirect contact, erection of fences, use of pesticides or use of veterinary drugs (Box 4).

> Box 4:
> How pain relief for cattle increased the risk to people from rabies
>
> Diclofenac (a non-steroidal anti-inflammatory drug) was used to provide pain relief for cattle in India, Pakistan and Nepal where these animals are allowed to die naturally, in accordance with Hindu beliefs.
>
> Vultures scavenged the carcases of cattle left to decay in the open.
>
> Diclofenac residues in the tissues of treated dead cattle have been found to be highly toxic to vultures, resulting in up to 99% mortality in some species.
>
> The decline in vultures has favoured an increase in packs of rabies-carrying feral dogs scavenging cattle remains.
>
> The number of cases of rabies in people due to dog bites has since increased.
>
> *References: Oaks* et al. *2004; Sharp 2006; Markandya* et al. *2008; see also Appendix 7 (p. 119) of this* Manual

3. Wildlife management

Wildlife management actions may include animal movements, reintroductions, veterinary treatments, *vaccination*, fencing (e.g. creation of a *wildlife* reserve). For instance, see Box 5.

> Box 5:
> The spread of crayfish plague by fisheries management
>
> Healthy North American signal crayfish, *Pacifastacus leniusculus*, are carriers of a fungus, *Aphanomyces astaci*.
>
> These apparently healthy crayfish were translocated and released into European crayfisheries in the 1970s.
>
> European white-clawed crayfish, *Austopotamobius pallipes*, had no immunity to the fungal organism which, in these previously unexposed animals, caused 'crayfish plague', leading to mass mortality.
>
> In Britain since 1970 native crayfish populations from 88.6% of sites have either been eliminated, or are directly threatened, by crayfish plague infection, or habitat invasion by signal crayfish or pollution.
>
> *References: Holdich and Reeve 1991; Alderman 1996; Daszak* et al. *2000*

4. Climatic events

Climatic events that may be associated with *wildlife* disease emergence include climate change, El Niño and La Niña events, fire, flooding and drought (Box 6).

> Box 6:
> Examples of disease spread associated with climatic events
>
> **1. Impacts of climate change on sheep parasites in Northern Ireland**
>
> 'The results of this [10 year study] … revealed shifts in seasonal abundance and appearance times of parasites during the calendar year, which are likely due to the effects of climate, specifically: an increased abundance of trichostrongylosis/ teladorsagiosis and strongyloidosis in the south and west of the Province.'
>
> *Reference: McMahon* et al. *2012*
>
> **2. Mosquito-borne malaria and El Niño**
>
> Ecuador, Peru and Bolivia suffered serious malaria *epidemics* after heavy rainfall in the 1983 El Niño. The *epidemic* in Ecuador was exacerbated by displacement of populations due to the flooding.
>
> *Reference: World Health Organization 2000*
>
> **3. Plant diseases favoured by drought**
>
> 'Drought reduces the breakdown of plant residues. This means that inoculum of some [*pathogens*] does not decrease as expected and will carry over for more than one growing season. The expected benefits of crop rotation may not occur.
>
> Bacterial numbers decline in dry soil. Some bacteria are important antagonists of soil borne fungal diseases. These diseases can be more severe after drought'.
>
> *Reference: Murray* et al. *2006*

The consequences of pathogen introduction or spread at the individual level may be obvious (e.g. overt *clinical signs* of ill health or death), or may be more subtle such as a reduction in immune function, impaired reproduction, subtle behavioural changes that may render individuals more prone to predation or accident, or decreased growth rate (Wobeser 2006).

As illustrated in Figure 3, diseases that affect many individuals may result in adverse effects on the population. These effects may be driven by multiple factors such as changes in birth rates, death rates, immigration and emigration. The population effect exerted by disease may, in turn, result in *ecosystem*–scale consequences through changes in community composition (competitors, predators, prey), productivity and stability (Tompkins *et al.* 2011).

The examples described in Boxes 3 to 6, illustrate that sometimes the less visible and longer term effects of disease on individuals or populations can have a profound impact. Consequently these potential impacts need to be considered in a *wildlife* DRA.

Objectivity

It is often said that *risk analysis* is an 'objective' process. The reality is that in disease risk analyses there are often so few data available that the analyst begins, unconsciously, to substitute value judgments for facts. Indeed, in assessing the consequences of disease introduction a degree of subjectivity is almost unavoidable. Risk analyses are seldom truly *objective* and for this reason *transparency* in declaring all assumptions made is essential (MacDiarmid 2001).

Proportionality

Actions taken to prevent or minimise disease risks to *wildlife* populations or biodiversity conservation must be in proportion to the likely consequences of disease entry. For instance, a *risk analysis* may conclude that there is a significant likelihood that an introduction of animals into a new area would introduce a particular disease agent. However, if there are other, unmanaged movements of animals, people or their chattels into the same area, the application of risk mitigation measures to the planned introduction may not be warranted.

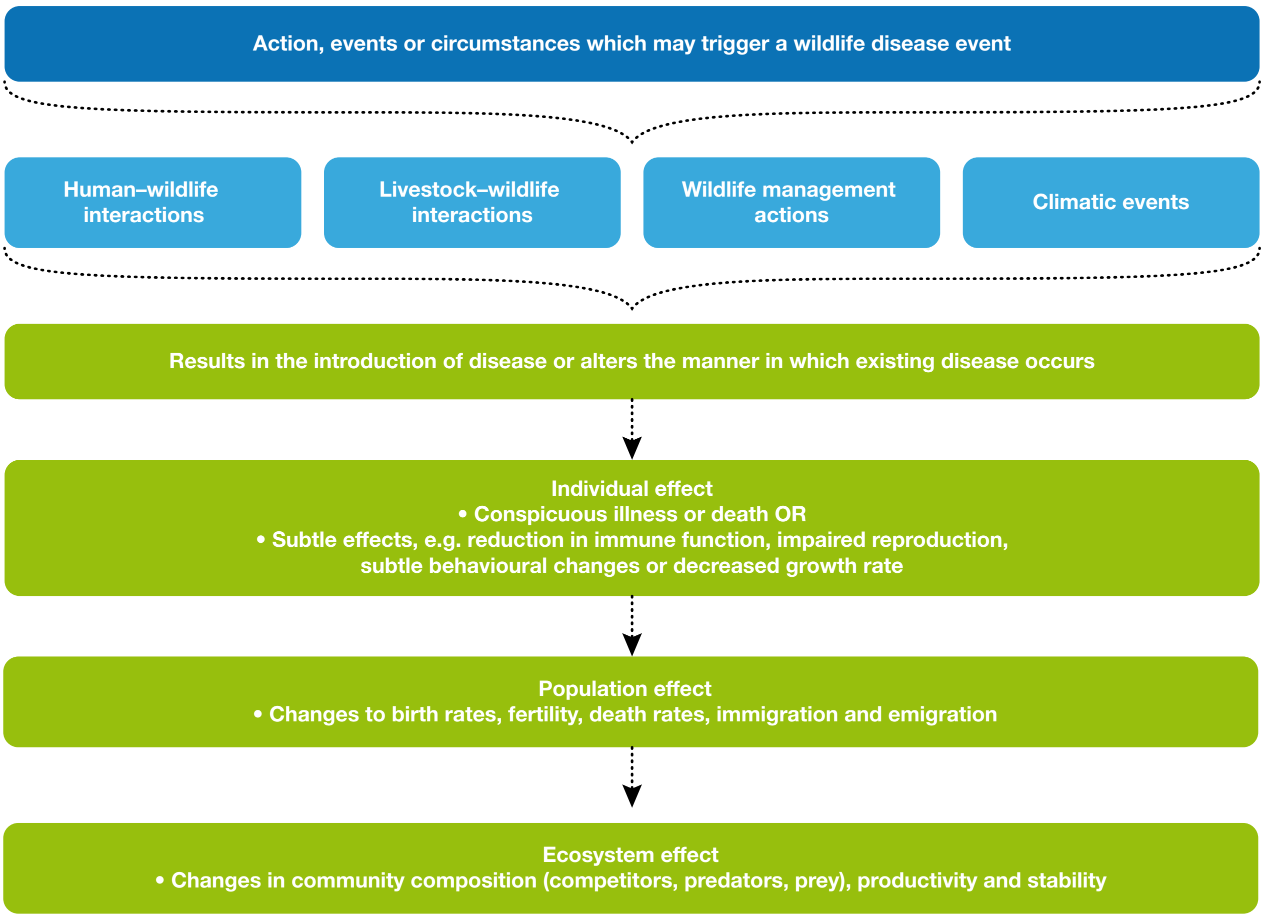


Fig. 3
Possible drivers of disease introduction and associated consequences

Worthington and MacDiarmid (2011) pointed out that it is important to consider this issue of proportionality in an analysis of the disease risks posed by the importation of non-human primates into zoos. As an example they considered a situation in which there is some likelihood of an imported primate carrying a *pathogen* that is equally likely to be carried by a human. It would not be justified to impose stringent measures on the importation of a few primates when there are no meaningful preventive measures that could be applied to the hundreds of thousands of humans who enter the country each year. In this situation, the imposition of risk mitigation measures to the primate importation would do nothing to significantly reduce the biosecurity risk to the importing country. (However, the manager of the zoo might well impose measures to reduce risks to other animals in the zoo.)

Acceptable risk

The *risk communication* process is essential in helping decision makers to deal with one of the most difficult problems encountered during the *risk analysis* process, namely determining what constitutes an 'acceptable risk' (MacDiarmid and Pharo 2003).

Zero risk is seldom, if ever, attainable and some degree of risk is unavoidable. For this reason, deciding whether or not a particular risk is acceptable is generally a societal or political decision because the benefits of a particular activity for one stakeholder group may have adverse consequences for another (MacDiarmid and Pharo 2003; Thrusfield 2007).

For example, when considering the disease risks to an unspoiled *ecosystem* posed by the construction of a road, risks considered acceptable by a government agency tasked with economic development may be quite unacceptable to the government agency tasked with *wildlife* conservation. Similarly, the disease risks posed by relocation of wild animals into a conservation reserve may be acceptable to those ecologists concerned with maintenance of a genetically diverse population of endangered animals but be considered unacceptable to neighbouring farmers or ranchers concerned with the health of their livestock.

An example of an acceptable disease risk may be the translocation of kiwi harbouring a low number of coccidian intestinal parasites providing that other, specified, health indicators (e.g. body condition, behaviour, haematology parameters, etc.) are within the range considered healthy for the species.

The 'precautionary principle'

In situations in which there is significant scientific *uncertainty* regarding a risk and its consequences, such as a cause-and-effect relationship not being fully established, the 'precautionary principle' may be invoked. This principle holds that the implementation of preventive measures can be justified even in the absence of such a risk. This precautionary approach has a useful protective effect as the initial response to a new potential threat and may be an appropriate reaction to complex problems such as loss of biodiversity, where more formal *risk analysis* may not be adequate (Thrusfield 2007).

Assumptions

A *risk assessment* may sometimes be criticised because some of its inputs are based on assumptions. However, all decision making is based on assumptions, and *uncertainty* and subjectivity do not mean that valid conclusions cannot be drawn. Although many of the inputs of a *risk assessment* are surrounded by *uncertainty*, one may be able to have confidence that the 'true risk' is unlikely to exceed the estimate resulting from a careful and conservative analysis (MacDiarmid 2001).

Planning and conducting a wildlife disease risk analysis

R.M. Jakob-Hoff, T. Grillo, A. Reiss, S.C. MacDiarmid, C. Lees, H. Hodgkin, K. McInnes, S. Unwin & R. Barraclough

Collaboration

A *robust risk analysis* involving *wildlife* disease is usually beyond the scope of a single individual and is more effectively approached as a collaborative exercise.

Typically, a conservation manager, veterinarian or public health practitioner is tasked with responding to a request for a *wildlife disease risk analysis* (DRA) within a very short time-frame and with few relevant data. Even in this situation, however, it is advisable to consult and seek input from key people with relevant knowledge or expertise or relevant decision-making responsibility.

At the 'ideal' end of the DRA spectrum is a well-prepared and -funded workshop in which an appropriate range of experts, stakeholders and decision makers are gathered for a facilitated, structured review and analysis of the scenario, over one or more days. This group of individuals may meet only once but be engaged in dialogue with each other over a more extended time, both before and after the workshop. Table I lists some of the benefits and limitations of a collaborative versus an individual approach to *wildlife* DRA. Appendix 5 (p. 112) provides some additional guidance on planning a workshop and developing and maintaining a DRA team.

Technical, social and political considerations

This *Manual* has been written with the aim of enabling anyone tasked with conducting a *wildlife* DRA, or implementing its recommendations, to do so with the confidence that they are basing their work on the 'best practice' possible within the constraints of their circumstances. This includes the application of scientific rigour and the most appropriate tools and technology available. However, even the best science does not guarantee that the findings of a *wildlife* DRA will be translated into actions in the 'real world'. Taking into consideration relevant technical, social and political aspects of the DRA scenario and implementing an appropriate *risk communication* strategy from the outset, will help to ensure that time and effort is well spent and the recommendations of the *risk analysis* are more likely to be implemented.

Technically, more often than not, data on disease in *wildlife* populations are very limited or completely absent. Relevant information, where it exists, is more likely to be unpublished and in the heads or files of a few key individuals. The selection and use of the most appropriate DRA tools and interpretation of results may also require the help of individuals with those skills. Therefore, enlisting the collaboration of people with relevant knowledge and expertise will help ensure that the *wildlife* DRA is as technically *robust* as possible within the circumstances.

Table I
Benefits and limitations of individual and collaborative approaches to a wildlife disease risk analysis (DRA)

DRA by a single individual		DRA by collaboration	
Benefits	**Limitations**	**Benefits**	**Limitations**
– Supports rapid decision making – Cheap – No disputes – Relatively minimal effort	– Individual bias – Knowledge and skill limitations – More prone to errors – Less likely to get decision maker support – May alienate other stakeholders not consulted	– Less influenced by individual bias – Broader understanding of problem – Wider knowledge and skills – Less prone to errors – More likely to get stakeholder and decision maker support	– Slower – May be more expensive – Can involve conflicts – Significantly more effort

Socially, disease in *wildlife* and its management has the potential to impact a wide range of people who may have many different and, sometimes, conflicting concerns. These 'stakeholders' may have significant influence on the ability to conduct a meaningful *risk analysis* or the implementation of recommendations arising from it. Each individual or group may have very different concerns, interests and levels of knowledge of the situation. However, as noted by Westley and Vredenburg (1997) and Brückner *et al.* (2010) stakeholders who have been involved in the decision-making process from the outset are more likely to support the outcomes and become involved in implementing the resulting activities.

Politically, the recommendations of the DRA will need to convince those with the necessary policy or decision-making authority, especially if significant changes in social behaviour (e.g. restricting access to previously accessible sites, changes in farm practices, etc.) or commitment of resources are required. Consequently, understanding the political factors at play and the support that may be needed is important. The DRA *risk communication* strategy should identify and involve key decision makers from the outset to help them make informed decisions and thereby help to ensure the success of the DRA exercise.

Some challenges in wildlife disease risk analysis

Before embarking on a *wildlife* DRA it is important to be aware of some of the special challenges associated with analysis of situations involving *wildlife* disease risks.

Complexity There are always multiple variables influencing the introduction, establishment and spread of disease-causing agents within and between populations of single or multiple species. The collaborative, *transdisciplinary* approach recommended in this *Manual* is one way of addressing this challenge. Taking an adaptive management approach in which the DRA includes a schedule to monitor and review its findings and implementation will also help to ensure that new information is captured to expand knowledge and refine decision making over time.

Uncertainty As in all complex situations not all the relevant facts are available when dealing with *wildlife* disease. As noted above, more often than not, available data are scant. Consequently, qualitative analysis is the most common approach used. A comprehensive literature review, the use of appropriate analytical and decision-making tools (such as those provided in this *Manual*) and the explicit recording of assumptions and limitations will ensure the best use of available information, identification of significant data gaps for further research and the level of *uncertainty* decision makers should take into consideration.

Multiple stakeholders As mentioned, invariably there will be a range of people and organisations with diverse and sometimes conflicting interests in any situation involving *wildlife* disease. Identifying key stakeholders and developing an appropriate communications plan at the outset will help to avoid conflicts and ensure that the best available expertise has been incorporated into the analysis.

Transdisciplinary terminology Differences in interpretation of terms will inevitably emerge in a collaborative process involving individuals from a number of disciplines (e.g. veterinary science, ecology, *risk analysis*, etc.). A glossary of commonly used technical terms associated with *wildlife* DRA is included in this *Manual* to help consistency of language and avoid misunderstandings.

Resources Time, money, equipment, people and relevant expertise for a *wildlife* DRA are among the resources often in short supply. The systematic process outlined in this *Manual* is designed to enable a single person with some knowledge of *wildlife* management and access to relevant information and expertise to conduct a basic *wildlife* DRA. However, for situations in which the consequences of disease *transmission* are severe (e.g. threatening the viability of an endangered species) or in which there is a high level of public interest (e.g. threatening human health or economics), a collaborative approach is highly recommended. This will invariably produce a DRA that is more *robust* and better able to withstand critical scrutiny.

The risk analysis process

Figure 4 hereafter provides an overview of the systematic process of DRA described in this *Manual*. For easy reference this figure is also included at the front of the book. When applied in the sequence depicted, each step and its sub-steps build on the work of the previous step.

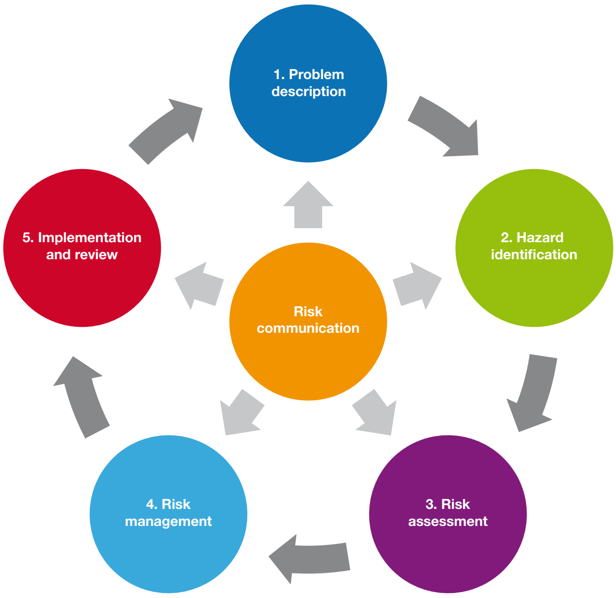


Fig. 4
Steps in the disease risk analysis process

However, insights gained in later steps may suggest a review of assumptions or questions formulated in earlier steps. For this reason it is valuable to constantly keep the context or 'big picture' of the problem in mind. A detailed description of each step in the process follows.

Risk communication

> *The risk communication step asks 'Who has an interest in, who has knowledge of value to, and who can influence implementation of recommendations arising from the DRA?'*

Risk communication is the practice of continuous communication between interested stakeholders and experts and, as depicted in Figure 4, runs throughout the DRA process. Its purpose is to engage with relevant experts and stakeholders in a way that will maximise the quality of the analysis and the probability that recommendations arising will be implemented. It is also essential to determine the level of risk that is acceptable to stakeholders. (See 'Problem description', p. 24).

Tools that can help

– DRA Worksheet, p. 58
– Graphical models, p. 60
– Decision trees, p. 63
– Influence diagrams, p. 66
– Fault trees, p. 68
– Scenario trees, p. 69
– GIS, p. 75
– OIE Handbook, p. 76
– Risk communications plan template, p. 91

Effective communication involves both listening and speaking. The messages heard are influenced by both the content and the manner in which they are delivered and received. While it is beyond the scope of this *Manual* to review the theory and methods of effective communication, some familiarity with this topic is recommended. A useful resource relevant to this text is Jacobson (2009), *Communication Skills for Conservation Professionals*.

Stakeholder and expert identification

The first step in developing a *risk communications* strategy is the identification of stakeholders, experts and key decision makers associated with the issues to be considered. These are identified by answering the questions 'Who has an interest in, and who has knowledge of value to, the DRA topic?' and 'Who may have influence to support or block recommendations resulting from the analysis?' Where communication between relevant experts and stakeholders can be facilitated, opportunities can arise to share information and gain insights that might not otherwise be possible. As all *wildlife* DRA scenarios attract interest from a range of people this applies whether the *risk analysis* is conducted by a single individual or a group. An example of a stakeholder and expert list developed for a DRA focused on Tasmanian devils is provided in Table II.

While it is not always possible to involve a wide range of experts and stakeholders, consideration of who could potentially assist and who might be impacted by the results will be of value in framing the DRA report and its recommendations in a manner appropriate to the audience.

Communications strategy and plan

Following the identification of appropriate stakeholders and experts it is useful to develop a communications strategy and plan (see Table III for an example). This is a helpful tool for thinking through the communication issues associated with a *wildlife* DRA. It is useful to map this out at the start of each *risk analysis* and to continually update it as needed.

The communication plan is developed in consultation with the stakeholders and experts and should include what information they may be able to provide, what information they are interested in receiving and how frequently and in what form it should be delivered.

An example taken from the same Tasmanian devil DRA is provided in Table III. Once the list of stakeholders has been completed the names of specific individuals and their contact details can be added.

Table II
Stakeholder and expert list for Tasmanian devil disease risk analysis workshop, Hobart, 2008

Stakeholder groups and organisations represented	Wildlife disease expert participants
Researchers School of Zoology, University of Tasmania Macquarie University	Cytogeneticist Conservation geneticist Government Veterinary Officer, State of Tasmania Wildlife veterinary pathologist Medical immunologist Field veterinary officers, Save the Tasmanian Devil Programme Representatives of the Steering Committee, Save the Tasmanian Devil Programme and the Australian Wildlife Health Network
Captive breeding Taronga Conservation Society Australia (TCSA) Latitude 42 Environmental Consultants Pty Ltd East Coast Natureworld Trowunna Wildlife Park Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA) Healesville Sanctuary Australian Reptile Park	
Indigenous communities Tasmanian Aboriginal Land and Sea Council (TALSC)	
Government departments Office of the Minister of Primary Industries and Water Department of Primary Industries and Water (DPIW) Department of the Environment, Water, Heritage and the Arts (DEWHA) Reserve and Wildlife Conservation Branch (DECC) Wildlife and Marine Conservation Section (DPIW)	
Funding agencies Foundation for Australia's Most Endangered Species Inc.	
Media: local and national	

Communication etiquette

Communication etiquette should include appropriate acknowledgement of contributors and sources of information and respect of issues of confidentiality and intellectual property. The method of communication should always be tailored to the audience. Where individuals from different disciplines or cultures are involved the use of technical terms should be avoided wherever possible. Where such terms must be used for clarity their meaning should also be explained in non-technical language.

As noted above, the messages received by people are influenced by both the content and the manner of communication. What may be clear to one person may be confusing to another. Misunderstandings can be avoided through initial discussion of the forms of communication best suited to each person or organisation and their specific needs or interests. These could include face-to-face or telephone conversations, meeting minutes, formal reports, oral presentations to groups, a press release, newsletter, email, etc. The emphasis is on effective two-way communication. A periodic survey of stakeholders to monitor the effectiveness of the communications methods employed can be of great value.

Problem description

The problem description step asks 'What is the specific question for this DRA?' and 'What kind of risk analysis is needed?'

The problem description step (sometimes referred to as 'problem formulation' or 'problem identification') outlines the background and context of the problem, and identifies the goal, scope and focus of the DRA. To ensure *transparency*, assumptions and limitations are documented and a statement on the acceptable level of risk formulated, bearing in mind that there are no 'zero risk' options.

Tools that can help

– DRAT, p. 52
– DRA Worksheet, p. 58
– Graphical models, p. 60
– OIE Handbook, p. 76

The *risk communications* plan outlined above is developed concurrently during this phase.

Table III
Extract of a communications plan from the Tasmanian devil disease risk analysis, Hobart, 2008

Group role	Stakeholder/Expert	Information needs	Communication method(s)	When	Responsibility
Operational/ implementation	Managers of devil captive facilities, e.g. wildlife parks	Biosecurity protocol/ animal movement requirements Details of individual animal movements Timing of moves	Personal direct (email, phone, fax, etc.)	Need most lead-in time	Individual coordinator for each movement
	Veterinarians associated with devil health care	As above plus: – Specific *diagnostic tests* required – Medical histories	Personal direct (email, phone, fax, etc.)	Two weeks in advance of movement	As above
Governance	Steering Committee	Overarching information on: protocols, plans, implementation/ update reports, issues	Formal reporting to committee	At three month intervals	Insurance population coordinator
Compliance, auditing and monitoring	Chief Veterinary Officer, Tasmanian *quarantine*, Australian Quarantine Inspection Service	Protocols Movements Issues around biosecurity Reports of breaches	Personal direct (email, phone, fax, etc.) (formally provided with translocation and biosecurity protocols)	Advise at time of movement	Planning team Individual coordinator for each movement
Public	Media (press, radio, television)	Need to have information available so that public can know how to minimise their impact General information on conservation strategy: – Ways to prevent disease spread – Point of contact for information	Via media liaison officer Press release Save the Tasmanian Devil Website (public area) Newsletter	In advance of significant events/ moves that may impact public	Department of Primary Industry and Water media liaison officer

Establishing the goals, scope and focus of the DRA at the outset will provide useful points of reference for ensuring that the DRA, as it proceeds, remains consistent with its original intent. Ultimately, conducting separate problem description and *hazard* identification exercises helps to protect the scientific evaluation of risk (*hazard* identification and *risk assessment* steps) from being overly influenced by political and social issues that may arise during problem description (US Environmental Protection Agency 1998).

There is little consensus in the literature regarding the stage at which this step is completed (Power and McCarty 2002). Problem description is sometimes included within the first step of the *risk analysis* framework along with *hazard* identification (e.g. US Environmental Protection Agency 1998) or is a step undertaken prior to commencing a *risk analysis* (e.g. US Food and Drug Administration 2002). For the purpose of this *Manual*, problem description is the first step in the DRA process (Fig. 4, p. 23).

In the end, whether solutions are difficult or easy to understand or implement, minimising disease risk to *wildlife* is a policy problem for decision makers. Framing the issues within their bigger context and logically describing and organising them will help to determine if a DRA will add value to the policy decision-making process. The problem description step consists of logically describing the overall policy issue at hand in order to define specific questions that need to be thoroughly assessed using the *risk analysis* process. Depending on the complexity of the issues and the information and resources available, this analysis may be conducted in a single meeting or may require a well-facilitated workshop or series of workshops.

Once a problem has been described it will be possible to estimate the level of detail required in the DRA. For example, when conducting a DRA for a *wildlife* translocation programme, fewer *hazards* may need to be assessed in detail if the translocation pathway does not cross an ecological or geographical barrier (Sainsbury *et al.* 2012). In these relatively short distance translocations source and destination *hazards* can effectively be considered equal. (See Tool 1 in this *Manual* for an example of a process to assist this decision making).

Questions to assist problem description

In an effort to direct this step the US Environmental Protection Agency (1998) poses a series of questions. These questions are listed below, with some having been adapted for the purposes of this *Manual*:

- What is the nature of the problem?
- What are the management goals and decisions needed, and how will the *risk analysis* help?
- What is the ecological level of concern (population, community, *ecosystem*)?
- Are there any policy or regulation considerations?
- What precedents are set by similar DRAs and previous decisions?
- What is the cultural and political history and current context of the problem as represented through the eyes and values of different stakeholders?
- What resources (e.g. personnel, time, money) are needed and available?
- What level of risk is acceptable?
- What documents or data exist to describe the state of knowledge of the problem?

Addressing these questions may highlight other types of information not previously recognised as needed. DRAs frequently proceed without all the information one might wish for and extrapolations from what information is available must be made. It is important to make explicit the areas and extent of *uncertainty* that is likely given the available information and resources. Subsequent steps of the DRA may aid in the identification of missing data or knowledge gaps and can thereby help to direct future research. The following two examples of a DRA problem description are provided to illustrate the application of these concepts to actual *wildlife* DRA scenarios.

Problem description example 1 Disease risk analysis for tuberculosis infection in an orang-utan (*Pongo pygmaeus*) reintroduction programme

Based on a DRA submitted by Fransiska Sulistyo and Rosalie Dench, The Borneo Orang-utan Survival Foundation at Nyaru Menteng

Note that this and other examples are specific to the site and circumstances described and may not be appropriate for other locations.

Context

The Central Kalimantan Orang-utan Reintroduction Program of The Borneo Orang-utan Survival Foundation at Nyaru Menteng (CKORP-NM BOSF) is taking care of more than 600 orang-utans in the centre. At the moment there are 14 orang-utans (2.3%) that have been identified as non-clinical carriers of the bacterial agent of tuberculosis, *Mycobacterium tuberculosis*. They are kept in an isolated facility within the centre but are taken care of by technicians (keepers) who also care for the rest of the population. Resources are not available to assign dedicated technicians to the exclusive care of the infected orang-utans.

Tuberculosis is a *contagious disease* that may cause serious illness in primates, including humans and orang-utans. The disease is *endemic* in the human population, especially in the region of Palangkaraya, within the province of Central Kalimantan.

Goal of the DRA

The risk assessment question is: 'What is the risk of transmission of tuberculosis to and between the orang-utans within, and living near to, the Nyaru Menteng Reintroduction Centre?'

The goal of the DRA is to develop a plan to minimise the risk of spread of tuberculosis to those orang-utans in the Nyaru Menteng centre currently considered to be uninfected, and to improve confidence that orang-utans selected for reintroduction to the wild are free of tuberculosis.

Scope and focus

- To identify disease transmission pathways to healthy orang-utans in the centre from the infected orang-utans and from other potential carrier mammals living in and around the centre (orang-utans and other *wildlife*: macaques, rodents, domestic animals, etc.) including workers and local villagers.

– To assess the relative risks of the tuberculosis transmission pathways to uninfected orang-utans and identify critical control points at which to apply risk mitigation actions.

– To evaluate risk mitigation options and develop an implementation and review plan.

Assumptions

– That tuberculosis is not present in the general population of orang-utans in the centre, nor in the wild population of orang-utans living near to the centre, and

– that tuberculosis is not present in *wildlife reservoirs* at sites selected for orang-utan reintroduction, and

– that disease has the potential to cause mortality in orang-utans.

Limitations

– There is no standardised procedure or 'gold standard' for diagnosis of tuberculosis infection in orang-utans. Screening and diagnostic methods available either have low sensitivity (culture may detect only 60% of active cases) or low specificity (tuberculin skin test can show 60% positive in apparently healthy orang-utans with no known exposure to tuberculosis [Calle 1999]). The resources for more advanced molecular diagnostic tests are lacking, and these methods have not been validated for use in orang-utans.

– The long-term effect of a tuberculosis infection in orang-utans is unknown.

– Risk mitigation strategies must ensure that the welfare of the infected orang-utans is not compromised. This includes keeping them in a healthy condition and enabling them to express natural behaviours with sufficient stimulation to maintain their mental and physical welfare.

– Euthanasia of clinically healthy carriers of *Mycobacterium tuberculosi*s is, politically, unacceptable.

Acceptable levels of risk

It is acknowledged that there is a population of tuberculosis-infected, but healthy, orang-utans within the reintroduction centre. Given the limitations to management of these animal outlined above, this is unlikely to change in the short to medium term. Therefore, the continued presence of a small number of infected orang-utans held in isolation from other orang-utans is considered an acceptable level of risk.

Problem description example 2
Foot and mouth disease risk analysis in Mongolian gazelles (*Procapra gutturosa*) on the Eastern Steppe of Mongolia

Based on a DRA submitted by Enkhtuvshin Shiilegdamba and Amanda Fine, Wildlife Conservation Society (WCS) Mongolia Country Programme, Ulaanbaatar, Mongolia

Context

Mongolian gazelles are one of Asia's last *wildlife* migration spectacles, with herds of over 1 million individuals moving nomadically across the Daurian Steppe Eco-region, concentrated in the Eastern Steppe of Mongolia. Mongolian gazelle are listed as endangered in the Mongolian Red List of Mammals (Clark *et al.* 2006) owing to decreases in both the range and the numbers of this species in recent decades. The Mongolian gazelle herds are a source of pride for local people, a source of protein for subsistence hunters and a potential focus of nature-based tourism in the region (Heffernan 2005). Overhunting, habitat loss, die-off due to disease and competition with livestock for forage have contributed to the species' decline, and recent investments in the extractive industries (oil and mineral extraction) have put additional pressures on the landscape (Lhagvasuren and Millner-Gulland 1997; Olson 2007; Heiner *et al.* 2011).

Although the role of mining in Mongolia's economy is growing, the livestock sector remains a major component and will continue to employ the majority of Mongolians. On Mongolia's Eastern Steppe, Mongolian gazelle are an important part of the grazing eco-system and there is a strong desire among government agencies and conservation organisations to co-manage the rangelands for *wildlife* and livestock (Garratt and Chimed-Ochir 2001; Heffernan 2005; Wildlife Conservation Society 2009; Olson *et al.* 2010; Wildlife Conservation Society 2010).

To achieve this, a number of issues must be addressed, including the potential fragmentation effects of roads, railroads and other infrastructure developments in the region. However, the subject of this case study is managing the risk of livestock/*wildlife* disease transmission with a focus on foot and mouth disease virus (FMDV). Foot-and-mouth disease is one of the major threats to livestock and *wildlife* such as Mongolian gazelle on the Eastern Steppe. Foot and mouth disease is a highly contagious, viral disease that affects most ruminant and porcine species. Periodic outbreaks on Mongolia's Eastern Steppe affect Mongolian gazelles as well as livestock such as cattle, sheep, goats and camels.

At least four new FMDV incursions occurred in Mongolia between 2000 and 2010: three belonging to serotype O and a single Asia 1 introduction in 2005. These introductions were part of an Asian pandemic that affected many countries.

Country-wide livestock *surveillance* conducted in 2007 indicated that FMD was not *endemic* in livestock populations in Mongolia. Serological surveys of gazelles conducted by the Wildlife Conservation Society (WCS) in 1998–1999 and 2005–2008 (Bolortsetseg *et al.* 2012) demonstrated that antibodies were either not present in gazelle populations before livestock outbreaks (1998–1999) or declining to non-detectable levels between livestock outbreaks (2005–2008). However, during an FMD outbreak in livestock in 2001, researchers detected antibodies in 67% (22/33) of gazelles tested (Nyamsuren *et al.* 2006). Although sample sizes were not large, this finding suggests that, during widespread FMD outbreaks in livestock across the Eastern Steppe of Mongolia, Mongolian gazelle do become exposed to the virus.

Foot and mouth disease may threaten the long-term persistence of the Mongolian gazelle. The threat is both direct, through morbidity and mortality, and indirect, through disease management actions that may have additional negative impacts on the species (Nyamsuren *et al.* 2006; Thomson 2011; Bolortsetseg *et al.* 2012). While mass culling of gazelle has been discussed as a management option during outbreaks of FMD in livestock, it has never been carried out as the perceived financial and biodiversity costs have been considered too high. Management actions directed at gazelle in Mongolia to date have included:

- chasing gazelle suspected of being exposed to FMD away from livestock or disease quarantine zones
- selectively culling gazelle that appear to be clinically affected by FMD (weak and lame).

Calls for science-based national policy approaches to FMD control, which take into account the conservation value of species such as the Mongolian gazelle, have been made by local and national conservation organisations in Mongolia including the Wildlife Conservation Society, the Worldwide Fund for Nature (WWF), The Nature Conservancy (TNC) and citizens through the media (*Daily News*, 5 October 2010, p. 12; *Daily News*, 9 October 2010, p. 6; *Udriin Shuudan*, 5 October 2010, p. 11; *Unuudur*, 4 October 2010, p. C2; *Unuudur*, 11 October 2010, p. A6).

Reviews of the literature and official FMD disease reports suggest that one of the seven FMD outbreaks that occurred between 2000 and 2010 may have been introduced by Mongolian gazelles but that the six other outbreaks were introduced by other means (Thomson 2011). To date there has been no clear epidemiological investigation of the role of *wildlife* in FMD introduction in Mongolia and further study is needed.

Goals, scope and focus

The DRA question is 'What is the risk of Mongolian gazelles facilitating FMDV transmission to domestic livestock on the Eastern Steppe of Mongolia?'

The goal of this WCS-led DRA is to develop a science-based FMD control and management policy for the Eastern Steppe of Mongolia incorporating appropriate actions for the conservation of Mongolian gazelles.

The scope will be confined to analysis of relevant published and unpublished information on FMD and the population biology of Mongolian gazelles, combined with the input of relevant experts and stakeholders.

The focus is the long-term sustainability of Mongolian gazelle populations on the Eastern Steppe along with free ranging livestock.

Assumptions

- The control of FMD will remain a high priority for the Mongolian government, given the important role of the livestock sector in the national economy and the livelihoods of the majority of Mongolian people.
- Serological *surveillance* in both livestock and Mongolian gazelle populations will remain an important part of FMD management and control in Mongolia.
- There is general acceptance that FMDV spills over to Mongolian gazelle populations during livestock outbreaks and these populations may transmit the disease among *wildlife* and livestock populations as the gazelle exposure to FMD was confirmed during FMD outbreaks on the Eastern Steppe.
- Mongolia is currently free from FMD with an ongoing livestock FMD *vaccination* programme.

Limitations

Population-based longitudinal studies of FMD on Mongolia's Eastern Steppe (in Mongolian gazelle and livestock) are lacking. Consequently this DRA must draw upon the limited studies and FMD outbreak reports from Mongolia that are available. Comparable studies of populations in similar systems must be used for this risk analysis pending further research within the Eastern Steppe.

Discussion of acceptable levels of risk

Owing to the huge economic, social, animal welfare and conservation impacts of FMD there is a low risk tolerance associated with this disease in Mongolia. A national FMD-free status is the government's ultimate objective. (The Mongolian Government has already applied to the World Organisation for Animal Health for an FMD-free zone status in the western part of the country where this disease has not been reported since 2002).

Hazard identification

The hazard identification step asks 'What can cause disease in the population(s) of concern?', 'How can this happen?' and 'What is the potential range of consequences?'

A *hazard* is defined as a biological, chemical or physical agent in, or a condition of, an animal or animal product with the potential to cause an adverse effect on health.

When embarking on the process of *hazard* identification it is important to consider both the problem of concern as well as the broader environmental context within which the *wildlife* population resides (see Fig. 3).

Tools that can help

– DRA Worksheet, p. 58
– Paired ranking, p. 59
– Graphical models, p. 60
– Decision trees, p. 63
– Influence diagrams, p. 66
– Fault trees, p. 68
– Scenario trees, p. 69
– Cmap, p. 74
– GIS, p. 75
– OIE Handbook, p. 76

The purpose of the *hazard* identification step is to identify all possible health *hazards* of concern. Criteria are established for ranking the importance of each *hazard* and its possible direct and indirect consequences within the bounds of the defined problem. Exclude hazards that have a zero or negligible probability of release or exposure and construct a scenario tree for the remaining, higher priority hazards of concern. These can then be further investigated using tools for *risk assessment* (Harvey *et al.* 1995; Sarnet *et al.* 1998; Armstrong *et al.* 2002; Clancy *et al.* 2009).

The completion of this step involves a thorough review of published literature and unpublished sources and consultation with relevant experts.

The previous 'Problem description' step may have resulted in two different scenarios:

1. There is already a problem identified that is specifically associated with one or more well-defined hazards that stakeholders believe need to be assessed (e.g. an outbreak of salmonellosis in an island population of an endangered bird species; the introduction of rabies into a rabies-free island; the spread of West Nile virus after its emergence in North America) OR

2. The problem is broader in scope and specific priority hazards have not yet been defined (e.g. a widespread population decline due to unknown factors).

In the latter case, the *hazard identification* process should list all potential hazards. In the former scenario, the *hazard identification* step may be relatively simple but performing and documenting this step provides additional *transparency* to the process. It also helps to validate or challenge assumptions that may have been made during the problem description step. For instance, in a mass mortality of free-living penguins due to the fungal disease aspergillosis, discussion during the problem description step revealed that this infection was not the primary hazard (as originally thought) but a consequence of chronic stressful environmental disturbances due to multiple off-shore mining and fishing activities.

If a specific aspect of the *hazard identification* step is omitted the decision should be justified. For example in a DRA undertaken for a translocation that does not cross an ecological or geographic barrier, it should be stated that source hazards have been discounted for this reason.

Hazard categorisation

In order to minimise the risk of overlooking any potential hazards it can be helpful to consider the following categories:

– *Infectious* (i.e. the entry and development or multiplication of a parasite in the body of a host, where it may or may not cause disease):
  - viral
  - bacterial
  - fungal
  - parasitic (external and internal *macroparasites*)
  - prions (infectious agents responsible for transmissible spongiform encephalopathies).

– *Non-infectious* (i.e. diseases that cannot be transmitted between organisms):
  - toxic
  - genetic, developmental
  - degenerative
  - neoplastic (cancer causing)
  - nutritional
  - metabolic
  - traumatic (e.g. road kill)
  - immune-mediated (e.g. allergic)
  - environmental (e.g. pollution of air, soil, water, radiation, climatic events such as floods or droughts).

Hazard consequences

Considering the potential direct and indirect consequences of each hazard is a useful exercise when deciding which hazards should be subjected to a full risk assessment. This is discussed in some detail in a Council of Canadian Academies 2011 publication 'Healthy Animals Healthy Canada' and summarised below. These authors suggest the categories of consequences for consideration illustrated in Figure 5.

Examples of the listed consequences include:

– **Animal health** – direct consequences on the individual health of animals.

– **Animal welfare** – animal suffering either directly associated with the hazard or indirectly associated as a result of efforts to mitigate the effects of the hazard such as holding in quarantine and handling for collection of diagnostic samples.

– **Human health** – direct consequences from zoonotic disease or indirect effects such as food security due to loss of *wildlife* or domestic animal populations or ecosystem services such as pollination by bees afflicted by colony collapse disorder.

– **Social and psychological** – a component of human health that can be severely impacted by loss of animals or measures to control outbreaks such as mass culling, restrictions on movements and loss of income.

– **Environmental and ecological** – often the most complex and difficult to predict. Examples include the increase in rotting carcases associated with the decline in top predators such as Tasmanian devils in Australia or scavengers such *Gyps* spp. vultures in Asia.

– **Economic** – massive losses of jobs, income and animals have been associated with measures to control outbreaks of animal diseases such as bovine spongiform encephalopathy (BSE) and highly pathogenic avian influenza

Fig. 5
Categories of consequences associated with animal health hazards
(From Council of Canadian Academies, 2011)

- **Political** – as previously discussed there are always political consequences to disease in *wildlife*, the extent of which will vary with the species involved, the severity of impacts and the level of public concern. In considering the range of consequences of various risk management options it should be recognised that actions that benefit some stakeholders may disadvantage others.

- **National Security** – these consequences are usually associated with widespread impacts of animal disease on human health, economics, social stability and the associated politics. A good example is a pandemic due to highly pathogenic avian influenza.

Sources of information and transparency

In addition to an extensive literature review, efforts should be made to access unpublished information (e.g. from diagnostic laboratories, researchers, etc.) and seek expert opinion from a multidisciplinary group of stakeholders with relevant expertise. If this process of consultation is undertaken, it is important that it be done in a formal and structured manner (such as an official workshop forum or questionnaire). It should be transparent and inclusive in nature to ensure that viewpoints from all participants are heard and considered (See Tool 17: Formal elicitation of expert opinion as an example of one such process).

Hazard identification example 1 Kakapo (*Strigops habroptilus*) disease risk analysis and management planning workshop, 2008

R.M. Jakob-Hoff, CBSG Australasia; NZCCM, Auckland Zoo, New Zealand

The kakapo is an intensively managed critically endangered *endemic* species restricted to a small number of predator-free offshore islands in New Zealand. Emphasis at this DRA workshop was placed on the risks associated with anticipated movements of people and birds between Codfish Island/Whenua Hau and the New Zealand mainland owing to the major kakapo breeding event anticipated for the summer of 2008–2009. From a review of published and unpublished sources circulated prior to the workshop the following hazards of concern were identified for kakapo (Table IV).

For each disease a brief synopsis was provided as a basis for discussion by stakeholders. An example is provided below.

Table IV
Disease hazards identified for kakapo

Infectious	Non-infectious
Viral Psittacine beak and feather disease virus (BFDV) Psittacine polyomavirus Psittacine herpesvirus (Pacheco's disease) Highly pathogenic avian influenza Psittacine pox Avian paramyxovirus 1 (Newcastle disease)	Aflatoxicosis
Aetiology unknown but suspected viral Myeloproliferative disease of Antipodes parakeets	
Bacterial Salmonellosis Yersiniosis Erysipelas Chlamydiosis/Psittacosis Macrorhabdosis (Megabacteriosis)	
Fungal Aspergillosis	
Internal parasitic Avian malaria Coccidiosis Trichomoniasis Cryptococcosis	
External parasitic Mites Ticks Lice Fleas Hippoboscid flies	

Salmonellosis

Organism: The zoonotic bacterium *Salmonella enterica* subsp. *enterica* serovar Typhimurium is one of the most common species of *Salmonella* found in psittacine birds.

Clinical signs: Asymptomatic carriers are common. The disease can manifest in many forms but the most common is diarrhoea or sudden death.

Incubation period: As a carrier state is common, the time from infection to onset of *clinical signs* in birds can be highly variable; in humans it is 8 to 48 hours.

Sources of infection: The intestinal tract of a wide range of vertebrate animals including other birds, rodents and people

Transmission: The infection is usually transmitted by ingestion of faecally contaminated material but some serotypes (e.g. *S.* Pullorum in poultry) can also be transmitted in utero.

Wildlife disease in New Zealand: Salmonellae are widespread throughout New Zealand although some strains have a more local distribution. *S.* Typhimurium DT195 caused deaths in the *endemic* passerine, hihi (*Notiomystis cincta*) in 2006, as did DT160 in house sparrows (*Passer domesticus*) in 2007. Both serotypes were also isolated from sick people in New Zealand around the same time.

Control: The organism is susceptible to most disinfectants and to temperatures over 60°C.

Prevention:

- Avoid exposure to rodents.
- Personnel working with kakapo should observe strict hand hygiene.
- Avoid overcrowding in captivity.
- Test for the organism during *quarantine*.

References

Alley *et al.* 2002; Hirsch 2004; Alley and Gartrell 2006.

Hazard identification example 2 Risk analysis for the import of sand tiger (grey nurse) shark (*Carcharias taurus*) into New Zealand (Prepared for the New Zealand Ministry of Agriculture and Forestry)

R. Jones, The Aquarium Vet, Moorabin, Australia

In order to identify all the diseases, *pathogens* and parasites associated with the sand tiger shark, a comprehensive literature review was undertaken utilising the services and databases of the Commonwealth Scientific and Industrial Research Organization (CSIRO) Australian Animal Health Laboratory (AAHL) at Geelong, VIC, Australia.

The initial literature search revealed very few diseases recorded in the sand tiger shark and so the search was extended to include diseases in sharks in general particularly with respect to viruses and bacteria. Another two resources used extensively were the *Elasmobranch Husbandry Manual* by Smith *et al.* (2004) and *Fish Medicine* by Stoskopf (1993). The author also contacted a network of professional colleagues in public aquaria and other institutions around the world, in particular the United States and South Africa (these were listed in Appendix 2 of the original document but are not included here).

For each organism identified the epidemiology is briefly discussed, including a consideration of the following questions (Table V):

1. whether the imported sand tiger sharks could act as a vehicle for the introduction of the organism, and
2. if the organism requires a *vector*, whether competent *vectors* might be present in New Zealand, and
3. whether the organism is *exotic* to New Zealand but likely to be present in exporting countries, and
4. if it is present in New Zealand:
   - whether it is under official control, which could be by government departments, by national or regional pest management strategies or by a small-scale programme, or
   - whether more virulent strains are known to exist in other countries.

For any organism, if the answer to question 1 is 'yes' (and the answer to question 2 is 'yes' in the case of organisms requiring a *vector*) and the answer to either question 3 or 4 is 'yes', it is classified as a potential hazard requiring *risk assessment*.

Under this framework, organisms that are present in New Zealand cannot be considered as potential hazards unless there is evidence that strains with higher *pathogenicity* are likely to be present in the sand tiger sharks to be imported. Therefore, although there may be potential for organisms to be present in the imported sand tiger sharks, the risks to human or animal health are no different from risks resulting from the presence of the organism already in this country.

Table V
Hazard identification for proposed importation of sand tiger sharks (extract)

Disease name	Scientific name	Recorded in sand tiger shark	Recorded in other sharks	Vector of a hazard	Already in NZ	Potential hazard	Reference
Virus							
Dusky smooth-hound viral dermatitis	Herpesvirus	No	Yes	No	No	No	Terrell (2004)
Viral erythrocytic necrosis	Iridovirus	No	Yes	No	No	Yes	Terrell (2004) Johnston (1975) Khan and Newman (1981)
Bacteria							
Shark meningitis	*Vibrio carchariae* (syn. *V. harveyi*)	Yes	Yes	No	Yes	No	Grimes *et al.* (1984)
Vibrio spp.	*Vibrio* spp.	Yes	Yes	No	Yes	No	Terrell (2004) Tuttle *et al.* (2008)
Furunculosis	*Aeromonas salmonicida* subsp. *Salmonicida*	No	Yes	No	No	Yes	Briones *et al.* (1988)
Aeromonas hydrophila	*Aeromonas hydrophila*	Yes		No	Yes	No	Gál *et al.* (2005)
Flavobacterium spp.	*Flavobacterium* spp.	No	Yes	No	Yes	Yes	Terrell (2004)
Miscellaneous bacteria	*Citrobacter freundii*	Yes		No	Yes	No	Stoskopf (1993)
	Pseudomonas aeruginosa	Yes		No	Yes	No	Stoskopf (1993)
	Pseudomonas fluorescens	Yes		No	Yes	No	Stoskopf (1993)
	Staphylococcus epidermidis	Yes		No	Yes	No	Craig A. Harms, North Carolina State University, pers. comm. November 2009
	Enterococcus faecalis	Yes		No	Yes	No	Craig A. Harms, North Carolina State University, pers. comm. November 2009

Example disease synopsis:

Shark meningitis

Aetiological agent: *Vibrio carchariae* (syn. *Vibrio harveyi*).

OIE listing: This disease is not OIE listed.

New Zealand status: *V. harveyi* is already present in New Zealand.

Epidemiology: *V. carchariae* was originally cultured and then identified as a new species from a brown shark or sandbar shark (*Carcharhinus plumbeus*) that died in an aquarium (Grimes *et al.* 1984). It was the first recorded *Vibrio* spp. in an elasmobranch. In brown sharks, meningitis is a prominent feature of the disease and *V. carchariae* has been isolated from cerebrospinal fluid. There has been natural infection in the sand tiger shark. It is important to note that all cases have been in captive sharks originally from the mouth of the Delaware Bay (Stoskopf 1993).

In a study by Pedersen *et al.* (1998), *V. carchariae* was shown to be a junior synonym of *V. harveyi*. This is confirmed by the National Centre for Biotechnology Information (2009).

Conclusion: As *V. harveyi* is already present in New Zealand (Biosecurity New Zealand, 2005), it will not be considered further in this import risk assessment.

Hazard identification example 3 Tasmanian devil disease risk analysis

Initially a list of over 60 infectious and non-infectious potential hazards were identified from a search of the literature (including references provided by Dr Philip Ladd and Dr Peter Holtz) and unpublished cases recorded in the Australian Wildlife Pathology Registry (supplied by Dr Karrie Rose, Taronga Zoo, Sydney). An excerpt is shown in Table VI below.

In this case, the expert knowledge of a group of *wildlife* veterinarians and researchers working with Tasmanian devils was combined in a workshop setting to review this list and identify a subset for further analysis based on their understanding of which were the most probable and significant health hazards to the Tasmanian devil. Those chosen are highlighted in bold in the following list.

Infectious hazards

- **Devil facial tumour disease (DFTD)**
- **Salmonellosis**
- **Pseudotrichinosis (Trichinella)**
- **Ectoparasites (mites, *Uropsylla*, ticks)**
- Sarcocystosis (muscle condition)
- Toxoplasmosis?
- Fungal infections
- Intestinal helminths (cestodes, nematodes)
- Protozoa (Giardia, Entamoeba, Sarcocystis sporocysts, coccidia)
- Bacterial infections (abscess, septicaemia etc)
- Viral infections (herpesvirus, endogenous retroviruses)
- Mycobacterial diseases

Non-infectious hazards

- **Young age onset neoplasia (other than DFTD)**
- **Other neoplasia (other than the above)**
- **Lymphoproliferative diseases**
- Metabolic diseases (eg osteodystrophy)
- Degenerative diseases (eg spondylosis and osteoarthritis in aged animals)
- Nutritional disease (eg obesity)
- Allergic dermatitis
- Road accidents (note devils are attracted to scavenge other road kill so are more at risk)[2]
- Persecution (poisoning – mostly with organophosphates)
- Predation by dogs (especially two dogs together)
- Shooting.

Reference

Conservation Breeding Specialist Group, 2008.

Table VI
Excerpt from Tasmanian devil (non-devil facial tumour disease) hazard review

Disease Category	Disease	Comment	Author	Year	Title	Journal/Publisher
Allergy	Hypersensitivity dermatitis	Adult female	Rose Karrie	2007	Australian Registry of Wildlife Pathology, Taronga Conservation Society, Australia, pers. comm.	Tasmanian Devil – Australasian wildlife pathology register
Bacterial	Salmonellosis	Comment that this is one of the most common conditions in larger dasyurids but reference does not mention Tasmanian devil (also note high carrier rate in marsupials)	Finnie Edward P.	1988	Diseases and Injuries of Other Australian Mammals	in Proceedings No. 104 'Australian Wildlife', University of Sydney Post-Graduate Committee in Veterinary Science
Neoplasia	Neoplasms	Review	Griner Lynn A.	1979	Neoplasms in Tasmanian Devils (*Sarcophilus harrisii*)	J. Nat. Cancer Inst. 62, 589–595
Non-infectious	Ulcerated alimentary canal	Ulcers in stomach, pylorus or duodenum and anaemia. Possible association with stress in captivity	Griner Lynn A.	1983	Pathology of Zoo Animals – Ch 35 Mammals	Zoological Society of San Diego

2 Road kill mortality can be very high in local areas, e.g. 50% devils and 100% quolls in one area where a road was upgraded and average vehicle speed increased from 40 to 80km/hour. Furthermore, 20% mortality was recorded in Fraycinet National Park in a drought year.

Risk assessment

The risk assessment step asks 'what is the likelihood and what are the consequences of a specified hazard occurring within an identified pathway or event?'

The purpose of the *risk assessment* step is to assess:

– the likelihood of release (introduction) into the area of concern

– the likelihood that the species of interest will be exposed to the hazard once released, and

– the consequence of exposure.

On this basis the hazards can be prioritised in descending order of importance.

Tools that can help

– Stella and Vensim, p. 57
– DRA Worksheet, p. 58
– Paired ranking, p. 59
– Graphic models, p. 60
– Cmap, p. 74
– OIE Handbook, p. 76
– @Risk, p. 78
– OUTBREAK, p. 78
– PopTools, p. 80
– Formal elicitation of expert opinion, p. 84
– Netica, p. 86
– Precision tree, p. 87
– Vortex, p. 88
– RAMAS, p. 90
– Monte Carlo modelling, p. 103

Stated another way, disease risk assessment is the process of estimating the likelihood of a pathogenic agent (from any defined source) entering, establishing or spreading in a country, zone or population and its accompanying impact(s) on animal or human health, the environment or the economy. It is important that this be specifically laid out during the problem description step.

Risk assessment may be qualitative, expressed in terms such as 'high', 'medium' or 'low' risk, or quantitative, expressed in numerical terms such as 'one disease outbreak per 100 animal introductions' or 'failure to correctly identify one diseased herd out of 100'.

For each hazard identified in the preceding step, the best available information is used to assess the likelihood of introduction into the environment of concern (*release assessment*) and exposure of the population of interest to the hazard (*exposure assessment*). If there is a significant risk of exposure an assessment is made of the consequences (biological, environmental, social, economic) of the entry, establishment or spread of the hazard, together with an estimate of the likely magnitude of the consequences. This process provides the basis for prioritising hazards to determine whether or not risk mitigation measures are warranted.

Valid risk assessments are:

– based on a specific question

– transparent

– fully disclose the assumptions made

– include a discussion of factors that add to the uncertainty surrounding conclusions

Example risk assessment questions (from Unwin and Travis 2009):

'What is the likelihood of introducing TB (tuberculosis) into lemurs in Betampona given that the population is TB-free?'

'What is the probability of introducing chimpanzee x into the wild with pathogen y?'

In the *risk analysis* methodology adopted by the World Organisation for Animal Health (OIE), *risk assessment* follows *hazard identification*, and comprises four steps: *release assessment*, *exposure assessment*, *consequence assessment* and *risk estimation* (Brückner *et al.* 2010).

The assessments commonly associated with the OIE usually revolve around international trade in animals or animal products. In the biodiversity conservation and *wildlife* health arena, this basic framework needs to be adapted to many different kinds of scenarios. The output of the *risk assessment* can then be used to decide whether the risk is acceptable as it stands or whether mitigation measures are required to reduce the risk to an acceptable level. This method is versatile and can be applied to various risk questions, making it the system of choice for many risk assessors (Brückner *et al.* 2010).

Scenario trees

Prior to embarking on the disease risk assessment itself, it can be helpful to draw a scenario tree (see Fig. 6 and DRA Tool 10, Scenario trees) for each hazard under consideration. This will facilitate the identification of the various biological pathways leading to exposure of the susceptible animals or people to the hazard as well as potential 'outbreak' scenarios (sometimes called 'pathways analysis'; see Fig. 6).

Uncertainty

As in all complex situations, not all the relevant facts are available, and this is always so when dealing with *wildlife* disease where available data are generally scant. Consequently, qualitative analysis is the most common approach used in *wildlife* disease risk assessments. A comprehensive literature review, the use of appropriate analytical and decision-making tools (such as those provided in the Tools section of this *Manual*) and the explicit recording of assumptions and limitations will ensure the best use of available information and identification of significant data gaps for further research and the level of *uncertainty* that decision makers should take into consideration.

However, it is important to distinguish the precision of a risk assessment from its accuracy. For instance the population management software, Vortex (see Tool 20), can calculate population growth rates to any number of decimal places in a very repeatable way. But the predicted rate could be highly inaccurate, i.e. very different from the 'true' rate expected in the 'real' system under study. In a DRA it is more important to estimate and discuss the *accuracy* of the assessments, rather than the precision.

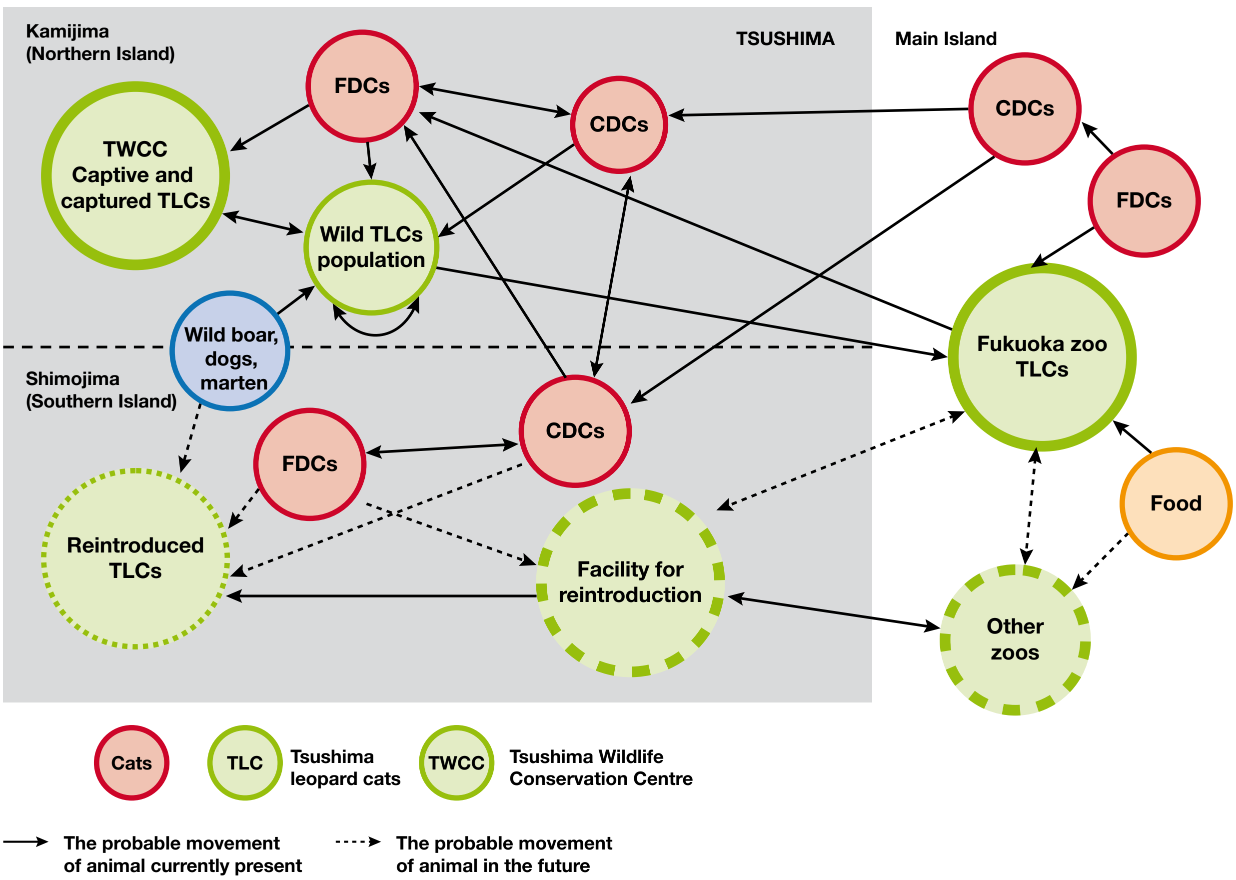


Fig. 6
Possible pathogen transmission pathways relating to Tsushima leopard cats
Diagram of possible pathways of transmission of infectious disease agents between Tsushima leopard cats (TLCs), feral domestic cats (FDCs) 'captive' (pet) domestic cats (CDCs) and other animals within specified geographic regions in Japan (Murayama *et al.* 2006)

Qualitative vs quantitative risk assessments

In *qualitative risk assessments* the likelihood of the outcome, or the magnitude of the consequences, is expressed in terms such as 'high', 'medium' or 'low'[3]. In *quantitative risk assessments* the likelihood is expressed in terms such as 'one disease outbreak per 100 animal introductions' or 'failure to correctly identify one diseased animal out of 100'. Both qualitative and quantitative approaches to *risk assessment* are valid and, in practice, all *risk assessments* are usually first conducted qualitatively (MacDiarmid 2001; MacDiarmid and Pharo 2003). Only if further insight is required is it necessary to attempt to quantify the risk (Brückner *et al.* 2010). As North (1995) explains, quantitative '… *risk analysis* is best used to develop insights, and not to develop numerical results which might mistakenly be considered to be highly precise. The discipline of numerical calculation can help to sharpen thinking about risks involving high levels of complexity and *uncertainty*, and thereby enable conclusions to be drawn which could not have been reached solely on the basis of qualitative reasoning.'

Semi-quantitative risk assessment

Semi-quantitative methods have been promoted by some as being more *objective* than strictly qualitative techniques. These methods involve assigning numbers in the form of probability ranges, weights or scores to qualitative estimates and combining them by addition, multiplication, etc. with the goal of achieving a greater level of objectivity. While superficially appealing, there are, however, significant problems with such semi-quantitative methods when the numbers are assigned and combined arbitrarily without adequate *transparency*. Inconsistent outcomes frequently arise and conclusions are reached that may be statistically and logically incorrect. These methods do not offer any advantages over a well-researched, transparent, peer-reviewed qualitative approach and seldom stand up well in adversarial situations (Brückner *et al.* 2010)

However, provided that there is an explicitly stated interpretation of a numerical scale and that it is consistently applied, the assignment of a 'score' to the designations of a qualitative assessment can be a useful means to gain consensus on relative risk from a diverse group of experts when discussing and assigning levels of risk across a range of criteria. An example in which such a scoring system was used to rank disease hazards is provided in Table VII below.

The rankings against each disease in this table were based on consideration of published and unpublished data combined with expert opinion elicited at a DRA workshop. To ensure *transparency* an explanation of the ranking ascribed to each disease was provided. An example of this for the disease erysipelas is given below.

Disease: Erysipelas

Erysipelas is caused by infection with the bacterium *Erysipelothrix rhusiopathiae*. This organism is shed in the faeces of affected animals, and may survive for long periods in the environment.

Table VII
Excerpt of semi-quantitative assessment for diseases hazards to kakapo, *Strigops habroptilus*, on Codfish Island, New Zealand

Disease	1. Likelihood of susceptibility	2. Likelihood of exposure	3. Severity for the population	Impact *(columns 1 × 2 × 3)*
Erysipelas (*Erysipelothrix rhusiopathiae*)	5	5	3	75
Psittacine circovirus (BFDV)	5	2	5	50
Salmonellosis	3	5	3	45
Chlamydiosis (Psittacosis)	5	3	2	30
Psittacine polyomavirus	5	1	5	25
Trichomoniasis (*Trichomonas* spp.)	5	4	1	20
Aflatoxicosis	3	1	3	9
Myeloproliferative disease of Antipodes parakeets	1	1	1	1
Pacheco's disease (Psittacine herpesvirus)	5	0	5	0

(Scale for columns 2 and 3: 0 = zero probability; 1 = highly unlikely; 2 = unlikely; 3 = moderately likely; 4 = likely; 5 = highly likely)
(Scale for column 3: 0 = nil, 1= very low; 2 = low; 3 = moderately severe; 4 = severe; 5 = very severe)
From Jakob-Hoff 2008

3 As these terms are context specific, definitions of each should be included whenever they are used in a DRA.

Likelihood of susceptibility (5): Kakapo have been shown to be highly susceptible, particularly young birds when stressed.

Likelihood of exposure (5): Given the widespread occurrence in seabirds on Codfish Island, exposure is highly likely. This is supported by serological surveys of kakapo.

Severity for the population (3): Moderate – an outbreak severely impacting the population is unlikely.

Reference

Gartrell *et al.* 2005.

Release assessment

The *release assessment* results in an estimate of the likelihood that the hazard of concern is present or will be introduced into the environment of concern, or exit its source or *reservoir*, and thus be 'released' into an environment where susceptible animals or humans may be exposed.

Depending upon the natural history of the disease, release may result in contamination of the environment or in risk of direct exposure between animals or humans. Examples include the reintroduction or translocation of animals carrying a novel infectious organism into a new environment, the accidental release of non-native species into a new environment or a change in land use resulting in greater contact between previously isolated species. The *release assessment* includes a description of the biological pathways necessary for that hazard to be introduced into the area or population under consideration. For each step, one should list the relevant biological, ecological or geographical factors considered and the assumptions made.

The *risk assessment* may be concluded at this point if there is a negligible likelihood of the *wildlife* of interest being affected by the hazard at the time under consideration.

Example of a qualitative release assessment for West Nile virus (WNV) as a hazard to the reintroduction of white-tailed sea eagles (WTSEs, *Haliaeetus albicilla*) to the United Kingdom from Eastern Europe (from Sainsbury *et al.* 2012)

'Serological surveys in Eastern Europe suggest that there is a low likelihood that WTSE, like other birds, will be infected with WNV through contact with ornithophilic [bird-favouring] mosquitoes, and the latter are present in Eastern Europe (McLean and Ubico 2007). Fatal infection in raptors (including red-tailed hawks [*Buteo jamaicensis*] and great horned owls [*Bubo virginianus*]) has been reported (Saito *et al.* 2007) but other bird Orders, including Passeriformes, are more susceptible to the infection and the disease (McLean and Ubico 2007). No cases of WNV disease have been reported in birds in Eastern Europe, which suggests that disease is rare. However, viraemia may occur without disease. Therefore there is a low likelihood of infection in a translocated WTSE.'[4]

Exposure assessment

An *exposure assessment* consists of assessing the likelihood that the susceptible animal(s) will come into contact with the hazard in a manner in which transmission may potentially occur. For each step, one should again list the relevant biological, ecological and geographical factors which were considered and the assumptions made. The risk assessment for this hazard may be concluded at this point if the likelihood of exposure is negligible.

Example of a qualitative exposure assessment for WNV as a hazard to the reintroduction WTSEs (*H. albicilla*) to the United Kingdom from Eastern Europe (from Sainsbury *et al.* 2012)

> 'Falconiformes are known to develop a sufficient viraemia for infection to be transmitted to mosquitoes (Defra 2009) and viraemia has a duration of approximately one week and so the arrival of a viraemic WTSE is possible. Since other bird species, particularly passerines, are highly susceptible to West Nile virus infection there is a high likelihood that these species will be exposed from ornithophilic mosquitoes (which are present in the United Kingdom) in contact with WTSE. There is a high probability that highly susceptible bird species will be infected. There is a high probability of dissemination of WNV through susceptible bird species because at the time of importation in the summer, ornithophilic mosquitoes will be common. Humans are susceptible to infection and there is a low probability that they may be exposed through vector-borne transmission (Zeller and Schuffenecker 2004)'.

Consequence assessment

A *consequence assessment* identifies the biological, environmental and economic consequences associated with the entry, establishment or spread of the hazard, together with an estimate of their likely magnitude and likelihood of occurrence. For each step, one should list the relevant direct and indirect consequences that were considered. The *risk analysis* may be concluded at this point if either consequences are not identified or the likelihood of all the consequences is negligible.

4 In addition it is also important to assess the risk of the translocated birds being exposed to the hazard(s) of concern at the destination site.

Example of a qualitative consequence assessment for WNV as a hazard to the reintroduction of WTSEs (*H. albicilla*) to the United Kingdom from Eastern Europe (from Sainsbury *et al.* 2012)

> 'There is a high probability that disseminated infection would occur if the virus is introduced because many passerine birds will be in the vicinity of WTSE at the release site. West Nile virus has given rise to epidemic disease in Passeriformes in the United States, where birds were naive to infection (McLean and Ubico 2007) and, assuming the epidemiological parameters are similar in the UK, epidemic disease would be predicted. However, antibodies to WNV in UK bird populations have been detected without signs of epidemic disease. Such evidence suggests that differing epidemiological parameters (possibly cross-protection from other flaviviruses [Gubler 2007 cited by Defra 2009] in the UK and incidentally also in continental Europe) have reduced the likelihood of disease outbreaks. An epidemic would have a major economic, environmental and biological impact, as witnessed by the effect of the WNV outbreak in North America over the last ten years (McLean and Ubico 2007), but the evidence suggests that there is a low [probability] of this happening in the UK.'

Risk estimation

The *risk estimation* step summarises the results or conclusions arising from the *release assessment*, *exposure assessment* and *consequence assessment* of all hazards evaluated. It is a prerequisite, before moving on to the *risk management* step that determines whether or not risk mitigation measures are warranted. In weighing up the results of the risk assessment it is important to consider the broader context identified in the problem formulation step. The objective is to ensure that any *risk management* recommendations are appropriately proportional to the risks within the 'real world' situation of concern (see Proportionality, p. 19).

Example of a risk estimation for WNV as a hazard to the reintroduction of WTSEs (*H. albicilla*) to the United Kingdom from Eastern Europe (from Sainsbury *et al.* 2012)

'The likelihood of release through importation in a WTSE is low but the likelihood of exposure of susceptible species to infection is high. Evidence suggests that the likelihood of a significant epidemic disease is low. Therefore the overall risk level is considered low.'

Risk management

> *The risk management step asks 'What can be done to decrease the likelihood of a hazardous event?' and 'What can be done to reduce the implications once it has happened?'*

The purpose of this step is to review the potential risk reduction or management options and evaluate their likely outcomes. On this basis decisions and recommendations can be made to mitigate risks associated with the identified hazards.

Risk management is the process of identifying and selecting measures that can be applied to reduce the level of risk. Hazards can be further prioritised based on the likelihood and magnitude of their adverse consequence in relation to the level of *acceptable risk*. *Risk management* options for each significant hazard are then reviewed according to their likely effectiveness and feasibility.

Tools that can help

- Stella and Vensim, p. 57
- DRA Worksheet, p. 58
- Graphical models, p. 60
- Decision trees, p. 63
- Influence diagrams, p. 66
- Fault trees, p. 68
- Scenario trees, p. 69
- GIS, p. 75
- OIE Handbook, p. 76
- OUTBREAK, p. 78
- Precision tree, p. 87
- Vortex, p. 88
- RAMAS, p. 90

Risk evaluation

The first step is to consider whether or not *risk management* measures are needed given the level of *acceptable risk* agreed to in the problem description step. The result can be displayed using simple or complex matrices depending upon the level of data and the complexity of the *risk assessment* (see 'Implementation' step below). In addition, the level of *uncertainty* in the *risk assessment* should be taken into account at this time.

Option evaluation

The second step is to review and evaluate the effectiveness and feasibility of options available to mitigate risks at the critical control points identified in the biological pathway for each hazard of concern.

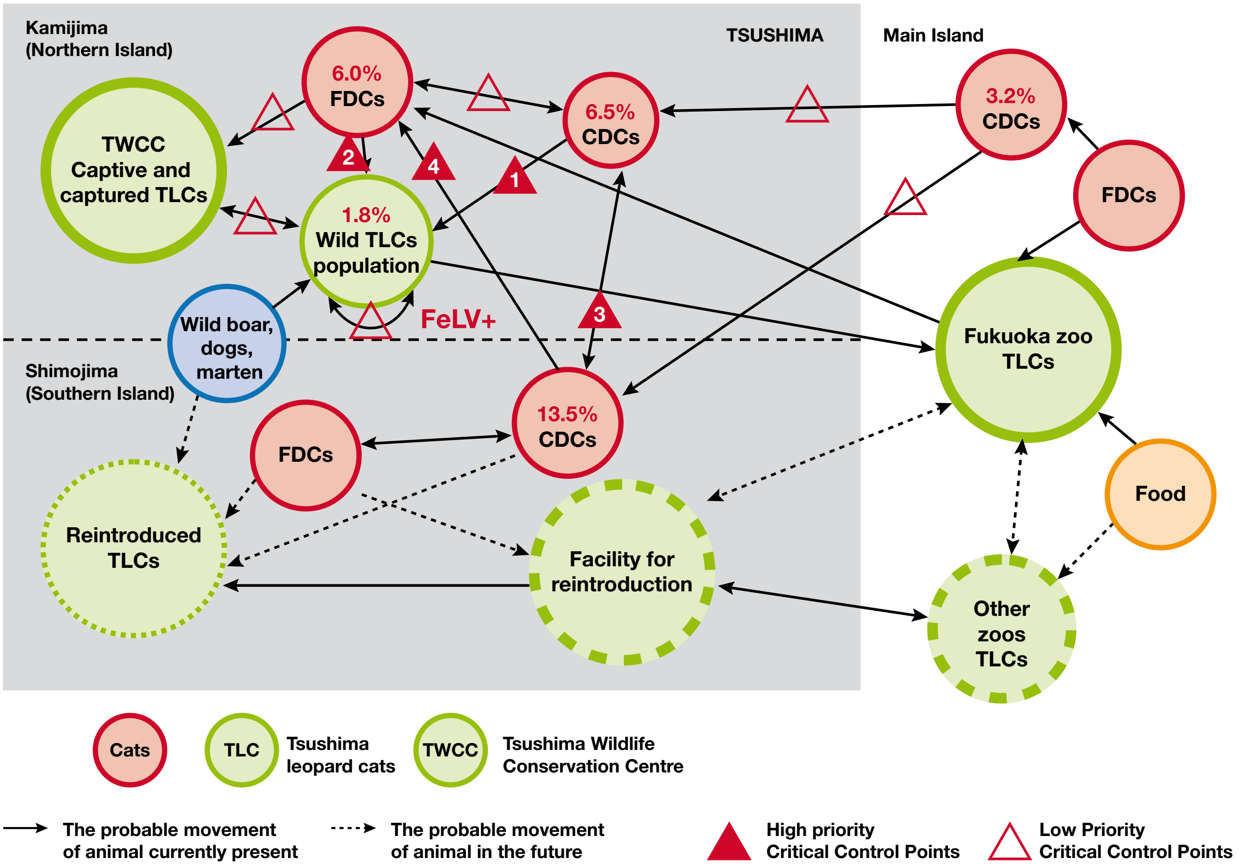


Fig. 7
Example of the application of critical control points (CCPs)

The effectiveness is the degree to which an option reduces the likelihood or magnitude of the potential adverse consequences (health, economic, etc.). Each option should be evaluated according to the expected outcome when implemented against the acceptable level of risk.

The feasibility takes into consideration technical, operational and economic factors affecting the implementation of the *risk management* options. In addition, the management of risks to and from *wildlife* must consider the cultural, ethical and political acceptability of the various *risk management* options.

Critical Control Points

Critical Control Points (CCPs) are identified as points in a hazard's biological pathway (see Figs 6 and 7) at which practical risk reduction or prevention strategies could be implemented. This graphical analysis can assist managers to make decisions on where to focus interventions and consider which *risk management* options are feasible at these points in the pathway.

In this case, using Figure 7, CCPs (△) have been identified for feline leukaemia virus (FeLV) *transmission* routes to the Tsushima (TLCs). Solid numbered triangles indicate priority CCPs (Murayama *et al.* 2006)

Risk management decisions

A matrix such as the one shown below can be a useful tool to assess a range of risk management options according to their feasibility and effectiveness (Table VIII). This can provide a valuable starting place for decision making before specific measures are developed and evaluated further:

Table VIII
Option evaluation decision matrix

Option	Feasibility	Effectiveness	Decision
A	H	H	Yes
B	H	M	Possible
C	H	L	No
D	M	H	Yes
E	M	M	Possible
F	M	L	No
G	L	H	Possible
H	L	M	No
I	L	L	No

In this table, options with a medium to high feasibility and high effectiveness (A and D) are the most desirable options. An option with low feasibility but high effectiveness (G) might be considered but would probably need further investigation before making a decision.

Risk management contingency planning

I. Langstaff

In situations in which diseases pose a significant threat to animals or humans, cost–benefit analysis of management and policy solutions may delay the implementation of an adequate response. Thus, predetermined strategies, or contingency plans, for emergency response are useful parts of the *risk management* implementation plan. For instance, once disease risks have been categorised and compared with previously agreed levels of *acceptable risk*, thresholds may be established above which risks will not be tolerated and above which a response will be made. Alternatively, response planning can focus on the highest and most extreme risks first, working though to lower risks as resources allow.

Disease categorisation

With both approaches it can be useful to group the risks into some broad categories. Structuring response planning around these categories is one operational approach that enables common risk pathways of many diseases to be identified and managed simultaneously. For instance, diseases could be categorised as follows:

1. Disease risks attributable to *pathogen pollution*
   This category refers to risks posed by diseases that may have recently arrived and those that are not known to be in the country of interest (*'exotic'*) but are a risk as a result of human activities. (e.g. spread of *exotic* diseases such as foot and mouth disease to Australia)

2. *Endemic* disease risks
   These diseases, by definition, have a long history of occurrence, and a constant presence in the *wildlife* populations of interest. Factors attributable to human activities pose little risk for further spread relative to the interaction among *wildlife* hosts, the disease agent and the environment (e.g. rabies and foot and mouth disease in parts of Africa)

3. Unknown or novel emerging *pathogens*
   Diseases that have not previously been recognised anywhere (e.g. white nose syndrome in North American bats).

A framework for contingency planning for these *wildlife* disease risks is outlined in Table IX (p. 43). This table shows contingency planning options for addressing each of these categories with a colour code used to illustrate the priority of each component relative to the others within the category.

The components of the strategy are:

– Risk analysis: an evaluation of the probability of disease entry and spread and potential consequences as outlined in this *Manual*.

– Passive *surveillance*: *monitoring* of *wildlife* for clinically diseased cases.

– Targeted *surveillance*: collecting specific information about a defined disease.

– Research: to understand the epidemiology of the disease.

– *Wildlife* health expertise: to implement the *wildlife* disease management strategy.

– Recording incident investigations: information management during *wildlife* disease incidents.

– Data storage and analysis: enhancing baseline *wildlife* disease information.

– Communication and education: dissemination of information on *wildlife* disease.

– Biosecurity measures: for managing disease risks associated with *wildlife* translocations.

– Hygiene standards: biosecurity measure to reduce the risk of disease spread (*pathogen pollution*).

An approach to managing pathogen pollution or spread of known exotic disease

Pathogen pollution refers to the introduction of *pathogens* to novel environments and hosts through human activities (Daszak *et al.* 2000), and most cases are considered to be related to trade and travel (Morrell 1999). *Pathogens* are known to be disseminated by trade in commodities, including livestock and their products, as well as trade in *wildlife* (MacDiarmid 2011; Travis *et al.* 2011).

Wildlife species are considered to be particularly vulnerable to introduced *pathogens* with which they have not evolved (Daszak *et al.* 2000) and therefore the consequence to *wildlife* from *pathogen pollution* can be the emergence of disease *epidemics* such as chytridiomycosis in frogs (Daszak *et al.* 2003). Examples of global human health risks from *pathogen pollution* include sudden acute respiratory syndrome (SARS) and highly pathogenic avian influenza ('bird flu').

A *disease risk analysis* (DRA) (Heading 1) utilising relevant *wildlife* health expertise (Heading 5) is an excellent process for identifying potential risk pathways for the spread of *pathogens* of concern, while the application of biosecurity measures (Heading 9) and appropriate hygiene standards (Heading 10) are the principal management options for mitigating the risk of *pathogen pollution*. These measures should be applied where high-risk human activities (critical control points) have been identified through the DRA. Targeted *surveillance* projects (Heading 3) are required to evaluate the efficacy of biosecurity standards while research (Heading 4) is needed to fill information gaps on risk pathways for human-mediated introduction and spread of *wildlife pathogens* and their potential consequences. (See Appendix 2, p. 95: Surveillance, monitoring and outbreak investigations as a source of information).

Passive *surveillance* (Heading 2) and incident investigations (Heading 6) are activities that reinforce targeted *surveillance* in detecting where biosecurity measures fail to limit the introduction or spread of *pathogens*. For example, investigating mortality in free-living *wildlife* may detect the occurrence of a disease thought to be *exotic* to a population and reveal the occurrence of a human activity previously thought to be at low risk of introducing disease or identify previously unknown disease *transmission* pathways.

Necessary information gathering, management and dissemination activities include storage and interpretation of *surveillance* data and communication of these data to other *wildlife* users and managers (Headings 6 to 8).

An approach to managing unknown or novel emerging pathogens

'Novel emerging *pathogens*' is a term used here to identify previously unknown disease agents detected for the first time, such as the Tasmanian devil facial tumour, or diseases caused by a *pathogen* infecting a species previously not considered susceptible. Susceptibility may emerge to typically benign microbes undergoing evolutionary changes in virulence or due to a reduced genetic pool or poor immune resistance in the host associated with a decline in environmental quality (Carey *et al.* 1999).

Causal factors contributing to the emergence of novel *pathogens* are typically poorly understood and are the focus of research in *ecosystem* health. *Risk factors* highlighted for emergence of disease in human and domestic animal populations are also likely to be *risk factors* for emerging disease in *wildlife* and include the expansion of human populations influencing agricultural development, urbanisation, deforestation and habitat fragmentation. These *risk factors* are considered to influence disease emergence by changing the density and ecology of disease hosts, *vectors* and *pathogens* (McMichael 2004).

The commonality of human activities influencing these *risk factors* suggests that management opportunities may lie in changes to human behaviour. However, a decision to attempt to influence these changes inevitably depends upon a good understanding of disease epidemiology. The priority components in this strategy for managing novel emerging *pathogens* are therefore passive *surveillance* to detect such diseases (Heading 2) and research (Heading 4) to understand them. A DRA (Heading 1) engaging *wildlife* health expertise (Heading 5) is then an effective method of analysing the information to provide stakeholders and decision makers with recommended options for *risk management*. In addition, applying the precautionary principle, such an analysis should be a component of environmental impact assessments (EIAs) for any new developments associated with important biodiversity or *wildlife* protected areas.

An approach to managing *endemic* pathogens

Endemic pathogens, by definition, are those established and sustained within an area or animal population. For example, *Toxoplasma gondii* (causative agent of toxoplasmosis) is a common *endemic pathogen* in most parts of the world and is spread by its definitive hosts, members of the cat family, Felidae. The lifecycle of *T. gondii* can involve a range of *wildlife* species and is commonly maintained by the presence of feral cats. *Endemic pathogens*, which are restricted in their geographic range to a local area, may also have the potential for further spread through various human activities (described above as *pathogen pollution*).

The threat from *endemic pathogens* arises as increases in their virulence, host range or geographic range may occur, for instance, owing to climatic shifts (Cowell 1997). Feasible management options can be identified and justified only through a good understanding of the interaction among the disease host, agent and their environment over time (i.e. their epidemiology).

Key components for understanding and managing *endemic* disease threats are a *risk analysis* (Heading 1), utilising *wildlife* health expertise (Heading 5) to identify and describe high-risk pathways of disease spread and research (Heading 4) designed to fill knowledge gaps identified through the *risk analysis*. Targeted *surveillance* (Heading 3) is a priority for species considered to be at risk of significant consequences from an *endemic* disease (such as a threatened species). Passive *surveillance* (Heading 2) can be complementary in gathering baseline incidence data. Management of *endemic* disease data (Headings 6 and 7) is important for identifying trends in disease incidence and *risk factors* for disease occurrence that can inform management decisions. Communication of information on *endemic* diseases (Heading 8) is vital for supporting the passive *surveillance* network, as *endemic* diseases are those most encountered

Table IX
Example of contingency planning to address three categories of infectious wildlife disease threat

	1. Risk analysis (DRA)	2. Passive surveillance	3. Targeted surveillance	4. Research projects	5. Wildlife Health Expertise	6. Recording incident investigations	7. Data storage and analysis (information management)	8. Communication and education	9. Biosecurity measures	10. Hygiene standards
Pathogen pollution	Identify and describe high-risk pathways for exotic disease entry and inform decisions to limit entry. Identify information gaps	Back-up to targeted surveillance and biosecurity measures	Surveys of a defined species to detect diseases or their pathogens identified as a priority by risk analysis	To understand risk pathways for anthropogenic introduction and spread of wildlife pathogens	Risk analyses and surveillance, disease intelligence and biosecurity measures	Morbidity and mortality incidents detected by scanning surveillance	Provide records of surveillance information	Communicate disease intelligence to wildlife users and managers	Identify and mitigate the risks from animal imports, exports and movements	Critical management activity for mitigating the risk of pathogen pollution
Novel emerging diseases	Identify and describe high risk pathways, e.g. for intensification of livestock systems next to wildlife habitats	A key system for detecting novel emerging diseases	For species and at sites identified as a priority owing to the potential consequence of a disease	To understand causal factors for disease emergence	Risk analyses and surveillance, disease intelligence and biosecurity measures	Morbidity and mortality incidents detected by scanning surveillance	Provide records of surveillance information, analyse research project data	To facilitate scanning surveillance networks by providing feedback on incidents	Not applicable	Not applicable
Endemic diseases	Identify and describe high-risk pathways of endemic disease spread and inform decisions to limit further spread. Identify information gaps	To gather baseline incident data	For species considered to be at risk of significant consequences from an endemic disease	To fill knowledge gaps identified through the risk analysis	Risk analyses and surveillance, disease intelligence and biosecurity measures.	Morbidity and mortality incidents detected by scanning surveillance	Identifying trends in disease incidence and risk factors for disease occurrence	To support the scanning surveillance networks by providing feedback on incidents	Identify and mitigate the risks from animal movements	To limit the prevalence of disease (e.g. in captive programmes)

Key: Colour codes to illustrate the priority of each component relative to other components within a wildlife disease threat category

Priority category	Highest	High	Medium	Lowest	Not applicable

and most problematic to members of the *wildlife* disease investigation network . Biosecurity actions (Headings 9 and 10) are a lower priority as they are likely to have limited impact if an *endemic* disease is widespread. However, it is prudent to implement biosecurity actions to limit further spread of *endemic* diseases through animal translocations and limit the *prevalence* of disease in populations at risk through appropriate hygiene practices.

Implementation and review

The implementation step asks 'How will the selected risk management options be implemented?' and, once implemented, 'Are the risk management actions having the desired effect?' and, if not, 'How can they be improved?'

The purpose of the implementation and review step is to formulate an action and contingency plan and establish a process for *monitoring*, evaluation and review of risk mitigation strategies. The review may result in a clearer understanding of the problem and enable refinement of the DRA (see 'Adaptive management' on p. 45).

Tools that can help

- DRA Worksheet, p. 58
- OIE Handbook, p. 76

Previous sections have framed the context of disease risk in *wildlife* populations and described a practical *risk analysis* framework for application to identified hazards. If this process has been followed a list of high-priority hazards will have been generated with an estimation of risk based upon the specific *risk assessment* question and some potential management strategies identified. In addition, the *risk assessment* process has helped place these risks into a larger context. This is in order to understand risk pathways for disease spread and identify *wildlife* species and geographic areas that are at risk of suffering significant consequences from disease. It also serves to identify gaps in our knowledge of disease threats. These insights are essential in communicating risk and planning for the implementation of possible management solutions.

Action and contingency plan

Implementation is initiated by the development of a *risk management* action and contingency plan for ensuring the *risk management* measures are in place and followed through.

This plan should include details of what actions are to be taken, why, when and by whom, the associated resource costs (time, money, people, equipment, etc.). Responsibility, with deadlines for actions, must be assigned to, and accepted by, individuals directly involved in the *risk management* discussions.

The contingency plan identifies corrective actions that may be taken if the risk manifests itself under the conditions that were accepted as a part of the *risk management* process. Although this is a real-world application, many of the contingencies can be modelled during the *risk management* step in order to help further prioritise actions. See the preceding section and Table IX (p. 43) for one approach to contingency planning.

Monitoring and review

This is the ongoing process by which the *risk management* measures are continuously monitored to ensure that they are achieving the results intended(see 'Adaptive management' on p. 45). A process must be developed to evaluate the effectiveness and practicality of *risk management* options. To enable this, measurable criteria must be established against which to base decisions to continue to monitor (if favourable outcomes are being achieved) or modify the *risk management* strategy (if the risk is not being adequately mitigated). It is recommended that even 'acceptable' risks are monitored as DRAs are very dynamic processes. If the question was important enough to ask, and the hazard prioritised sufficiently to model, the situation probably warrants *monitoring* and evaluation. Either way, this must be addressed in the conclusions of the *risk analysis* report to ensure *transparency* and proper communication to stakeholders.

Evaluation

Considering the question 'How will success be measured?' during the problem description step will help to identify the data to be gathered to evaluate the DRA and consider refinements to increase its effectiveness. Involving all participants in the development of an evaluation plan and review of its findings helps ensure a common understanding of the issues and project goals.

Evaluation questions and sources of data to answer them should be included in the *risk management* action plan. When working with scarce and valuable resources (always the case with *wildlife* conservation scenarios), some means of measuring the effectiveness of the activity on a periodic basis is essential. This is standard practice in many businesses and government services and, increasingly, funding agencies are requiring documented evidence of progress against agreed goals. Regular structured analysis of project performance also provides valuable data to identify performance issues as they occur with opportunities for adjustments and refinements. An example and further information is provided in Appendix 6 (p. 118).

Adaptive management

As outlined in this *Manual*, the DRA should start with a clear statement of the problem(s) being addressed and the question(s) to be answered. In virtually all risk analyses, including those focused on *wildlife* disease, there will be a considerable degree of *uncertainty* and a need to make a range of assumptions. Assumptions will be based on the available information and current understanding of the problem and must be stated explicitly. As more information is gathered, assumptions can be tested and modified or reinforced depending on the outcome. In turn, *risk management* actions can be refined and re-tested. This is a process of adaptive management also referred to as 'learning by doing'.

An adaptive management or continuous improvement cycle is illustrated in Figure 8 and can be applied to any project. This cycle continues through the life of the project, ensuring adaptation to changing circumstances and the incorporation of new information and insights

In Figure 8 the initial plan (Plan I) is implemented and monitored. At regular, pre-determined intervals, monitoring data is used to evaluate the project against its objectives. New insights and changes in circumstances identified in the evaluation enable the initial plan to be refined (Plan II) and so on.

Scientific peer review

Many *wildlife* disease risk analyses are conducted in response to an immediate need with the expectations of a rapid turnaround which may not allow time for scientific peer review prior to submission. However, any *risk management* recommendations will gain credibility if the DRA document has been reviewed by one or more appropriate experts. This is worth doing even if publication of the work is not intended.

Wildlife conservation agencies or universities with departments involved in *wildlife* studies and associated disciplines (such as veterinary science, ecology or epidemiology) can be good places to start looking for appropriate reviewers. Written feedback from individuals who are regarded as authorities in their field will have the greatest credibility with stakeholders.

Given that reviewers are being asked for a significant allocation of their time, the draft should be as close to a final copy as possible and should clearly explain the thinking and assumptions behind each step of the DRA. It is important to let reviewers know the deadline for receipt of comments (and check that this is acceptable) and to clarify what aspects of the DRA report you would like comment on. This could include comments on the technical robustness of the DRA, validity of the assumptions made, effectiveness of the communications, and how the work will withstand the criticism of stakeholders who may have opposing views (Brückner *et al.*, 2010).

Those involved in producing the DRA should be open and responsive to any feedback from independent peer review. A defensive attitude, while understandable at times, can undermine the benefits of such a review. Not all comments and criticisms from reviewers are valid or need to be

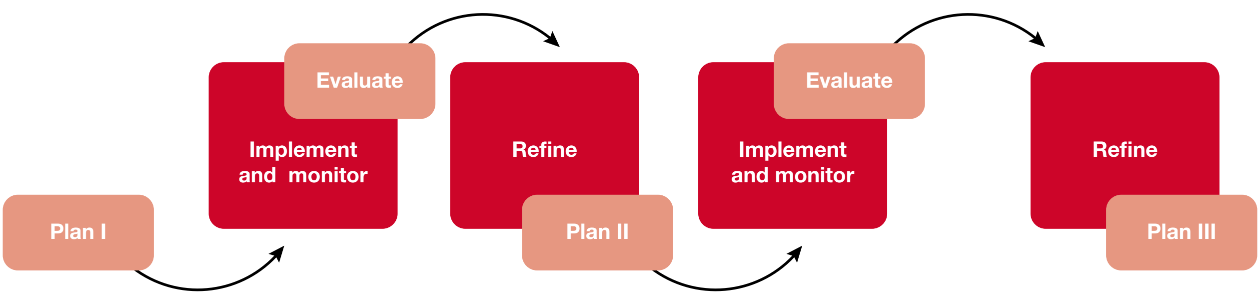


Fig. 8
A depiction of an adaptive management cycle

acted upon, but it is beneficial to accept that they are made in good faith and are worthy of serious consideration before making a decision to accept or reject one or more aspects of the feedback.

An example template for documenting an implementation and review plan is provided in Table X below.

Table X
Example implementation and review plan template

Problem/goal	Objective	Actions	Responsibility	Collaborators	Timeline	Cost	Evaluation	Obstacles
Problem 1: Contacts between feral domestic cats and wild Tsushima leopard cats **Goal 1:** No contact between feral domestic cats and wild Tsushima leopard cats	Remove all feral cats	**1.** Capture and remove feral cats in Kamijima especially where FIV infection rate is high **2.** Start capturing feral cats based on local agreement **3.** Launch 'No stray cat' campaign (implementation of good husbandry and veterinary care programme) **4.** Ensure shelters for captured cats, and find new owners for them	Tsushima city, Social Welfare Division (name or representative at workshop)	Liaison Conference for Implementation of Good Husbandry and Veterinary Care for Domestic Cats in Tsushima (LC)	Start within three years	To be determined: depends on the availability of a cat shelter	Monitor FIV infection rate Estimate size of population of feral cats	Domestic cat ownership is not clearly defined (need for a cat registration system). Both in and out of Tsushima, shelters and a system to find new owners for the captured feral cats has yet to be developed

Based on Murayama *et al.* 2006

A checklist for conducting a wildlife translocation disease risk analysis[5]

S.C. MacDiarmid

1. Problem description

1.1 Determine the scope of the *risk analysis*

Define as precisely as possible the animals (or germplasm) which are the subject of the *risk analysis* by specifying:

☐ the scientific names of the animal species

☐ the nature, source(s) (including country) and intended purpose of the animals (or germplasm)

☐ the likely number of animals to be moved and the frequency of such translocations.

Based on these, draft a suitable title for the *risk analysis*.

1.2 State the goal of the *risk analysis* clearly

The purpose of the *risk analysis* should be stated in an appropriate form, for example:

> 'To identify and assess the likelihood of (*the hazard(s)*) being introduced and spreading or becoming established in (*the area of translocation*) together with the likelihood of, and the likely magnitude of, the potential consequences for wild animal, domestic animal or human health as a result of (*the activity*).'
>
> 'To recommend risk mitigation measures, if appropriate.'

1.3 Identify sources of information for the *risk analysis*

Information to assist in identifying hazards, assessing risks and exploring options to manage risk can be found in a variety of sources (see Appendix 1, p. 93).

5 Adapted from: Brückner G., MacDiarmid S.C., Murray N.., Berthe F., Müller-Graf C., Sugiura K., Zepeda C., Kahn S. & Mylrea G. (2010). – Handbook on Import Risk Analysis for Animal and Animal Products, Volume I. Introduction and Qualitative Risk Analysis. Second edition. World Organisation for Animal health (OIE), Paris, 88 pp.

2. *Risk communication*

2.1 Develop a *risk communication* strategy

The risk communication strategy should:

– identify interested parties (stakeholders and experts)

– determine when you need to communicate with them

– determine the appropriate means of communication.

3. Hazard identification

3.1 Identify the hazards likely to be associated with the species under consideration:

– Draw up a preliminary list of the infectious and non-infectious *pathogens* associated with the species under consideration and, based on the following criteria, determine whether or not they can be classified as a hazard for further consideration in a *risk assessment*.

3.2 Is the live animal or germplasm under consideration a potential vehicle for the pathogenic agent?

If the answer is YES proceed to step 3.3, otherwise the pathogenic agent is not a hazard.

3.3 Is the pathogenic agent present in the area from which the animals or germplasm are sourced?

– If the answer is YES proceed to step 3.4.

– If the answer is NO, do you have sufficient confidence in the capacity and capability of the Competent Authority responsible for the source area or country to satisfactorily substantiate a claim that the pathogenic agent is absent?
  - If the answer is YES the pathogenic agent is not a hazard.
  - If the answer is NO, contact the Competent Authority to seek additional information or clarification and proceed to step 3.5, assuming that, until otherwise demonstrated, the pathogenic agent is likely to be present in the source area.

3.4 Are there zones from which the animals or germplasm will be sourced that are free of the pathogenic agent?

– If the answer is YES, do you have sufficient confidence in the capacity and capability of the Competent Authority to satisfactorily substantiate a claim that the pathogenic agent is absent from and ensure that the animals or germplasm are derived only from these zones or compartments?
  - If the answer is YES the pathogenic agent is not a hazard.
  - If the answer is NO, contact the Competent Authority to seek additional information or clarification and proceed to step 3.5), assuming that, until otherwise demonstrated, either the pathogenic agent is likely to be present in these zones or the animals or germplasm are likely to be derived from other areas.

– If the answer is NO proceed to step 3.5.

3.5 Is the pathogenic agent already present in the area to which animals or germplasm are to be translocated and which will be affected by the planned activity?

– If the answer is YES proceed to step 3.6.

– If the answer is NO, are you or the Competent Authority of your country able to satisfactorily substantiate a claim that it is absent?
  - If the answer is YES the pathogenic agent is classified as a hazard.
  - If the answer is NO, proceed to step 3.6.

3.6 For a pathogenic agent reported in both the source area and the area of translocation, if:

– it is subject to an official control programme, OR

– there are zones of different animal health status, OR

– local strains are likely to be less virulent than those reported in the source area,

THEN pathogenic agent may be classified as a hazard. Proceed to step 4.

A risk analysis may be concluded at this stage if none of the pathogenic agents considered are classified as potential hazards.

3.7 Has a previously conducted *disease risk analysis* for the same translocation or activity provided risk mitigation measures for the hazard under consideration?

– If the answer is YES, are you required by legislation, policy or other considerations within your country to undertake a complete *risk analysis*?
  - If the answer is YES, proceed to step 4 and conduct a *risk assessment*.
  - If the answer is NO, apply the risk mitigation measures prescribed in the previously conducted *disease risk analysis*.

4. Risk assessment

Conduct a *risk assessment* for each hazard:

☐ Identify the populations of interest:
– Potentially susceptible species need to be identified to ensure that all the appropriate biological pathways are considered in the *risk assessment*.
– Susceptible species may include terrestrial and aquatic animals in the wild or in captivity or being farmed, as well as humans if the hazard has zoonotic potential.

☐ Draw a scenario tree to identify the various biological (risk) pathways leading to:
– the translocated animals or germplasm harbouring the hazard when moved or animals impacted by the planned activity harbouring the hazard
– susceptible animals or humans being exposed
– potential 'outbreak' scenarios.

☐ Conduct a *release assessment* to estimate the likelihood of the animals or germplasm or activity introducing the hazard into the environment, *ecosystem* or area of concern:

List the relevant biological, environmental and animal factors that you considered in each step:

– Is the likelihood that the animals or germplasm to be translocated or which will be impacted by the activity are carrying the hazard negligible? If the answer is:
  - YES, the risk estimate (step 5.1) is classified as negligible and the *risk analysis* may be concluded at this point
  - NO, proceed to the next step.

☐ Conduct an *exposure assessment* to estimate the likelihood of susceptible animals or humans being exposed to the hazard.

List the relevant biological, environmental and animal factors that you considered in each step:

– Is the likelihood of susceptible animals or humans being exposed to the hazard via each and every exposure pathway negligible? If the answer is:
  - YES, the risk estimate (step 5.1) is classified as negligible and the *risk analysis* may be concluded at this point
  - NO, proceed to the next step.

☐ Conduct a *consequence assessment* to estimate the likely magnitude of potential biological, environmental and economic consequences associated with the entry establishment or spread of the hazard and the likelihood of their occurrence.

List the relevant direct and indirect consequences that you considered:

– Is the likelihood of each and every significant biological, environmental or economic consequence associated with the hazard negligible? If the answer is:
  - YES, the risk estimate (step 5.1) is classified as negligible and the *risk analysis* may be concluded at this point
  - NO, proceed to the next step.

☐ *Risk estimation:* summarise the results or conclusions arising from the release, exposure and consequence assessments and proceed to step 5.

5. Risk management

5.1 Risk evaluation:

– Is the risk estimate greater than *risk communication* has determined to be acceptable to stakeholders? If the answer is:
  - YES, proceed to step 5.2
  - NO, the risk mitigation measures are not required and the *risk analysis* may be concluded at this point.

5.2 Option evaluation:

– Formulate an objective that clearly states the intended outcome of the risk mitigation measure(s) by taking into account the risk pathways leading from the likelihood of introducing the hazard, the exposure of susceptible animals or humans and of significant consequences arising.

– Identify possible risk mitigation measures.

– Select an option or combination of options that will achieve an acceptable level of risk by ensuring that:
  - option(s) are not chosen or applied arbitrarily but are based on scientific principles and a *risk analysis*
    · evaluate the likelihood of the entry, exposure, establishment or spread of the hazard together with an estimate of the likely magnitude and likelihood of occurrence of biological, environmental and economic consequences according to the measure(s) that might be applied
    · choose measures that are technically, operationally and economically feasible
  - apply measures only to the extent that is necessary to protect human or animal life or health
  - avoid situations where some parts of a risk pathway are over managed
  - consider each measure from the overall perspective of the entire risk pathway, not in isolation
  - if the contribution of a particular measure to the overall reduction in risk is insignificant or negligible, it is effectively redundant and should not be included
  - it is unlikely to be necessary to apply a risk mitigation measure at each and every step in the risk pathway in order to achieve the *acceptable risk*.

6. Implementation

☐ Undertake a scientific peer review to ensure that the *risk analysis* is technically *robust* and that the risk mitigation measures chosen are appropriate to the circumstances.

☐ Make the final decision and implement the risk mitigation measure(s).

☐ Monitoring and review:
– Monitor factors that may have an immediate impact on the risk, for example changes in the animal disease status of the source population or related populations in neighbouring regions.
– Monitor factors associated with each *risk analysis* that may need to be reviewed periodically as updated or new information becomes available.
– Monitor the implementation of risk mitigation measures to ensure they are achieving the results intended.

Tools for wildlife disease risk analysis

C. Lees, P.S. Miller, B. Rideout, V. Dove, S.C. MacDiarmid, M. van Andel, D. Tompkins, K. McInnes, R.M. Jakob-Hoff, L. Skerratt, N. French & S. Siah

Introduction

This section will direct you to appropriate tools for your *disease risk analysis* (DRA) and to pertinent case studies illustrating their use. It is important to understand the DRA process as it is outlined in this *Manual* before exploring these complementary tools, and we refer you to the previous sections for this insight.

The library of tools presented here is representative rather than exhaustive, and highlights, where possible, tools that are well tested and readily accessed. We hope that this will provide most practitioners with the tools they need for most DRA scenarios, while recognising that more work is needed in this area to build a fully comprehensive resource.

The role of tools in disease risk analysis

The analysis of disease risk in biological systems is complex, involving many types of data with a variety of relationships among them. We can not necessarily rely on our own 'mental models' to evaluate such risks. Experimental studies on humans (e.g. Towse *et al.* 2000; Oberauer and Kliegl 2006) show that, at any given time, our 'working memory' can hold only a small number of specific pieces of information pertinent to a particular problem. Holding the necessary information on the relationships between these pieces of data poses an additional challenge to our already strained faculties. To solve complex problems, then, we must turn to other means, or 'tools' for assembling, relating and analysing information.

Tools for *disease risk analysis* range in complexity from simple, yet powerful spreadsheets for compiling and organising data, to sophisticated simulation *models* for exploring the impact of *variability* and *uncertainty* on our ability to predict future outcomes of alternative *risk management* strategies. Despite their differences, all tools have something in common: they serve as independent instruments of investigation (Morgan and Morrison 1999).

By representing some aspect of the real world (often in the form of *models* or simplified representations of complex systems), tools can teach us something about the world that they represent. The more we interact with those tools in our analysis of a system, the more we learn about that system. Further, because most tools are based on both theory and data, they can mediate between these two realms and connect them in meaningful ways.

In applying tools it is important to recognise that no tool is perfect in its design, and no accompanying dataset is without gaps. Consequently, tools will not accurately predict the future, nor will they necessarily provide a single 'right answer' to a specific problem. Uncertainty is a constant feature of DRAs that must be recognised and addressed. The advantage of using tools will often lie in helping us to make relative rather than absolute predictions, for example when assessing the risk of disease agent introduction or *transmission* under different circumstances. This kind of comparative assessment is often referred to as *sensitivity analysis* and it allows us to make much more *robust* predictions about disease dynamics in host populations under alternative management scenarios. Many of the predictive tools discussed here can be used effectively in a comparative framework, in addition to their use in a more traditional (and often more problematic) absolute predictive context.

Disease risk analysis tools, properly applied, should help us to learn more about the system we are studying: to understand what we know and do not know about the system; to understand what we most need to know in order to intervene effectively where needed; and to assess the comparative merits of different *risk management* approaches. We offer the tools discussed in this section in the firm belief that they will provide such benefits.

Figure 9 illustrates some of the tools that can be used in *wildlife* DRA, and how they fit into the DRA framework described.

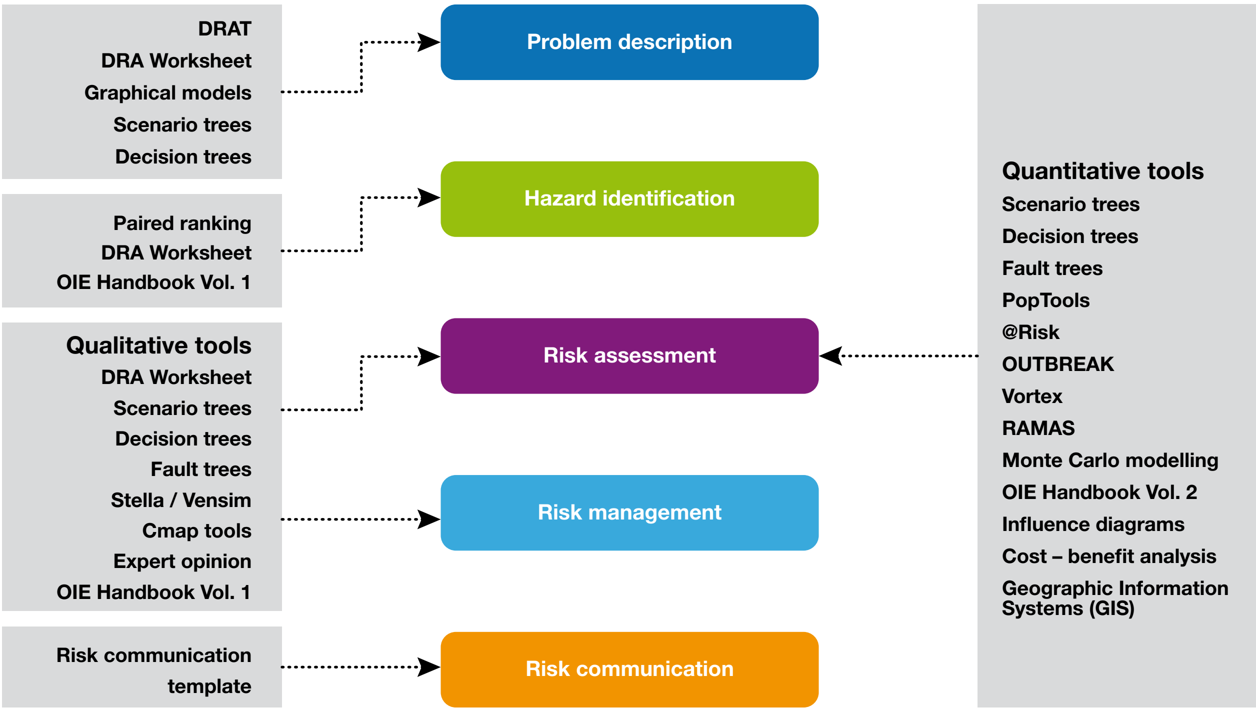


Fig. 9
Flow chart to illustrate where selected tool types can assist the disease risk analysis

Finding the right tool

Locating an appropriate tool for a specific scenario requires an understanding of what the tool will be required to do, some knowledge of the range of options available, and an understanding of any limitations in the areas of funding, data or expertise that might constrain your choice.

The tools matrix in Figure 10 is designed to point the user quickly and easily to tools that are suited both to specific stages in the DRA process and to different DRA contexts. It distinguishes between tools for quantitative versus qualitative analyses and clearly identifies those able to be used across multiple DRA stages; this is likely to be particularly useful for those designing a formal DRA from first principles. When several tools are highlighted for use during a particular stage, the matrix highlights their comparative suitability for situations in which data, resources or specialist expertise are in short supply. This should help practitioners to tailor the choice of tool to their specific circumstances.

Once the user has identified a promising tool or group of tools, further information on each, including case studies demonstrating their application and details of how and where they can be accessed, are provided in the Tools Introduction section below.

Tool introductions

This section provides further details about each of the tools listed in the tools matrix, including references to case studies that illustrate their use in real situations. The list is not intended to be exhaustive but rather to provide a representative sample of well-tested tools.

Tool 1: DRAT

K. McInnes

Name: DRAT – Disease Risk Assessment Tool for Wildlife Translocations in New Zealand.

Reference

Department of Conservation, New Zealand.

Source

DRAT will be available from the Department of Conservation, New Zealand website, www.doc.govt.nz/wildlifehealth, from March 2014.

								Suitable for situations with		
Tools	Qualitative	Quantitative	PD	HI	RA	RM	RC	Little technical expertise	Few ** financial resources	Few data
1. DRAT										
2. Stella										
3. Vensim										
4. DRA worksheet										
5. Paired ranking										
6. Graphical models										
7. Decision trees										
8. Influence diagrams										
9. Fault trees										Where used qualitatively
10. Scenario trees										Where used qualitatively
11. Cmap										
12. GIS										
13. OIE Handbook										
14. @Risk										
15.OUTBREAK										
16. PopTools										
17. Expert elicitation										
18. Netica										
19. Precision tree										
20. Vortex										
21. RAMAS										
22. Risk communicacion plan template										

PD, problem description; HI, hazard identification; RA, risk assessment; RM, risk management; RC, risk communication
***Indicates tool purchase costs of less than USD 200.00 at time of writing*

Fig. 10
DRA tools matrix

Cost

Free on the web.

Software requirements

None.

Stage(s) of risk analysis when this would be used

DRAT is to be used in the initial planning stage of a translocation where the user wishes to determine if there is a need to undertake a detailed *risk assessment*.

Description of tool use
The user progresses through a flow diagram, answering questions that determine the likelihood and consequences of disease *transmission* arising from *wildlife* translocation. Using geographic and habitat data, the user determines the ecological likelihood of transmitting or contracting disease through the translocation. Where the likelihood is negligible, the user is referred to minimum standards for managing *wildlife* health during the translocation. If the likelihood is not negligible, the user then makes a more detailed assessment based on the potential likelihood of encountering or transmitting novel *pathogen*s and the consequences to the species and release location, using whatever disease *prevalence* information is available. If the risk is considered not negligible, or there are insufficient data to make this assessment, the user is referred to a separate document requiring veterinary or disease ecologist assistance to undertake a more detailed assessment of risk and develop a *risk management* plan.

Experience and expertise required to use the tool

Users require no specific skills or knowledge.

Data requirements

Geographic details of source and release locations and type habitat mapping. Useful, but not essential information includes: presence or absence of diseases in the source and release locations and within the species being translocated.

Strengths and weaknesses, when to use and interpret with caution

DRAT allows anyone to make a general assessment of the risk of any *wildlife* translocation. It is user-friendly and simple to use. The assessment process is logical and transparent. DRAT quickly allows negligible risk translocations to be assessed and processed. It highlights where information gaps affect the assessment and educates the user in the process. It directs the user to more information and further assessment when required. It requires no special knowledge, no software and no training. It is a 'first cut' in the *risk assessment* process for translocations.

Use it for translocations as an initial screening tool to fast-track negligible risk translocations. Decisions made using the flow chart should be documented and reviewed by a neutral party.

It links to a more detailed *risk assessment* process document if the risk is not negligible. This requires veterinary or disease ecologist input and much more detailed disease information.

Case studies

These two case studies present different situations. In the first, birds are being moved locally. In the second, birds are being moved a great distance and there are known disease issues at the source location.

- In case study 1, the conclusion from the DRAT is that the risk of transferring or encountering a new *pathogen* is low, and the transfer can go ahead with some minimum requirements for ensuring individual birds are healthy at transfer.

- In case study 2, the DRAT demonstrates that there are disease issues that need to be examined more closely and mitigated. The user is directed to consult with a veterinarian. This involves some more detailed collection of data and *risk assessment*, and development of a comprehensive risk mitigation protocol.

Case study 1: Flow chart decisions record

Species	**North Island robin/toutouwai (*Petroica longipes*)**	
Source location	**Zealandia – Karori Sanctuary**	
Release location	**Eastbourne Regional Park**	
1. Is the source population captive?	Yes, go to Part B No, continue	No
2. Is the release site or the species listed as high priority by the Department of Conservation?	Yes, go to Part B No, continue	No
3. Are the release site and source site within the same or neighbouring ecological regions?	Yes, go to Q12 No, continue	Yes
4. Is the release site/nearby sites high value?	Yes, go to Q5 No, go to Q9	–
5. Are there diseases of concern in source site/species?	Yes, list them and go to Q6 No, go to Q9	–
6. Are they already present/likely to naturally reach the release site?	Yes for all, go to Q9 No for any, go to Q7	–
7. If they reach are they likely to spread?	Yes for any, go to Part B No for all, go to Q8	–
8. Is there a risk to future translocations?	Yes for any, go to Part B No for all, go to Q9	–
9. Are there novel *pathogen*s at the release site?	Yes, go to Q10 No, go to Q12	–
10. Can they infect your animals?	Yes, go to Q11 No, go to Q12	–
11. Can you justify it if it happens?	Yes, go to Q12 No, go to PART B	–
12. Minimum requirements, recommendations and reporting	Compulsory	Yes

Case study 1: Translocation map – ecological regions showing source and release locations (from DOC website http://gis.doc.govt.nz)

The translocation is from one ecological region into an adjoining one.

The species and locations are not listed as high priority. There is no requirement for further disease risk assessment.

Case study 2: Flow chart decisions record

Species	**South Island robin/toutouwai (*Petroica australis australis*)**	
Source location	**Motuara Island, Marlborough Sounds**	
Release location	**Orakanui Restoration Project, Dunedin**	
1. Is the source population captive?	Yes, go to Part B No, continue	No
2. Is the release site or the species listed as high priority by the Department of Conservation?	Yes, go to Part B No, continue	No
3. Are the release site and source site within the same or neighbouring ecological regions?	Yes, go to Q12 No, continue	No
4. Is the release site/nearby sites high value?	Yes, go to Q5 No, go to Q9	Yes
5. Are there diseases of concern in source site/species?	Yes, list them & go to Q6 No, go to Q9	Yes, avian pox, avian malaria, coccidia
6. Are they already present/likely to naturally reach the release site?	Yes for all, go to Q9 No for any, go to Q7	Pox – unknown strain therefore unknown risk Malaria – yes Coccidia – no, species specific
7. If they reach are they likely to spread?	Yes for any, go to Part B No for all, go to Q8	Pox – yes – PART B Malaria – n/a – already present Coccidia – no
8. Is there a risk to future translocations?	Yes for any, go to Part B No for all, go to Q9	Pox – yes – PART B Malaria – no Coccidia – no
9. Are there novel pathogens at the release site?	Yes, go to Q10 No, go to Q12	Unknown
10. Can they infect your animals?	Yes, go to Q11 No, go to Q12	Unknown
11. Can you justify it if it happens?	Yes, go to Q12 No, go to PART B	No
12. Minimum requirements, recommendations and reporting	Compulsory	Yes

Case study 2: Translocation map – ecological regions showing source and release locations (from DOC website http://gis.doc.govt.nz)

In this case:

- the species and locations are not listed as high priority
- the translocation crosses many ecological regions
- there are known disease risks within the source population
- there is a requirement for further disease risk assessment
- the user is referred to Part B.

Part B of the process involves consulting with a *wildlife* veterinarian and reviewing the situation in more detail to determine risks and mitigation measures.

Tools 2 and 3: Visual system-level simulation modelling – Stella and Vensim

P.S. Miller

References

ISEE Systems. An Introduction to Systems Thinking with Stella. Available for electronic or hardcopy purchase at www.iseesystems.com

Vensim Version 5.11 User's Manual. Available online at www.vensim.com

Source

Stella, a dynamic visual simulation modelling environment. See www.iseesystems.com/softwares/Education/StellaSoftware.aspx for detailed descriptions of the software.

Vensim, a graphical system simulation modelling tool. See www.vensim.com/software.html for detailed descriptions of the software.

Cost

A variety of packages are available. See the web links above for more information on pricing.

Software requirements

Stella: Windows: 233 MHz Pentium; Microsoft Windows™ 2000/XP/Vista/7; 128 MB RAM; 90 MB disk space; QuickTime 7.6.5 or earlier.

Macintosh: 120 MHz PowerPC or any Intel-based Mac; Mac OS 10.2.8-10.6.8; 128 MB RAM; 90 MB disk space; QuickTime 7.6.4 or earlier.

Vensim: Vensim runs on Windows XP and Windows 7. Vensim will run on the Macintosh under System X in 'Classic' mode.

Stage(s) of risk analysis when this would be used

Because of the 'systems level' approach to visualising and analysing a given question, these packages can be useful in the problem formulation step. When used in a more traditional modelling capacity, they can also be valuable in the *risk assessment* and *risk management* steps.

Description of tool use

The process of analysing a problem and making decisions on how to act on that problem begins by visualising the problem system. This is done in Stella and Vensim by converting a user's mental *model* into a graphical diagram of the problem system. Reflective thinking about the nature of the system and its components, combined with discussions with colleagues, leads to a refinement in realism and accuracy of the system's visual representation. Mathematical characterisation of the relationships among different elements of the system can be added, allowing the user to investigate the quantitative nature of these relationships and to simulate possible future states of the system under alternative assumptions and scenarios.

When beginning a new *model* in these packages, the user is presented with a blank window, almost like an artist's canvas. This is where the system description takes place. An intuitive icon-based graphical interface simplifies *model* building, with 'stock and flow' diagrams supporting the common language of systems thinking and providing insight into how systems work. A user can create causal loop diagrams to represent overall causal relationships, while model equations are automatically generated and made accessible beneath the model layer. A variety of tools is available to facilitate *model* presentation, including animations, storyboards, and other graphical elements (knobs, sliders, switches, etc.). Simulations 'run' systems over time, and *sensitivity analysis* reveals key system drivers and optimal conditions within the model structure. Simulation results are presented as graphs, tables, animations, QuickTime movies and files.

The emphasis with these software environments is on visualisation and analysis of almost any system imaginable, from complex problems in the physical sciences to art, literature and the process of human communication.

Experience and expertise required to use the tool

When used for purposes of system visualisation in the context of problem formulation, virtually no specific experience or expertise is required to use either Stella or Vensim; project success is limited largely by a user's imagination and creativity. If detailed quantitative analysis is the desired endpoint, the required expertise is similar to that desired for most other simulation modelling exercises. In particular, a thorough understanding of species biology and demography and disease ecology and epidemiology is necessary, and expertise in the statistical manipulation and analysis of model input and output data is essential.

Data requirements

Few specific data are required for visual system representation. For detailed *risk assessment* or *risk management*, specific data on host population demography, disease epidemiology and population-level impacts of disease are necessary.

Strengths and weaknesses, when to use and interpret with caution

The focus on system visualisation as a focus of learning is a major strength of these tools. The open-ended and very flexible approach to model construction and analysis results in a fairly steep learning curve in order to master the software's capabilities. A major strength of Vensim over other similar packages is the very competitive pricing options for the PLE and PLE Plus versions. Treatment of disease can be quite explicit and complex, limited only by the capabilities of the user. As with any modelling package, specific interpretation of simulation output is a direct function of the accuracy and realism of the input parameters.

Case studies

Sgrillo *et al.* 2005; Hannon and Ruth 2009 (a book focusing on the use of Stella for dynamic modelling of disease in a variety of situations).

See also Appendix 8 (p. 125) of this *Manual*.

Tool 4: DRA Worksheet

R.M. Jakob-Hoff

Name: Disease Risk Analysis Worksheet

Reference

Armstrong *et al*. 2003.

Source

Original version available within the above publication downloadable from the Conservation Breeding Specialist Group website at www.cbsg.org/risk/. For current version contact richard@cbsgaustralasia.org

Cost

The tool is freely available from the sources identified above.

Software requirements

Microsoft Word but can also be printed and used as a pencil and paper tool.

Stage(s) of risk analysis when this would be used

This tool guides the user through the entire *disease risk analysis* process and contains prompts for the use of specific analytical and decision-making tools at the relevant stages of the process.

Description of tool use

The Worksheet is designed for use by experienced *wildlife* managers with input from veterinarians and others who have some expertise in diseases of the *wildlife* taxonomic groups under consideration. While this tool can be used by one or two individuals, the best results are obtained when it is used to guide a facilitated discussion involving key stakeholder group representatives. It is of great value to include key decision makers in these discussions from the outset. As much relevant information as possible should be assembled and distributed to participants in advance of a face-to-face discussion.

Experience and expertise required to use the tool

No specialised expertise required. Requires the ability to think logically and communicate clearly.

Data requirements

- The species of concern's geographic distribution, behaviour, ecology and conservation management.
- The disease susceptibilities of relevant species (*wildlife* and domestic) at the geographic site(s) under consideration.

– Disease diagnostic and management options.
– Relevant social (e.g. public health; community cultural practices) and economic issues (e.g. costs of laboratory testing).

Strengths and weaknesses, when to use and interpret with caution

This tool has the flexibility to be applied to situation-specific DRA scenarios. It requires no (or minimal) technical equipment and is written in non-technical language. It provides a structured template for stakeholder discussion and prompts to encourage transparent decision making and consensus building when used with key stakeholder representatives in a workshop setting.

In its current form it is biased towards *wildlife* translocation scenarios and is limited to a *qualitative risk analysis*, although quantitative data generated through other tools can be imported and incorporated. An electronic version is under development but not yet available.

Case studies

Jakob-Hoff 2001; Jakob-Hoff 2009.

Tool 5: Paired ranking for hazard prioritisation

P.S. Miller and R.M. Jakob-Hoff

Name: Paired ranking

Reference

Armstrong *et al*. 2003.

Source

The above publication can be downloaded from the Conservation Breeding Specialist Group website at www.cbsg.org/risk/

Cost

The tool is freely available.

Software requirements

None.

Stage(s) of risk analysis when this would be used

During the hazard prioritisation component of the *hazard identification* stage.

Description of tool use

This is a means of producing a ranked list when it proves difficult to sort listed items into a priority list. It may be useful for an individual or a working group if the disease list is difficult to prioritise.

Experience and expertise required to use the tool

No specialised expertise is required but the process requires someone to facilitate the group discussion.

Data requirements

An initial list of potential hazards.

Strengths and weaknesses, when to use and interpret with caution

This is a tool for a *qualitative risk analysis* that assists groups to rank hazards based on their collective judgement. The process provides *transparency* to the ranking process for those directly involved and helps to build consensus. The limitation is that the ranking will be a reflection of the knowledge and expertise of those present and this needs to be acknowledged.

Case study

The mechanism for carrying out this technique is very simple. As an example here is a limited list of three cat diseases for demonstration purposes:

1. First list the diseases in any order:

Canine distemper
Tuberculosis
Toxascaris

2. Then define the criteria by which you will compare the diseases, such as effect on the individual, potential effect on the wild population, how transmissible the disease is, etc.

3. Then compare the first disease on the list with the second and decide which is more important for the criteria you have defined and place an X to the right of the disease that you feel is more important:

Canine distemper	**X**
Tuberculosis	
Toxascaris	

4. Then compare the first disease on the list with the third and decide which is more important according to your criteria and place an X beside it:

Canine distemper	**XX**
Tuberculosis	
Toxascaris	

5. Then compare the second disease on the list with the third and repeat the exercise, placing an X by the disease you consider more important according to your criteria:

Canine distemper	XX
Tuberculosis	
Toxascaris	**X**

6. Repeat this process until all the diseases on the list have been compared with all the other diseases one at a time. Then add up the number of X's by each disease and rewrite your list so that the disease with the most X's is at the top of the list:

Canine distemper	XX	2
Toxascaris	X	1
Tuberculosis		0

This exercise can be carried out individually or collectively by a working group or can be done individually by all the individuals in a group.

Tool 6: Graphical models

V. Dove

Other name: Epidemiology graphical *models*; conceptual *models*; path diagrams; causal webs

References

Dohoo *et al.* 2003; Murray *et al.* 2004; Thrusfield 2005.

Source

This is a tool that will be developed and constructed by the person or team conducting the DRA.

Cost

Free, if done on a computer using PowerPoint or using a pen and paper. Software such as Miradi is currently available as open source software.

Software requirements

Can be easily constructed in Microsoft PowerPoint or by using a programme such as Miradi (https://miradi.org).

Stage(s) of risk analysis when this would be used

These graphical *models*, which can be used both quantitatively and qualitatively, will identify the various factors involved in the *risk assessment*, and will be a vital resource that can be used in the *hazard identification*, *risk management* and *risk communication* stages of the DRA process.

Description of tool use

A graphical depiction of the steps involved in the DRA process (Fig. 11), together with the biological pathways involved (Figs 12 and 13) provides a useful conceptual framework for visually conveying the range and types of pathways to be considered in a DRA.

As disease is always multifactorial, it may be hard to visualise all the factors at play. A means of conceptualising how these multiple factors combine to cause disease is through a causal web, consisting of direct and indirect causes (Dohoo *et al.* 2003) or through a path diagram (Thrusfield 2005).

Experience and expertise required to use the tool

No specialist expertise is required to use the tool.

Data requirements

A thorough literature review of the relevant hazards that have been identified is required to obtain an understanding of the epidemiology of the disease, including the host factors, the environmental factors and the agent factors. Once all these factors are identified, the causal web can be constructed.

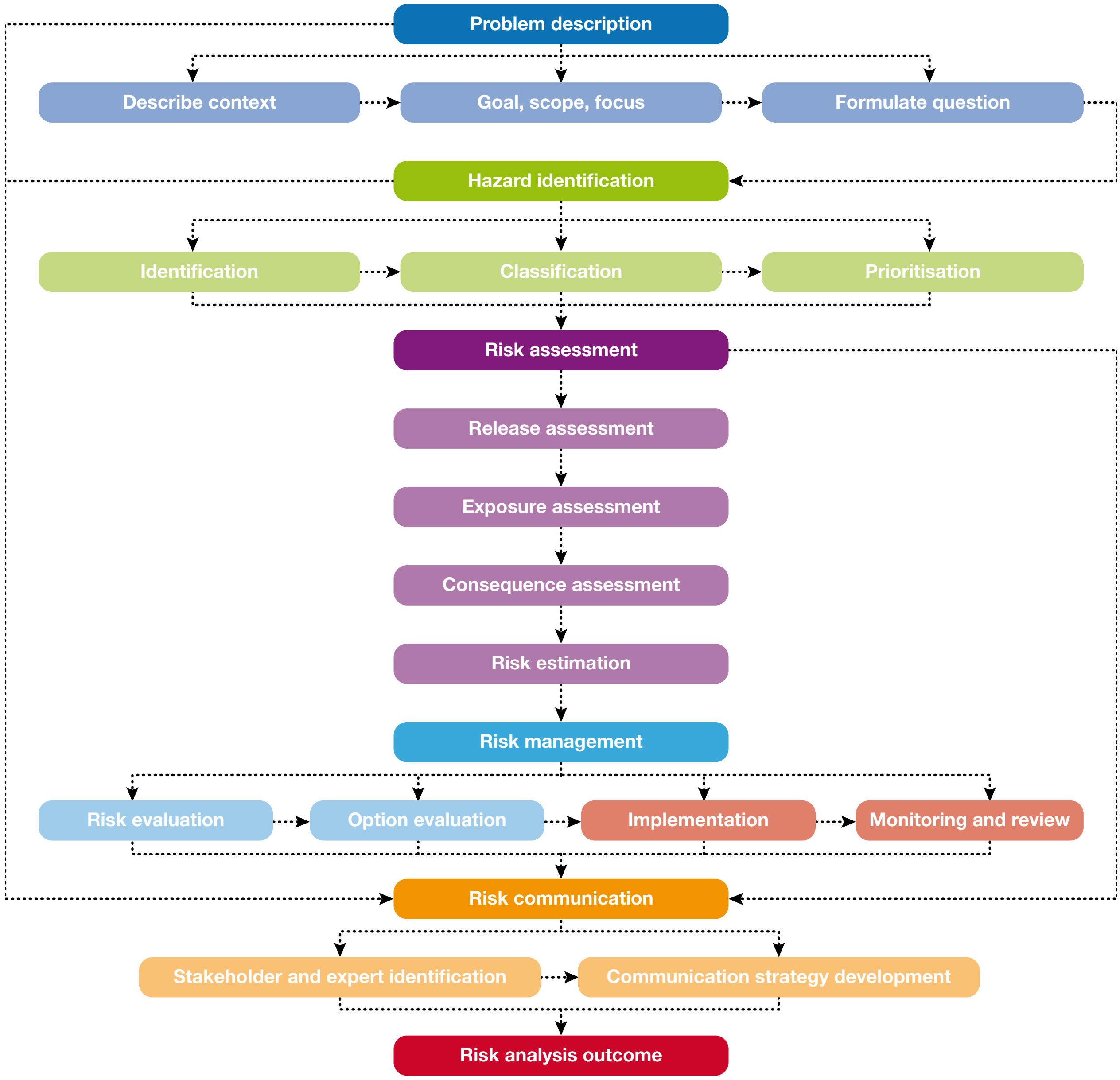


Fig. 11
Conceptual model of the generic disease risk analysis process

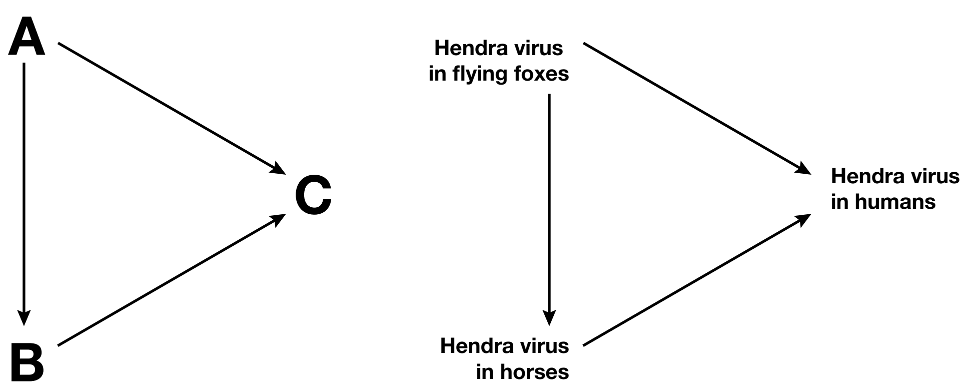


Fig. 12
Path diagram with direct and indirect causal association (A with C)
Adapted from Thrusfield (2005)

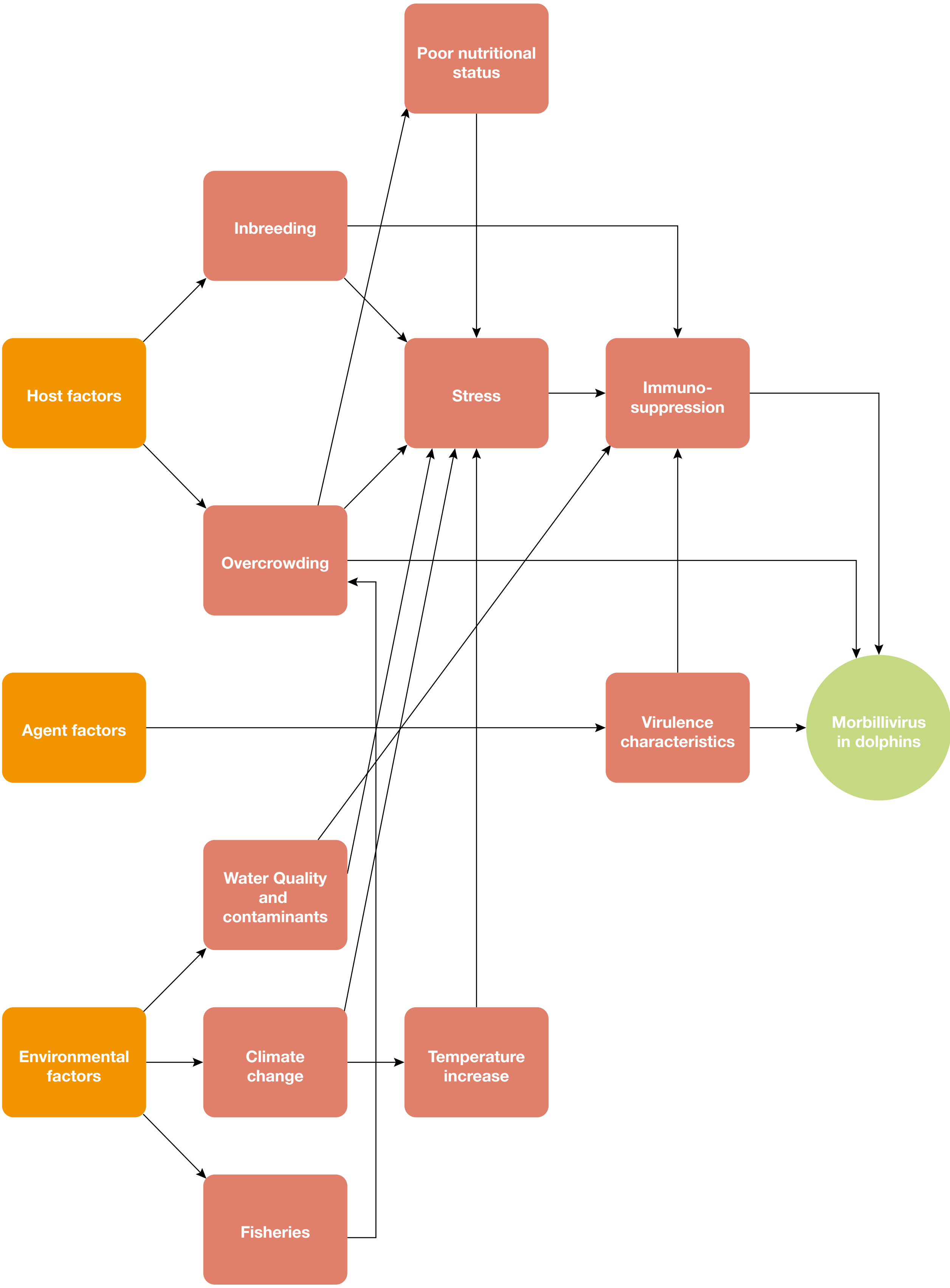


Fig. 13
Causal web model of morbillivirus infection in cetaceans
Figure 13 is a causal web of morbillivirus in dolphins. This was constructed easily using the program Miradi

Strengths and weaknesses, when to use and interpret with caution

Strengths (Murray *et al.* 2004):

- All variables can be identified.
- The relationship between variables can be identified.
- It ensures a logical chain of events.
- It provides a framework for quantification and mathematical modelling.
- It ensures *transparency* and accuracy with *risk estimation* for qualitative analyses.
- It assists with communicating the *model* structure.
- It clarifies ideas and the understanding of the problem.

This process needs to be thoroughly researched in order to be accurate, as the entire DRA process will be based on this information. If variables are ignored or accidentally excluded, this can significantly affect the validity of the DRA process.

Case study

An excellent example of a causal web is given in Thrusfield (2005), fig. 3.6, p. 42.

Tool 7: Decision trees

V. Dove

References

Marsh 1999; Noordhuizen 2001.

Source

This is a tool that will be developed and constructed by the person or team conducting the DRA.

Cost

Free if done manually. There is a software package called DATA that is available to help develop decision trees and simplify the process (see www.treeage.com/). Cost is moderate to high but the producer of the software also offers reduced student rates. Another programme that may be used is Precision Tree (see www.palisade.com/precisiontree/). The cost is high. This programme can also be purchased together with five other risk analysis software programmes, collectively called the Decision Tools Suite, which includes @Risk software. Prices are available through the website: www.palisade.com/decisiontools_suite/save.asp

Software requirements

Can be done manually with pen and paper or in Microsoft Office, including PowerPoint and Excel, but can also use the software programmes mentioned above.

Stage(s) of risk analysis when this would be used

Decision trees can be used both qualitatively and quantitatively, and are most valuable for the *hazard identification*, *risk management* and *risk communication* steps of the *risk analysis* process.

Description of tool use

Decision tree analysis offers a formal, structured, approach to decision making, taking into account the elements of *uncertainty* (Marsh 1999). These analyses allow us to model chance events related to sometimes complex decisions. Graphically these depictions represent the flow of events in a logical, time-related and structured way (Noordhuizen 2001). The first node of a decision tree is always a decision node (rectangular box), each branch of which leads to a terminal node or a chance node. The choice of the preferred course of action is made through a process called folding back, which is done by multiplying the monetary values at each terminal node by the probability at the proceeding chance node (Marsh 1999) The probabilities used can be obtained from the literature, field studies or expert opinion. If *diagnostic tests* are part of the decision process, then additional information such as test sensitivity, specificity and *predictive values* are required, as these are related to the probabilities of occurrence of events listed on the decision tree (Noordhuizen 2001). In order to build a meaningful decision tree, all the possible courses of action to address the problem need to be identified.

The following four steps can be used as a guide to building a decision tree:

1. Draw the decision tree using squares to represent decisions and circles to represent *uncertainty*.
2. Evaluate the decision tree to make sure all possible outcomes are included.
3. Calculate the tree values working from the right side back to the left.
4. Calculate the values of uncertain outcome nodes by multiplying the value of the outcomes by their probability (i.e. expected values).

An example of a simple hypothetical decision tree is shown in Figure 14.

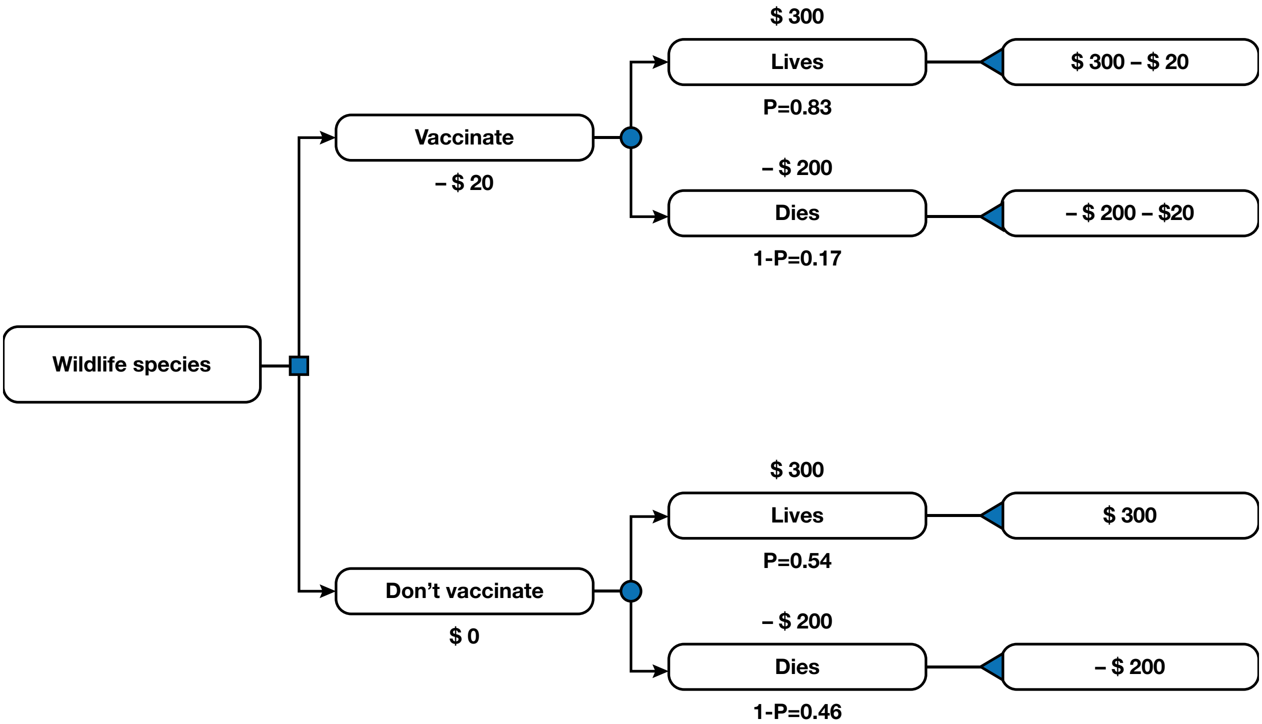


Fig. 14
Decision tree, assessing vaccination as a control strategy

Estimated value (EV)

- EV vaccination lives = 0.83 x (300–20) = $232.40
- EV vaccination dies = 0.17 x (–200–20) = –$37.40
- EV (vaccination) = $195
- EV No vaccination lives = 0.54 x 300 = $162
- EV No vaccination dies = 0.46 x –200 = –$92
- EV (No vaccination) = $70.

The value of the *wildlife* in this hypothetical example was given an arbitrary figure of $300 for the purpose of illustration. This may represent the value of the species in a captive facility, in a breeding programme, to conservation or to eco-tourism, etc. The value of the *wildlife* species that died was also given an arbitrary figure, taking into account necropsies, sample collection, loss to biodiversity, etc.

From this example, *vaccination* has been shown to be more profitable, assuming that the estimated values and probabilities are correct.

Decision trees can be more complex, as illustrated in Figure 15.

For complex decision trees, such as that in Figure 15, it is advisable also to construct an influence diagram, to simplify the decision-making process and aid in the communication of the analysis. For example the corresponding influence diagram would be as in Figure 16.

Influence diagrams are discussed in the following tools template.

Experience and expertise required to use the tool

An understanding of probability is an advantage.

Data requirements

A thorough understanding of the hazard of interest is required, as well as knowledge of all possible event outcomes, so that a meaningful decision tree can be constructed. Good-quality epidemiological data will be required for quantitative decision trees, for example known probabilities for the hazard of interest, test sensitivities and specificities, disease *prevalence*.

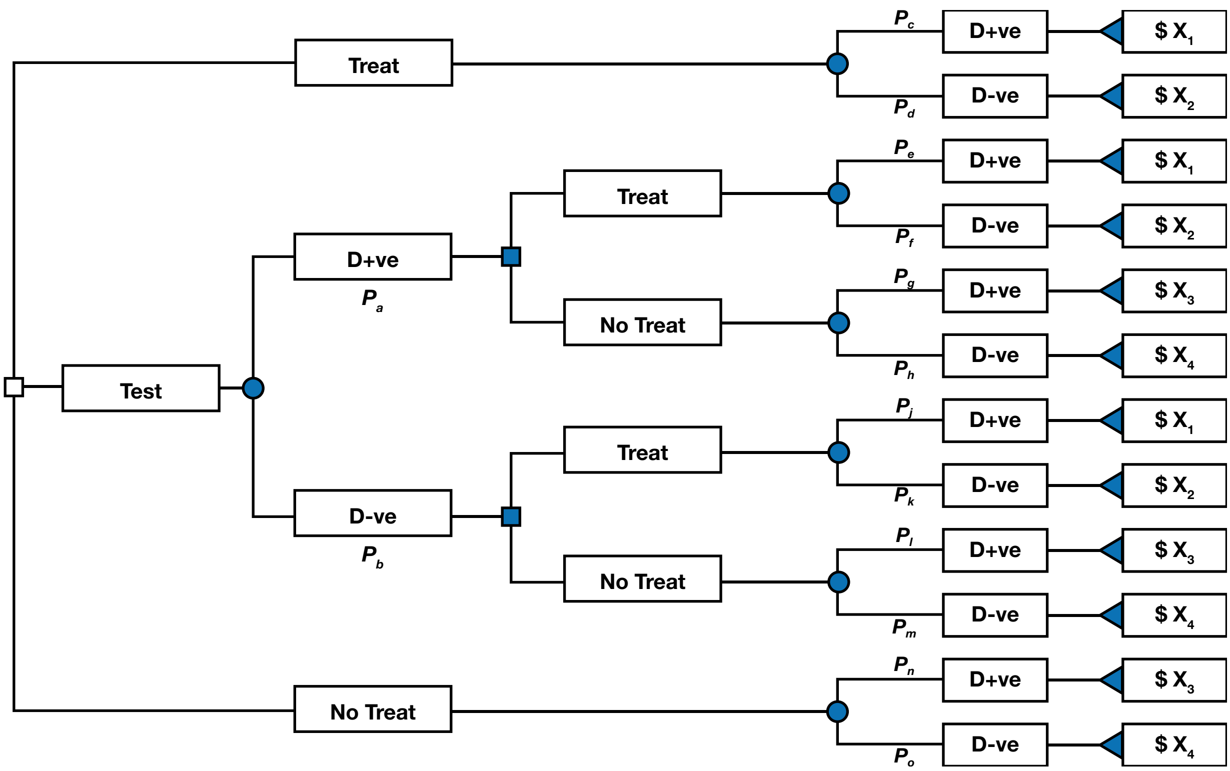


Fig. 15
Example of a more complex decision tree analysis
Where *p*(a–o) = probability; and X = dollar value.

Strengths and weaknesses, when to use and interpret with caution

Decision trees are useful as they:

- clearly demonstrate the various outcomes so that all options can be evaluated
- allow us to analyse fully the possible consequences of a decision
- provide a framework to quantify the values of outcomes and the probabilities of realising them
- help us to make the best decisions on the basis of existing information and expert opinion.

Decision trees have pitfalls in that the branch and node description of sequential decision problems can often become very complicated. Influence diagrams may be used together with decision trees, for added simplicity and *transparency* in the decision-making process. See Influence diagrams tool description.

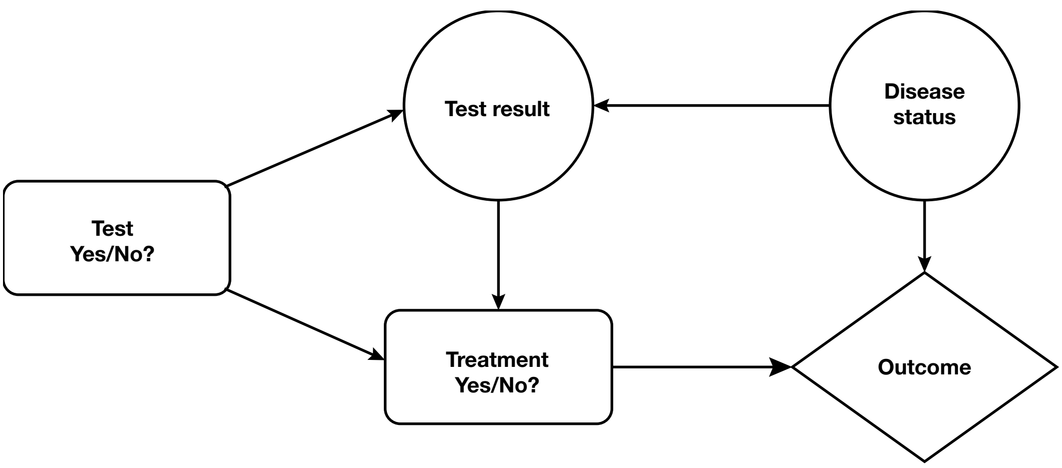


Fig. 16
Influence diagram that complements the decision tree in Fig. 15

Case study

Marsh (1999) offers an excellent example of a decision tree in fig. 1, p. 363.

Tool 8: Influence diagrams

V. Dove

References

Nease and Owens 1997; Murray *et al.* 2004; Ricci 2006.

Source

This is a tool that will be developed and constructed by the person or team doing the DRA. It can be done manually or with the aid of software programmes.

Cost

Free if done manually. Software programmes are available:

– Analytica creates decision models and can be used to build influence diagrams www.lumina.com/software/influencediagrams.html.

– Other programmes include DPL 6.0 www.syncopation.com/monte_60.html.

Software costs can be obtained from the websites.

Software requirements

None if done manually or Microsoft Office applications or the programmes mentioned above can be used.

Stage(s) of risk analysis when this would be used

Influence diagrams may be used in qualitative and *quantitative risk assessment*s and are especially useful at the *hazard identification*, *risk management* and *risk communication* steps.

Description of tool use

Influence diagrams are a conceptual modelling tool for the development of decision *models* and are useful as alternative graphical representations of decision trees, which can often become quite complex. These diagrams compactly and graphically represent the causal relationships among decisions, external factors, uncertainties and outcomes. In essence they demonstrate how different variables interact with one another as well as representing the probabilistic relationships between parameters in the *model*. Influence diagrams are mathematically equivalent to decision trees. However, when used together with decision trees they can be complementary, especially for representing probabilistic relationships among variables in a decision *model* (Nease and Owens 1997). Nease and Owens (1997) present five important principles for structuring a decision as an influence diagram:

1. Start at the value node and work back to the decision nodes.
2. Draw the arcs in the direction that makes the probabilities easiest to assess.
3. Use informational arcs (ending in a decision node) to specify which events will have been observed at the time each decision is made.
4. Ensure that missing arcs reflect intentional assertions about conditional independence and the timing of observations.
5. Ensure that there are no cycles in the influence diagram.

Influence diagrams have four types of nodes and two types of arc:

– *Decision node:* rectangle.

– *Chance node* (variables/*uncertainty*): circle or oval.

– *Deterministic node:* double circle or oval.

– *Value node (results/consequences):* diamond, or rectangle with rounded edges.

– *Influence/conditional arcs:* end on a chance node.

– *Informational arcs:* end in a decision node.

Figure 17 illustrates a simple influence diagram while Figure 18 illustrates a more complex example from a published *risk analysis*. The latter example models the risk of introducing and establishment of infectious bursal disease virus following importation of chicken meat into New Zealand (Ministry of Agriculture and Forestry Regulatory Authority 1999). While it is a useful depiction of a complex series of events, note that this figure does not observe the convention described above for the types of nodes.

Experience and expertise required to use the tool

Understanding of probability.

Data requirements

A good understanding of the hazard of interest is required; an influence diagram should be constructed with available probability data.

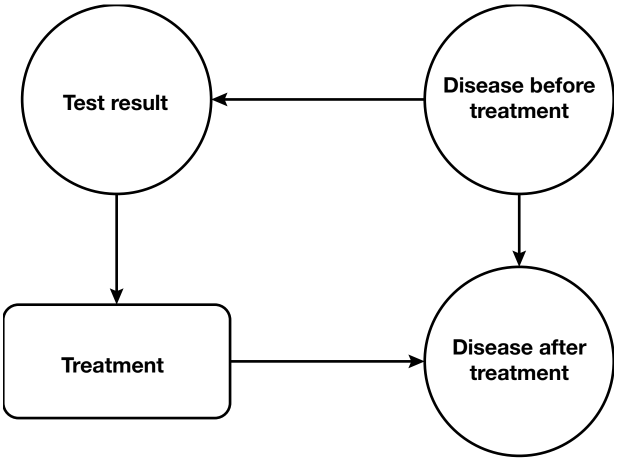


Fig. 17
Simplistic example of an influence diagram
Treatment: decision node
Test result, Disease status: chance nodes
Arrow ending on treatment: informational arc
Arrows ending on chance nodes: conditional arcs

Strengths and weaknesses, when to use and interpret with caution

Influence diagrams offer several strengths for structuring *risk assessment* decisions.

– They allow the *model* to be structured in a fashion that eases the necessary probability assessments, regardless of whether the assessments are based on available evidence or on expert opinion.

– They are useful for:
  - facilitating communication among technical experts, decision makers and stakeholders
  - integrating knowledge from different sources in decision making
  - encouraging disciplined thinking about cause and effect relationships
  - being explicit about *uncertainty*, in particular emphasising the existence of competing hypotheses and facilitating informed debate about them
  - structuring subsequent quantitative modelling
  - documenting the basis for and improving the *transparency* of the *risk assessment*.

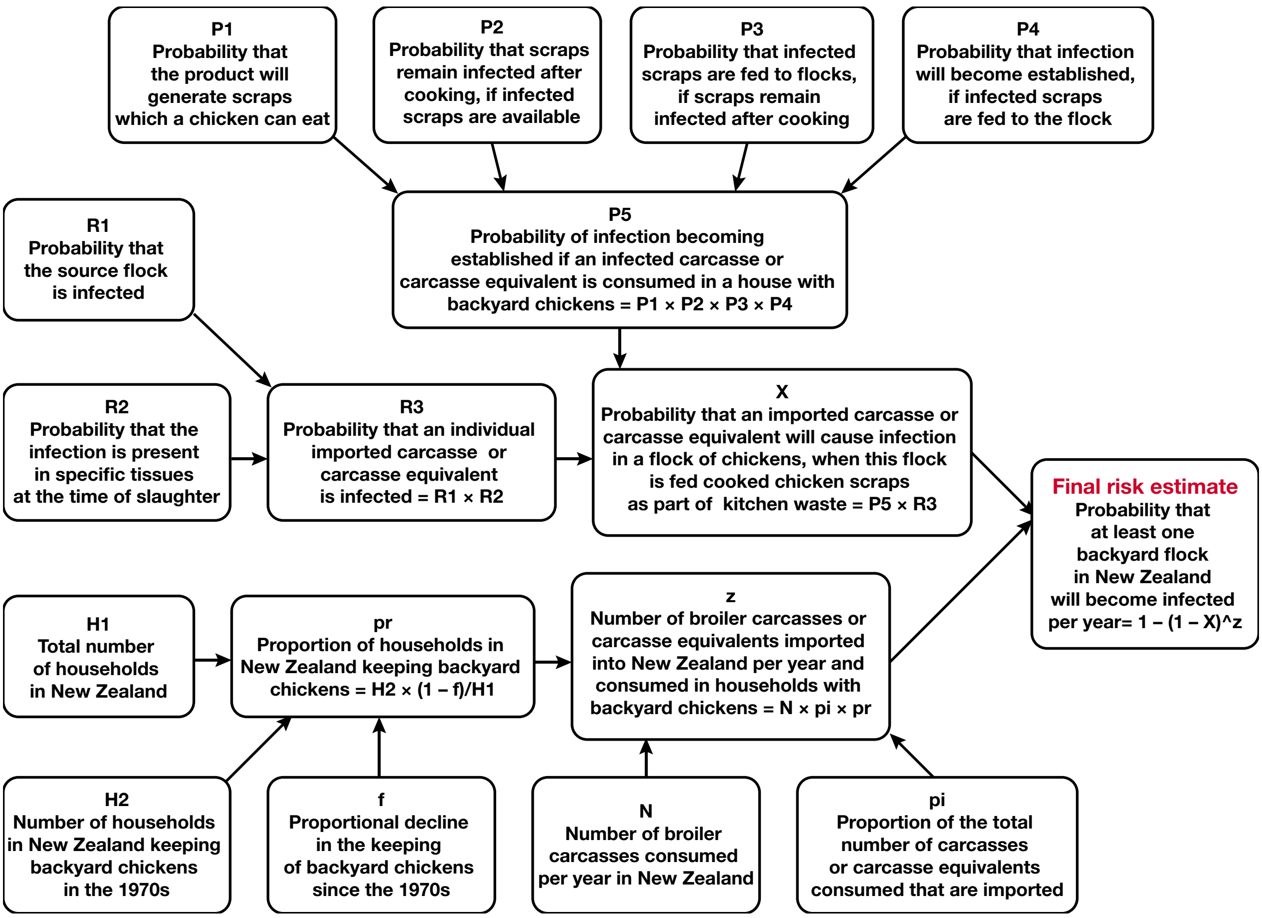


Fig. 18
An example of a complex influence diagram (Ministry of Agriculture and Forestry Regulatory Authority 1999)
From Murray *et al.* (2010). – Handbook on Import Risk Analysis for Animals and Animal Products, Volume 2. Quantitative Risk Analysis, 2nd Ed. World Organisation for Animal Health (OIE), Paris

Some common mistakes when constructing influence diagrams are:

– confusing influence diagrams with flow-charts, which are sequential in nature

– building influence diagrams with many chance nodes pointing to a primary decision node

– inclusion of cycles (circular paths among nodes).

Case studies

Ministry of Agriculture and Forestry (MAF) Regulatory Authority 1999.

Anonymous. – Difference between decision tree and decision table. Available at www.doc.ic.ac.uk/~frk/frank/da/9.Influence%20Diagrams.pdf.

Tool 9: Fault trees

V. Dove

References

Salman *et al*. 2003; Risebro *et al*. 2005.

Veseley W.E., Goldberg F.F., Roberts N.H. & Haasl D.F. (1981). – US Nuclear Regulatory Commission: Fault Tree Handbook. www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0492/sr0492.pdf. This reference has a good chapter that clearly explains fault tree logic, and how to use this qualitative model.

Source

To be developed by the DRA team.

Cost

Free.

Software requirements

None, or these trees can be constructed using Microsoft PowerPoint.

Stage(s) of risk analysis when this would be used

Usually in a qualitative *model*, but can also be used in quantitative assessment during the *hazard identification*, *risk management* and *risk communication* steps.

Description of tool use

Fault tree analysis is a method of analysing the ways in which complex systems can fail, and for calculating overall failure rates from the individual component failure rates. Fault trees begin with the occurrence of a hazard (Fig. 19) and from there move backwards to identify and describe the events that must have occurred for the hazard to be present using fault logic gates such as 'AND' or 'OR'. This provides a framework to analyse the likelihood of an event by determining the complete set of underlying conditions or events that allow the given event to occur.

Risebro *et al.* (2005) describe fault tree analysis as a diagrammatical *risk assessment* technique to describe the sequence and inter-relation of possible events leading to an undesirable outcome (in this case, an outbreak). Using a top-down approach, preconditions for the undesirable outcome are determined until the basic causes are identified. All events are joined by a series of branches and gates. An AND gate requires all input events to occur; an OR gate requires one or more input events to occur. Typically the likelihood of each event is determined and probabilities are assigned. When this is done, the qualitative fault tree *model* can be used quantitatively.

Salman *et al.* (2003) provide a good example of a fault tree used in animal disease *surveillance* systems.

Figure 19 is a hypothetical example of a fault tree, where the hazard is 'Disease outbreak' occurring from animals selected for translocation. The events resulting in a disease outbreak include: disease-positive animals must be translocated *AND* the disease agent must infect susceptible naive animals. In the disease-screening process the events that lead to a disease-positive animal being translocated include:

– the first *screening test* fails, *and*

– the second *screening test* fails, *and*

– *quarantine* fails.

Experience and expertise required to use the tool

This tool is used frequently in the engineering field but has been infrequently used in animal risk assessments. However, there are few medical references in which this tool has been used. An understanding of simple logic gates, 'AND' and 'OR' gates, is required to use this tool successfully. Minimal experience is required.

Data requirements

A good understanding of the hazard of interest is required, so that all possible failure scenarios can be incorporated into this *model*. Minimal data are required for qualitative modelling. However, for quantitative *models*, probability data will be required.

Strengths and weaknesses, when to use and interpret with caution

Fault trees have a number of rules for their construction. It is important that the user is aware of the sequence of events for fault tree construction, so that the analysis will be sound. When used correctly these are useful tools. However, if mistakes are made in the construction of the fault tree, this can lead to a faulty analysis.

Case study

Risebro *et al.* 2005.

Tool 10: Scenario trees

V. Dove

Reference

MacDiarmid and Pharo 2003.

Source

This is a tool that will be developed and constructed by the person or team conducting the DRA. Scenario trees are simple to construct, and the user can refer to MacDiarmid and Pharo (2003) in which the various steps in constructing them are clearly outlined.

Cost

Free.

Software requirements

None.

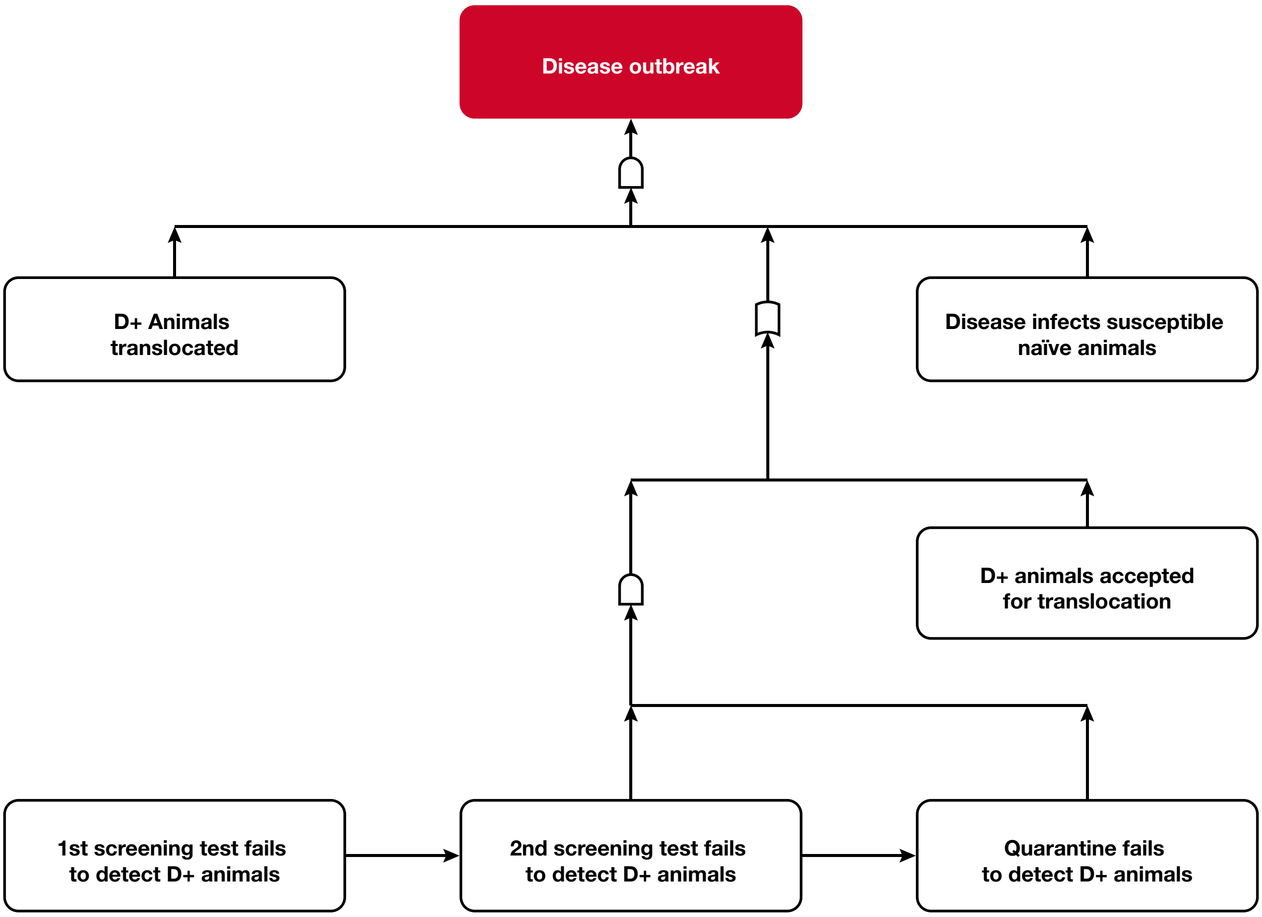


Fig. 19
Fault tree demonstrating the failures needed to result in disease outbreak

Stage(s) of risk analysis when this would be used

These graphical *models* will identify the various factors involved in the *risk assessment* process, and will be a vital resource that guides the *risk assessment* and can be used both qualitatively and quantitatively in the *hazard identification*, *risk management* and *risk communication* steps.

Description of tool use

Scenario trees are graphical depictions that outline the various biological pathways of expected events resulting in the occurrence of a defined outcome. Thus, these visual pictures provide a useful conceptual framework for the *risk assessment*. Scenario trees are useful tools in the *risk assessment* process, as they facilitate *transparency* and aid in communicating the risks to the various stakeholders, in a simple, logical and effective framework.

Scenario trees can be constructed for the following three steps in the *risk assessment* process:

- *release assessment*
- *exposure assessment*
- *consequence assessment.*

Scenario trees start with an initiating event such as:

- selecting a sample of animals to be tested that are potentially infected with the *pathogen* or *hazard* of concern
- disease exposure.

The scenario tree then has branches that outline the various pathways that lead to different outcomes such as:

- accepting animals (e.g. for translocation, export, captive breeding, etc.) that test negative for a particular agent of disease
- pathways that lead to a disease outbreak, or to other defined outcomes.

The following examples of scenario trees (Figs 20 to 25) are provided to give the reader a broad idea of how scenario trees can be used and adapted for different circumstances.

The consequence scenario tree in Figure 25 demonstrates the pathways leading to an outbreak (the consequence of interest) in animals selected for translocation.

Scenario trees can be used in both *qualitative risk assessments*, as shown above, and *quantitative risk assessments*. The difference between the scenario trees in the two different types of *risk assessment* is the addition of probability nodes in the quantitative analysis.

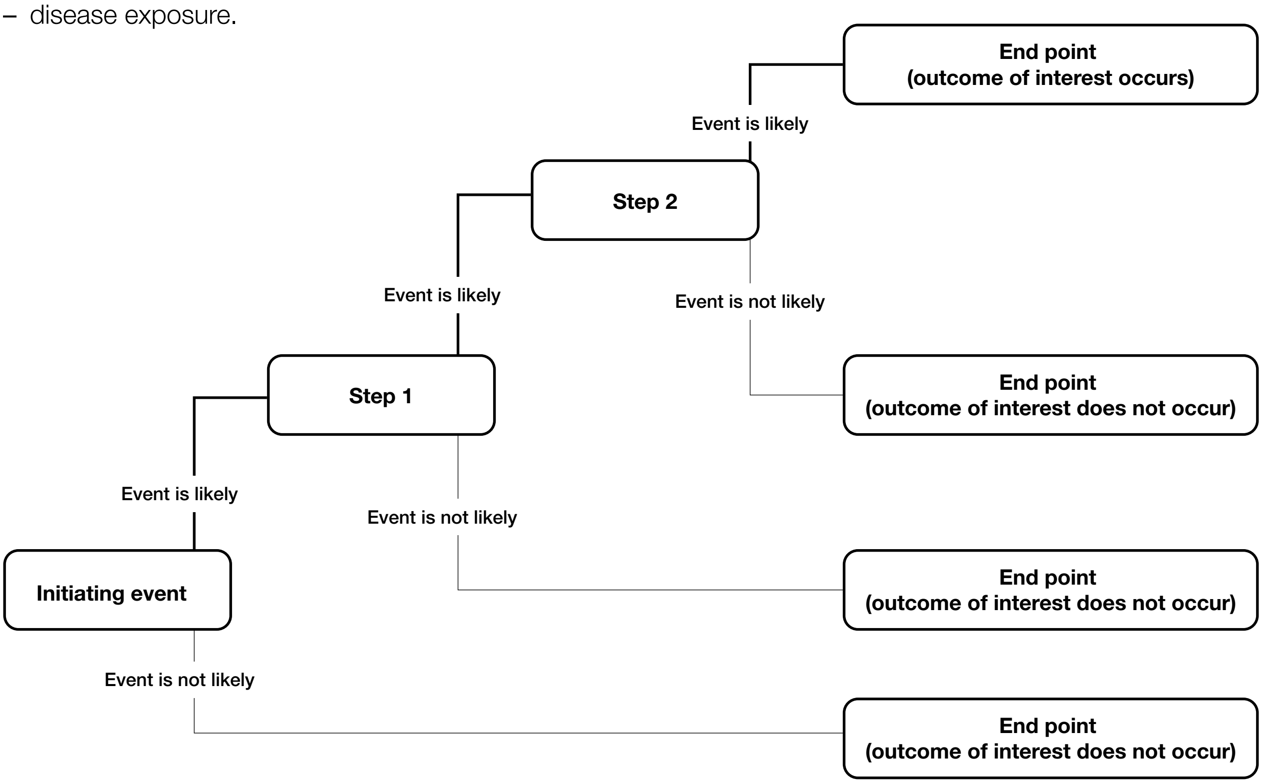


Fig. 20
Example framework for constructing a scenario tree (MacDiarmid and Pharo 2003)

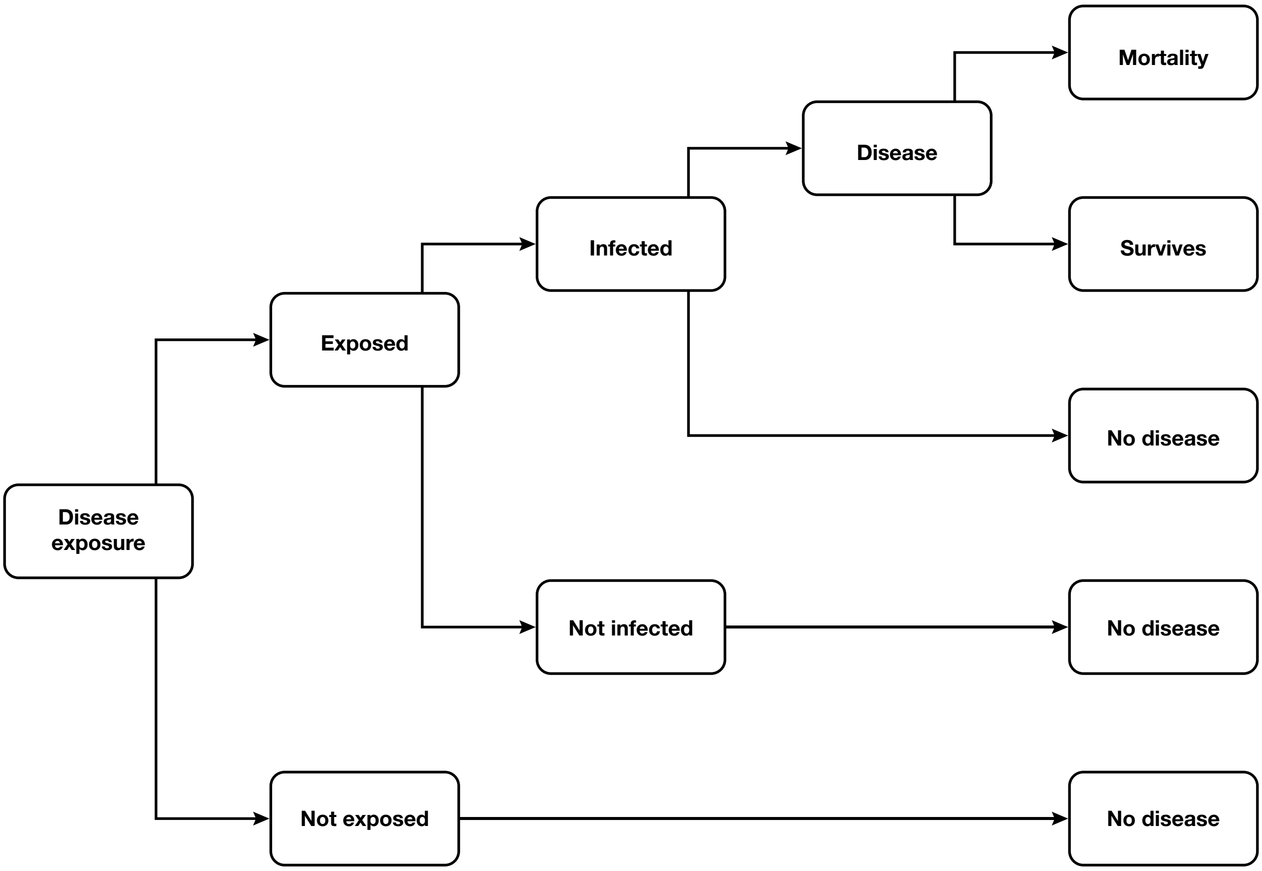


Fig. 21
Scenario tree outlining various events that may result in disease

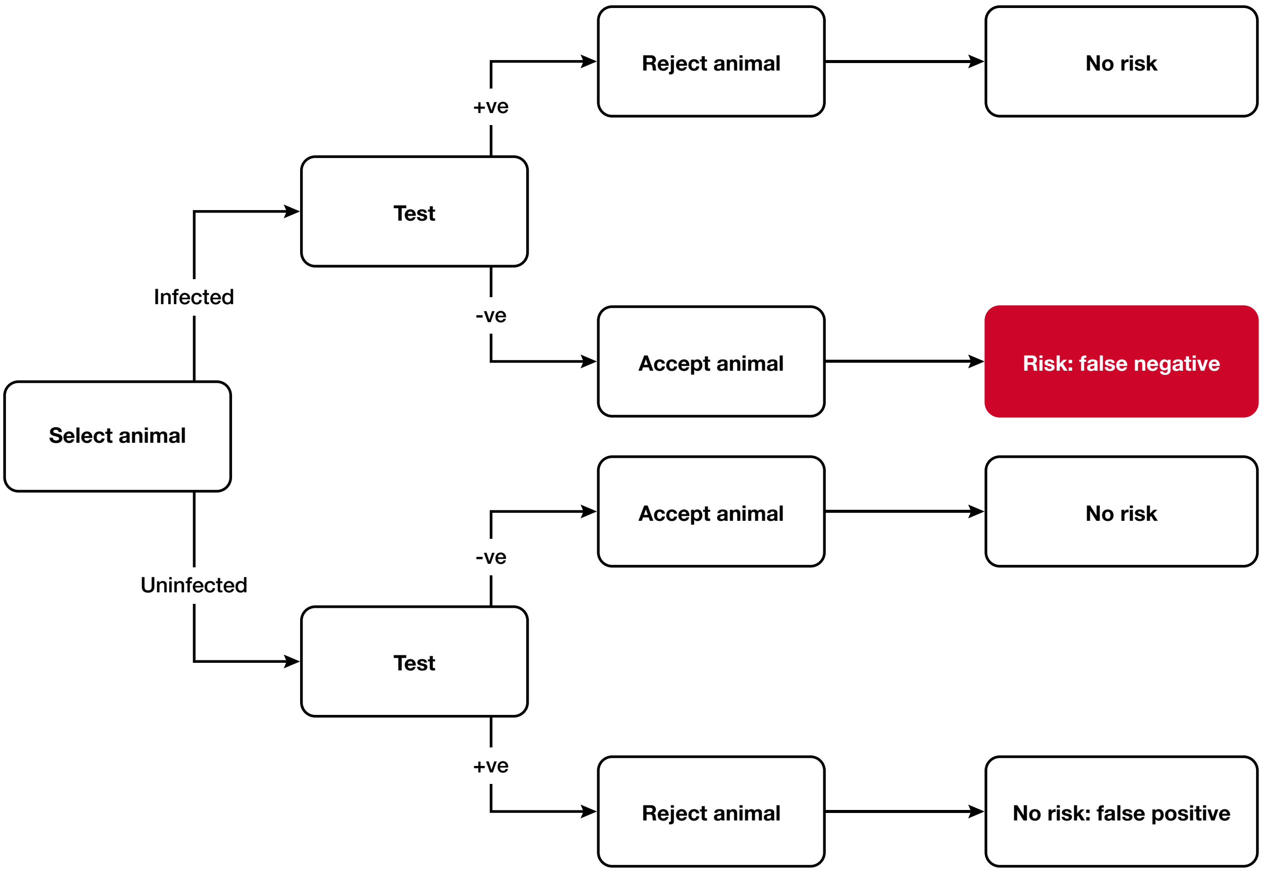


Fig. 22
Scenario tree outlining events that may result in a disease outbreak

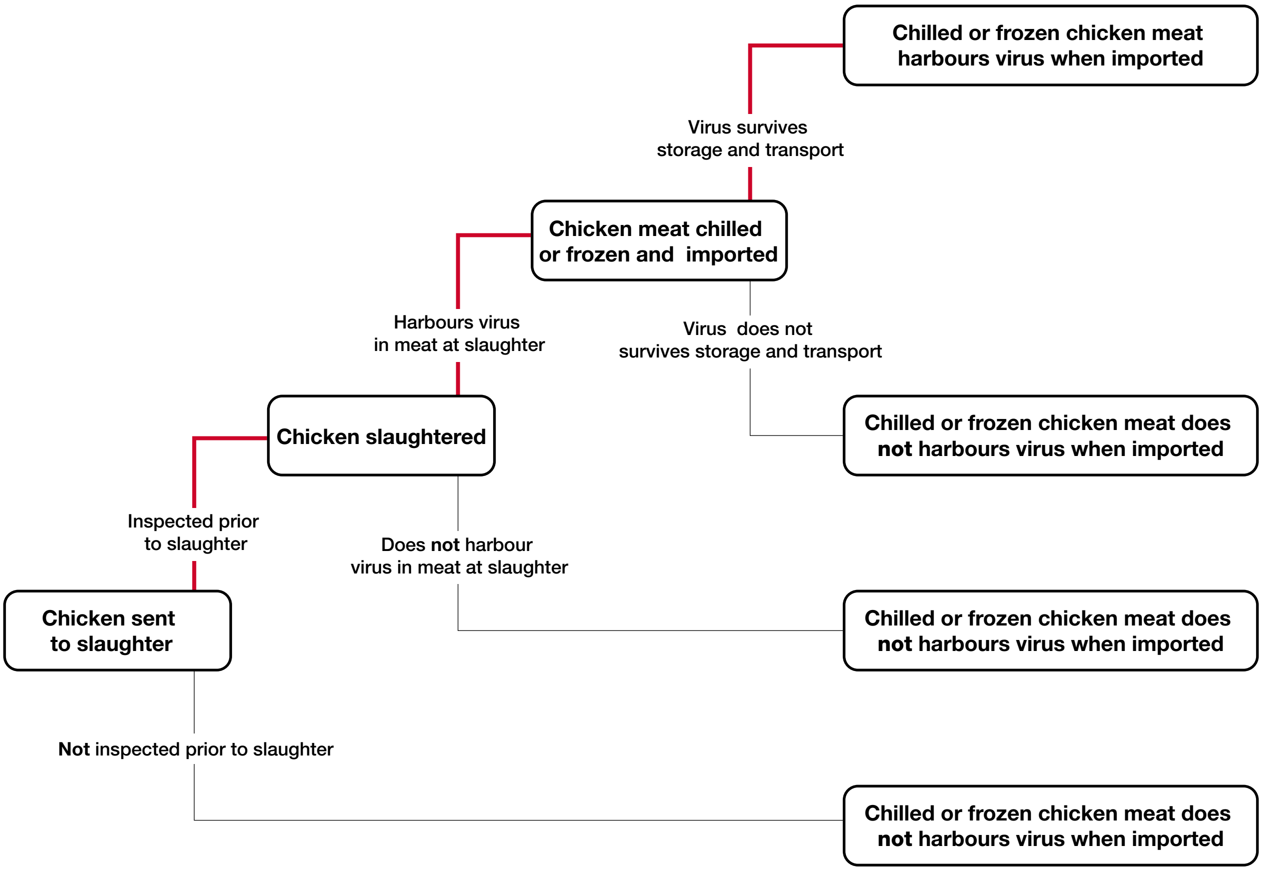


Fig. 23
Scenario tree for release assessment (MacDiarmid and Pharo 2003)

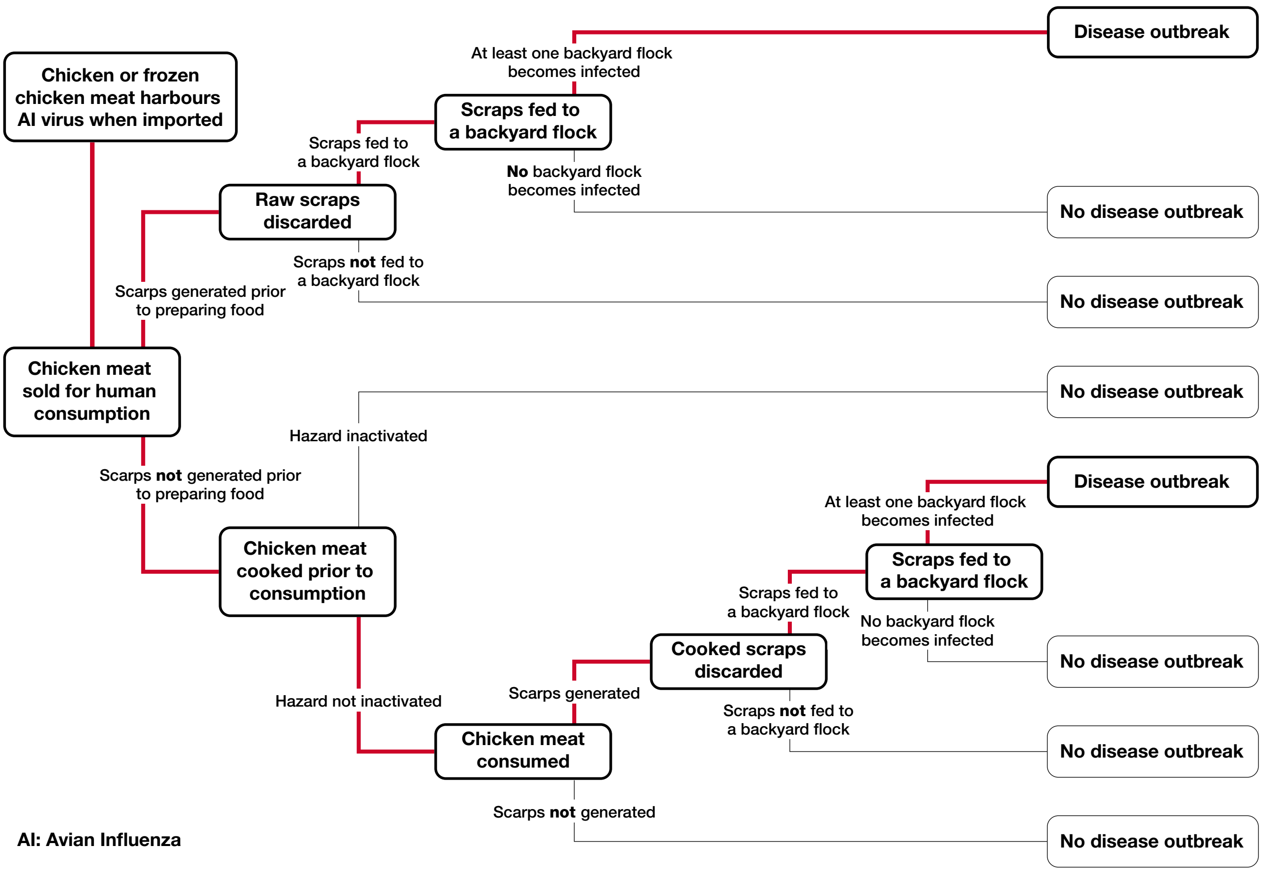


Fig. 24
Scenario tree for an exposure assessment
From MacDiarmid and Pharo (2003), *Rev. sci. tech. Off. int. Epiz.*, 22 (2)

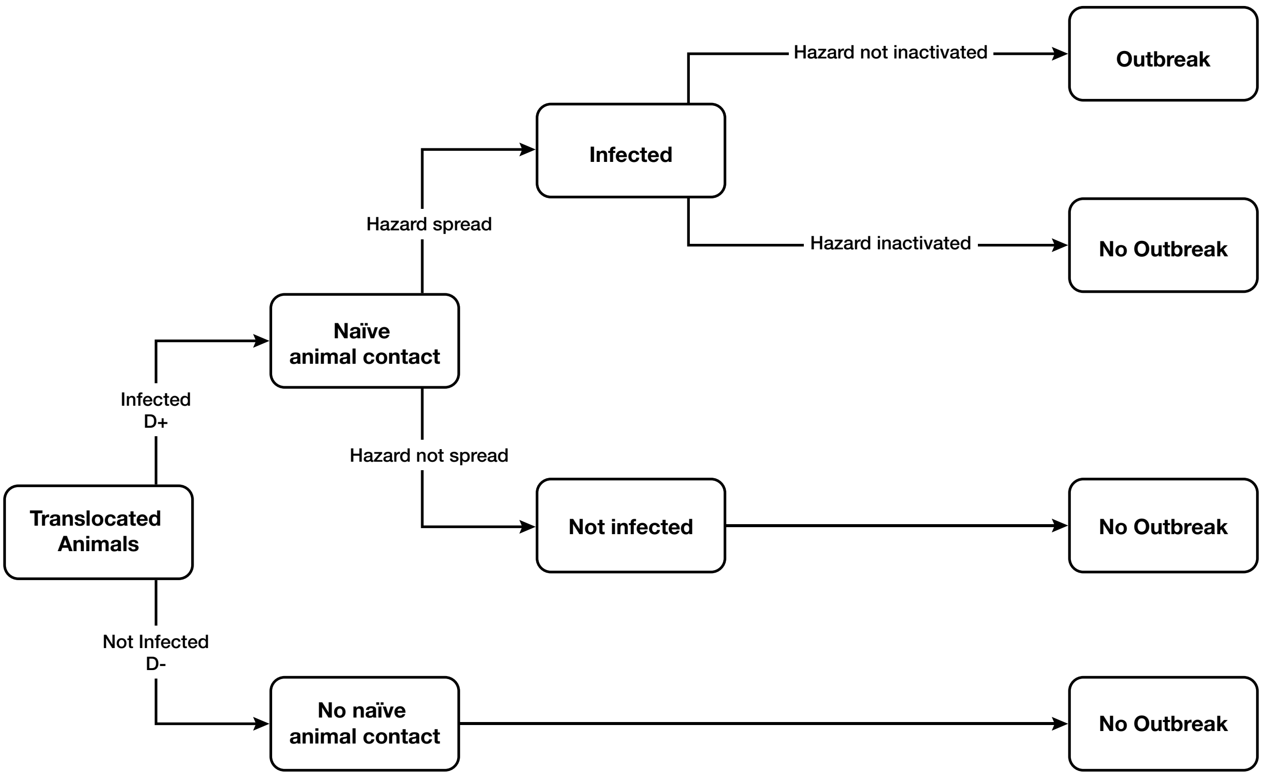
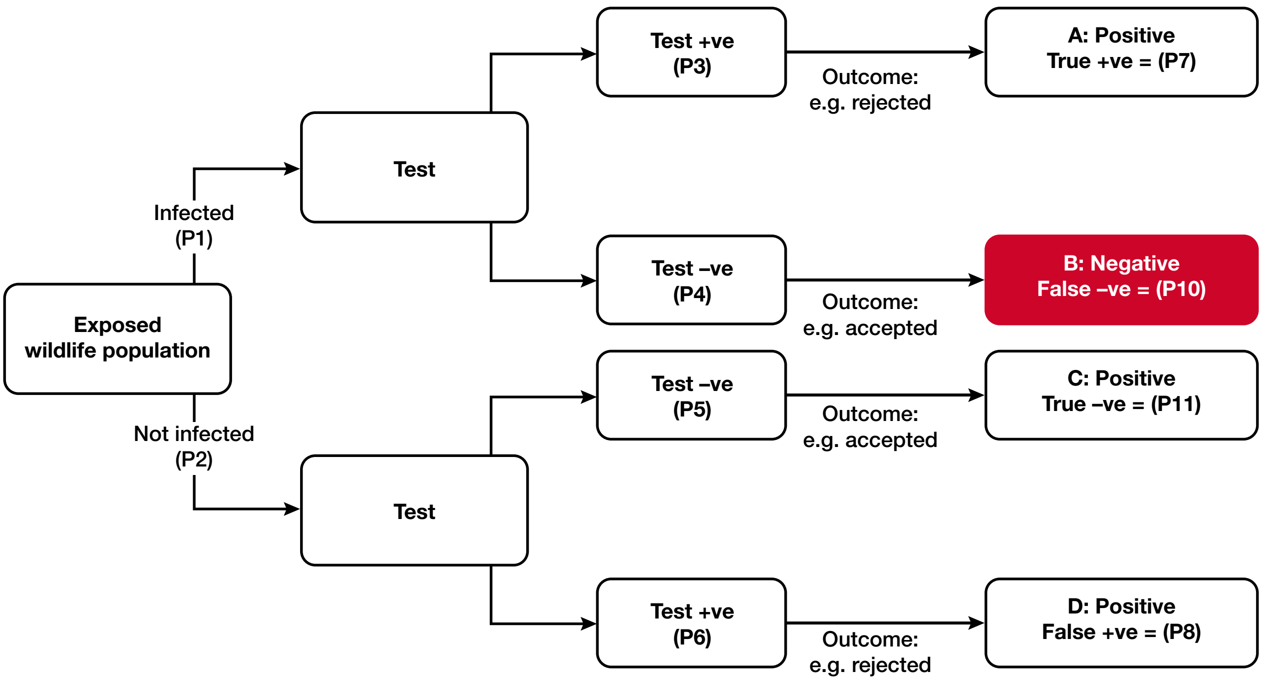


Fig. 25
Scenario tree for a consequence assessment



P1	p = probability of infection	P2	1–p	P7	p x Se
P3	Se = sensitivity	P4	1–Se	P8	(1–p) x Se
P5	Sp = specificity	P6	1–Sp	P10	p x (1–Se)
				P11	(1–p) x Sp

Fig. 26
Probability testing scenario tree

Example of a scenario tree (with probability nodes)

The scenario trees used in the qualitative analysis can be used here, with the addition of probabilities included (Fig. 26).

Experience and expertise required to use the tool

No expertise is required to use this tool in qualitative analysis, but a thorough understanding of the identified hazard is required. An understanding of probability is required to use this tool for quantitative analysis.

Data requirements

A good understanding of the hazard of interest is required, so that all possible scenarios can be incorporated into this tool. Minimal data are required for qualitative modelling, whereas probability data will be required for quantitative *models*.

Strengths and weaknesses, when to use and interpret with caution

Scenario trees are useful tools providing all the relevant information has been taken into account and the underlying assumptions clearly stated. Scenario trees can be very simplistic or can incorporate a lot of probability data, allowing for more complicated quantitative assessments to be carried out. They are useful as they can be used in both qualitative and *quantitative risk assessment*s. Owing to the ease with which scenario trees can be evaluated and their *transparency* these *models* have few shortcomings.

Case study

MacDiarmid and Pharo 2003.

● Tool 11: Cmap

M. van Andel

Reference

Novak J.D. & Cañas A.J. The theory underlying concept maps and how to construct and use them. Available at: http://cmapskm.ihmc.us/servlet/SBReadResourceServlet?rid=1064009710027_1637638703_27098.

Source

http://cmap.ihmc.us/download/

Cost

Free.

Software requirements

There are two versions available, Cmap and CmapLite. The latter is a version that has been reduced in functionality to allow it to run on machines with less available memory and older machines with a smaller main memory.

Stage(s) of risk analysis when this would be used

Used in the identification of hazards, *risk assessment* and *risk evaluation*. May also have use in the process of eliciting expert opinion. This software is a tool that allows mind maps to be represented and examined by other participants.

Description of tool use

A particular question or problem is identified. This could be in the form of a ‘focus question’. Key concepts relating to the focus question in the context of the discussions are identified and entered into Cmap. Concepts can be ranked with the most general concepts at the top of the list and most specific concepts at the end. This list of concepts is called the ‘parking lot’ and concepts are moved from this area into the concept map and linked to show how different areas of the map relate to each other. Words can be added to the cross-links to show the relationships between the concepts. A review of the map should be performed to make sure that the relationships are clear and well structured. Not all concepts have to be used.

Cmap allows photographs, images, diagrams, graphs and videos to be linked to different concepts in the map. Furthermore, Cmap has servers that allow collaboration via the internet, facilitating review by remote parties of concept maps created in one geographical location.

Experience and expertise required to use the tool

No experience required, simple to use.

Data requirements

None.

Strengths and weaknesses, when to use and interpret with caution

This is a descriptive tool, not one that provides quantitative results. The strength of this tool is that it is a way for participants in the process to share their beliefs about cause and effect in a standardised and clear way with other participants, some of whom may be collaborating remotely.

Case study

Decker *et al.* 2006.

Tool 12: Geographic information systems

V. Dove and N. French

Name: GIS

References

Robinson 2000; Ostfeld *et al.* 2005; Clements and Pfeiffer 2009.

Source

A number of GIS software programmes are available. Below is a list of some of the more commonly used ones:

- EpiMap: a freely available mapping package that can be used as an alternative to ArcView. It does not contain all the features available in ArcView but is nevertheless useful for mapping. www.abdn.ac.uk/immpact/resources/gis/epimap.php
- Quantum GIS (QGIS): also a freely available, user-friendly open source geographic information system licensed under the GNU General Public License. www.qgis.org
- GRASS: free software used for geospatial data management and analysis, image processing, graphics or maps production, spatial modelling, and visualisation. Can be used effectively in combination with QGIS. http://grass.fbk.eu
- gvSIG: another free GIS. www.gvsig.org/web/
- ILWIS: free raster-based software. www.itc.nl/Pub/research_programme/Research_output/ILWIS_-_Remote_Sensing_and_GIS_software.html
- SAGA: another raster-based free GIS. www.saga-gis.org/en/index.html
- ArcView: the entry-level licensing level of ArcGIS Desktop, a GIS software product produced by Esri. Cost can be obtained at this site: www.esri.com/software/arcview/index.html
- Map info: cost reduced in the second year of use. Price available at: www.rockware.com/product/overview. php?id=274&gclid=CKmNy8P3mqsCFZFU7Aod63JjPA
- Maptitude price available at: www.caliper.com/maptovu.htm
- IDRISI: price available at: www.clarklabs.org
- Google Earth www.google.com/earth/index.html: free. Many simple applications are now using Google Earth for displaying spatial and spatiotemporal data for decision making (e.g. used to create kml files for displaying disease data and kmz files for displaying dynamic patterns).

Cost

As noted above many excellent GIS applications are available free.

Software requirements

Depends on the type of software that you determine best fits your need and budget.

Stage(s) of risk analysis when this would be used

During the *hazard identification*, *risk management* and *risk communication* steps.

Description of tool use

Factors affecting the spatial locations of *hazards*, hosts and *vectors*, and their probability of close encounter, are all important to disease dynamics (Ostfeld *et al.* 2005). Spatial epidemiology (the study of the spatial distribution of disease and associated factors) has arisen as the principal scientific discipline devoted to understanding the causes and consequences of spatial heterogeneity in infectious diseases, environmental contaminants, road kills, etc. Risk maps pertaining to specific diseases and climate and weather patterns can be linked to distributions of arthropod *vectors*, vertebrate *reservoirs*, or actual cases of disease in the host (Ostfeld *et al.* 2005). The principal reason for using spatial characteristics of disease and their causal agents is to assist with the decision-making process for disease intervention (Robinson 2000). GIS can then be used to formulate specific plans to manage or control disease, based on the techniques of spatial epidemiology, which can generate recommendations concerning where to target interventions to prevent the spread of disease (Ostfeld *et al.* 2005), and based on cluster detection and early warning systems, which assist *surveillance* and can also permit timely interventions (Clements and Pfeiffer 2009). That is, GIS allows us to predict the spatial and temporal distribution of disease risk, so that appropriate intervention strategies can be developed (Robinson 2000).

GIS, together with remote sensing (RS), spatial statistics and spatially explicit mathematical *models*, constitute a powerful suite of tools for the study, prevention and control of infectious diseases (Clements and Pfeiffer 2009). However GIS alone is a tool that has been used to aid in decision-making and disease intervention strategies (Robinson 2000) as well as forming an underlying tool for examining landscape epidemiology (Ostfeld *et al.* 2005). It can be used to locate cases of disease and establish the spatiotemporal relationships among the cases and selected environmental features (Ostfeld *et al.* 2005). Mathematical *models* are particularly useful for testing and comparing alternative control strategies, whereas spatial decision-support systems integrate a variety of spatial epidemiological tools to facilitate widespread dissemination and interpretation of disease data (Clements and Pfeiffer 2009). Diseases tend to be limited geographically, with spatial variation arising from underlying variation in the physical or biological conditions that support the *pathogen* and its *vector*s and *reservoirs*. GIS allows these abiotic and biotic conditions to be delimited on maps, so both contemporaneous risk and future change in risk should be predictable (Ostfeld *et al.* 2005).

Ostfeld *et al.* (2005) describe the uses of GIS, which include:

– mapping how the spatial distribution of infectious diseases changes through time (spatiotemporal dynamics), e.g.:
  - retrospective analyses of spatiotemporally dynamic *epidemic*s to understand what factors govern the spatial pattern and rate of spread of diseases
  - characterisation of spatial variation in static ecological risk of infection and potential causes of that variation

– creating static risk maps based on distributions of *vector*s, *reservoirs* and disease incidence

– incorporating explicit landscape elements.

Experience and expertise required to use the tool

GIS is a specialist field, and expertise is required to use the available software tools.

Data requirements

Generally depends on good-quality data but varies with the software package being used.

Strengths and weaknesses, when to use and interpret with caution

One of the main strengths of GIS is their ability to integrate different types of spatial data (Robinson 2000). GIS can also be used with decision trees to implement effective control strategies. A major shortcoming of proprietary GIS programs is their limited but improving analytical capabilities (Robinson 2000). In addition good data are required for GIS analysis.

Case study

Ostfeld *et al*. 2005. Ostfeld and colleagues discuss the use of GIS with the foot and mouth disease outbreak that occurred in the United Kingdom during 2001.

Tool 13: OIE Handbook

V. Dove

Name: OIE Risk Analysis Handbook Volume 1 and Volume 2

Reference

Arrioja 2008; Brückner *et al*. 2010; Murray *et al*. 2010.

Source

Handbook on import risk analysis for animals and animal products. Volume 1: Introduction and qualitative risk analysis. Available at: http://web.oie.int/boutique/index.php?page=ficprod&id_produit=995&lang=en.

Handbook on import risk analysis for animals and animal products. Volume 2: Quantitative risk analysis. Available at: http://web.oie.int/boutique/index.php?page=ficprod&id_produit=45&lang=en.

Cost

These are relatively inexpensive and available through the OIE online bookshop at http://web.oie.int/boutique/index.php?lang=en

Software requirements

None.

Stage(s) of risk analysis when this would be used

These handbooks are an important resource that can be used throughout the entire DRA process. Volume 1 deals with *qualitative risk analysis*, and Volume 2 deals with *quantitative risk analysis*.

Description of tool use

Arrioja (2008) provides a comprehensive review of both volumes of the handbook, which is summarised below:

Volume 1 has three chapters:

– Chapter 1 introduces the concept of *risk analysis* in an international environment and defines terminology.

– Chapter 2 explains how to apply the *risk analysis* framework recommended by the OIE and describes the different components and tasks inherent in conducting a *risk analysis*. One of the components is *risk assessment*, which is a method for evaluating the likelihood and relevance of adverse consequences upon entry or spreading of a pathogenic agent in an importing country.

– Chapter 3 covers *risk communication*.

Volume 2 has eight chapters covering the statistical methods used in *risk analysis*:

– Chapters 1 to 4 introduce the principles of *quantitative risk assessment* and provide an overview of relevant statistical theory, for example probability distributions (binomial, central limit and Bayes's theorems) and binomial and Poisson's probability distributions.

– Chapters 5 to 7 further elaborate on statistical methods applicable to *risk assessment*, for example binomial versus hyper-geometric probability calculations, determining a suitable distribution for a given case, and second-order modelling. Tables of exact binomial confidence limits can be found in Appendix 1 of *Volume 2* of this publication.

– Chapter 8 provides guidelines for developing a *quantitative risk assessment model*.

Experience and expertise required to use the tool

Volume 1 is relatively simple and straight forward to use as a DRA tool. A background in epidemiology would be useful, and a thorough understanding of the hazard of interest and a comprehensive literature review should enable inexperienced persons to carry out a meaningful qualitative *risk analysis*.

Volume 2 is concise and comprehensive. However a background in statistics and statistical methodology is required in order for the user to fully understand and utilise the mathematical formulae.

Data requirements

Risk may be assessed qualitatively, according to the circumstances and data available, and this is a valid approach which is particularly useful when limited data are available. If sufficient data are available, evaluating likelihood in terms of statistical probability contributes to accuracy, provided all assumptions and limitations are clearly stated.

Strengths and weaknesses, when to use and interpret with caution

These volumes are an excellent reference tool that can be used to guide the DRA process, from simple *models* in *Volume 1*, to complex statistical *models* in *Volume 2*. The handbook however is focused on *risk analysis* with regard to importing animals and animal products, so this has to be kept in mind when adapting the situation to *wildlife* disease, and conservation scenarios.

Case studies

Case studies are given throughout the handbook to demonstrate the use of all DRA tools discussed.

An example case study that uses some principles of the handbook is Thrush *et al.* 2011.

MacDiarmid and Pharo (2003) closely follows the application of the DRA tools discussed in the Handbook.

Tool 14: @Risk

S.C. MacDiarmid

Name: @Risk. Risk analysis and simulation add-in for Microsoft Excel.

References

Vose 2000; Murray *et al*. 2004.

Source

Palisade Corporation, 31 Decker Road, Newfield, New York. www.palisade.com/risk/

Cost

Free trial version available for download; purchase price is available on the website.

Software requirements

Microsoft Excel

Stage(s) of risk analysis when this would be used

Throughout the process of a *quantitative risk assessment* step.

Description of tool use

@Risk is an add-in for Microsoft Excel. When constructing a *quantitative risk assessment* spreadsheet, @Risk allows the user to assign probability distributions, rather than single numerical values, to each input variable. Such a *model* is called a stochastic or Monte Carlo model. It allows the risk analyst to calculate the combined impact of variation in each of the model's inputs to determine a probability distribution of the possible outcomes. This is achieved by carrying out a simulation in which random values are automatically sampled from each input distribution and combining these, according to the mathematical logic of the *model*, to produce an output. This is repeated automatically in many iterations the outputs of which are combined to produce a probability distribution of possible model outcomes.

Experience and expertise required to use the tool

An intermediate level of experience and expertise is required to use @Risk, but it is advisable to have an experienced quantitative risk analyst review the appropriateness of the probability distributions applied to each input variable.

Data requirements

The data requirements can be minimal as @Risk lends itself to inputs elicited from expert opinion (see Vose 2000; Murray *et al.* 2004).

Strengths and weaknesses, when to use and interpret with caution

The strengths of @Risk are that it is relatively easy to use for anybody familiar with Microsoft Excel or other spreadsheets. It can be used for simple or complex *models* and can incorporate a range of data inputs ranging from simple uniform or triangular distributions obtained from expert opinion through over 30 other distributions selected on the basis of quantity, quality and type of data. *Sensitivity analysis* of *risk assessment models* is easy and straightforward with @Risk. The quality of outputs is determined by the logic of the *model* and the quality of the data used for the input variables.

Case studies

Paisley 2001; Pharo and MacDiarmid 2001.

Tool 15: OUTBREAK

P.S. Miller

Name: OUTBREAK, a stochastic computer simulation *model* of disease epidemiology in animal populations.

Reference

Verant M. & Miller P.S. (2011). – *OUTBREAK User's Manual*. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota.

Source

OUTBREAK is available from the Conservation Breeding Specialist Group website, www.cbsg.org.

Cost

The software is available at no cost from the CBSG website.

Software requirements

OUTBREAK is a Windows programme and will work under all modern versions of the operating system. While the programme will work with nearly any amount of memory (RAM), analysis of larger populations (e.g. > 5,000 individuals) will be hampered by insufficient memory. At least 1GB of RAM is recommended.

Stage(s) of risk analysis when this would be used

OUTBREAK is designed to be used in the *risk assessment* step, where detailed evaluation of the impacts of disease introduction or *transmission* in animal populations under alternative scenarios is required. Also, it can be used in the *risk management* step where the relative impacts of alternative disease management strategies – including *vaccination* and culling – may be explored.

Description of tool use

Input data on species demography and disease epidemiology, corresponding to a unique model scenario developed by the user, are entered into specific fields located on a set of tabbed input pages (Fig. 27). This set of input data, along with the resultant output, constitutes a modelling project. When model parameterisation is completed, the user specifies the number of iterations to run for that scenario. When the *model* has run through the designated number of iterations, the user interacts with a series of pages that depict the demographic and epidemiological structure of the population. Graphical output (Fig. 28) can be copied to a separate project report page where graphs and text can be combined to create a written description of the *model* results.

Experience and expertise required to use the tool

Users should be experienced in the use of computer simulation *models*, including the appropriate analysis of demographic and epidemiological data. While the software is rather simple to use at a basic level, expertise in the relevant biological and statistical fields is strongly recommended for proper use of the tool.

Data requirements

Simple demographic data (fecundity and survival rates) are required to characterise the growth potential of the population. In addition, detailed data on the epidemiology of a specific disease is necessary, such as contact rate, *transmission* probability, latent period, duration of *infectious period*, disease-based mortality rate, probability of recovery, etc.

Strengths and weaknesses, when to use and interpret with caution

OUTBREAK provides an outstanding platform to explore the epidemiological dynamics of infectious disease in animal (production and *wildlife*) populations, and the impact of the disease on population demographic structure and future viability.

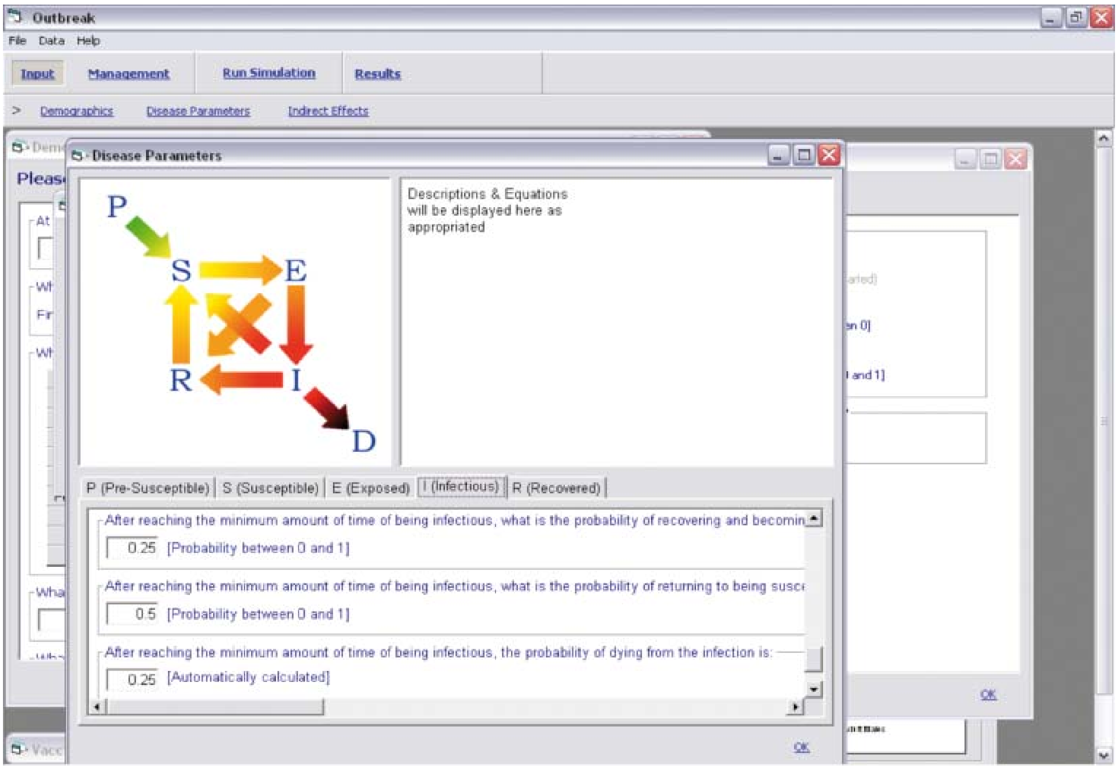


Fig. 27
Graphical interface for the OUTBREAK simulation software

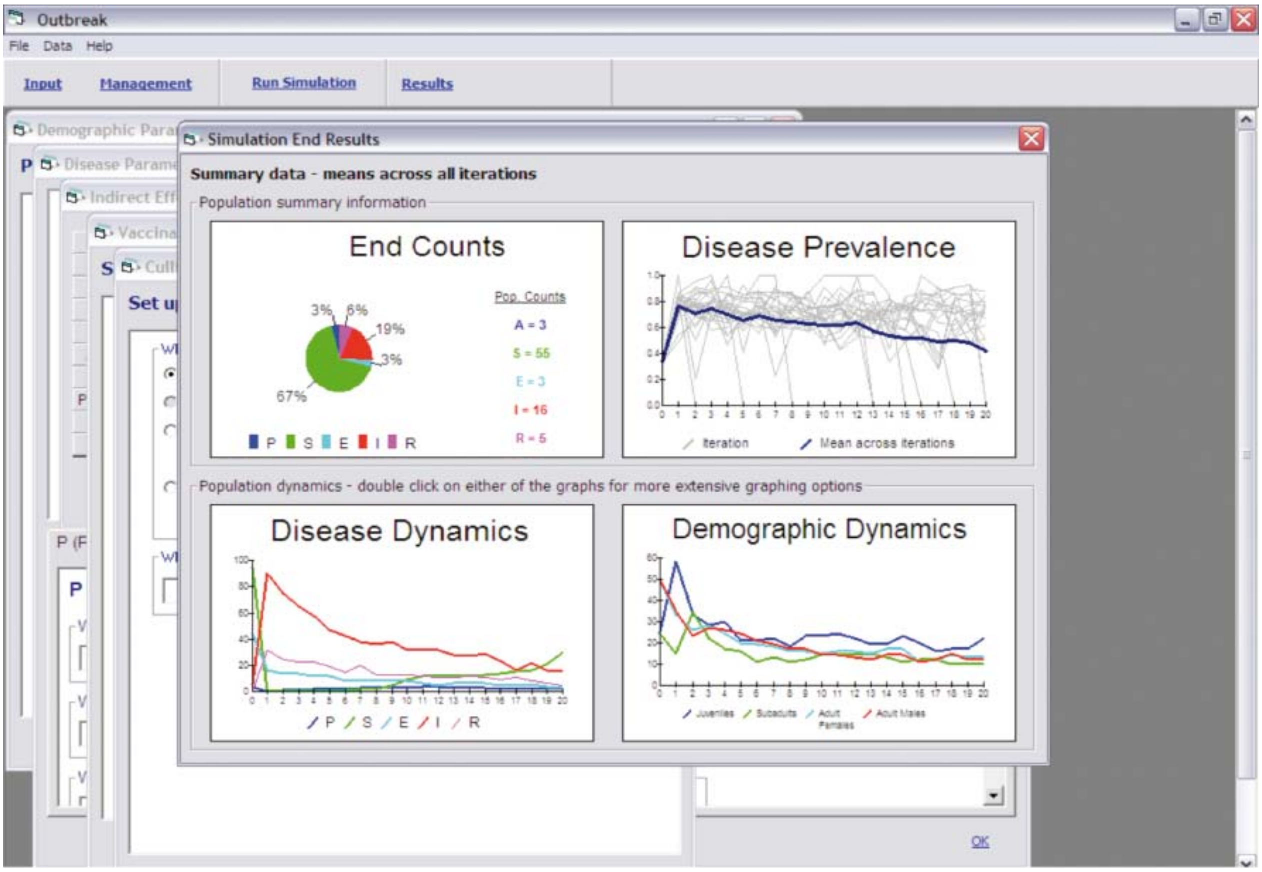


Fig. 28
Sample output from a simulation using OUTBREAK

The software is flexible and adaptable to a variety of infectious disease types, and can be tailored to a variety of species (mostly mammals, birds and reptiles). The software can also be linked to other demographic *models* such as Vortex (written by R.C. Lacy and available at www.vortex9.org) through a process known as metamodelling, thereby greatly increasing the *model's* realism and utility. (Contact pmiller@cbsg.org for more information on this capability). However, as the *model* counts each individual, there is a limit to the size of the population under consideration – typically in the order of 10,000 individuals. The *model* will run significantly more slowly when populations are large (e.g. >5,000) or when computer hardware is inadequate. In addition, as this is a relatively advanced quantitative tool for disease risk assessment, a rather high level of expertise in the relevant fields of study is strongly recommended for proper use of the tool.

Case studies

Keet *et al*. 2009; Bradshaw *et al.* 2012.

● Tool 16: PopTools

M. van Andel & V. Dove

References

www.poptools.org/

CSIRO (The Commonwealth Scientific and Industrial Research Organisation). Once installed PopTools has an extensive 'Help' file that describes each function.

Hood G.M. (2011). – PopTools version 3.2.5. Available on the internet. URL www.poptools.org; e-mail: poptools@csiro.au

Source

www.poptools.org/download/

Cost

Free.

Software requirements

Microsoft Excel (PopTools is an Excel add-in).

Stage(s) of risk analysis when this would be used

PopTools can be used at the *risk assessment* step once an appropriate probability distribution has been selected to model the available data using a Monte Carlo simulation (e.g. binomial, Poisson, hypergeometric, exponential, gamma, beta, pert, triangular, uniform, normal, log-normal distribution, etc.). A good understanding of probability distributions can be obtained in Murray *et al.* (2004)

Description of tool use

PopTools is an add-in for Microsoft Excel. PopTools helps with the analysis of matrix population *models* and the simulation of stochastic (random) processes. It adds more than 100 new worksheet functions to Excel, including the ability to generate random variables in different distributions without knowledge of programming. PopTools has four main functions:

1. Matrix tools: used for the analysis of population dynamics and life-history strategies.

2. Tools for stochastic processes, including generation of random variables in a variety of distributions. It includes statistics for random (stochastic) processes.

3. Simulation: models can be constructed to represent both random and predetermined (deterministic) processes.

4. Statistical and graphical processes.

Experience and expertise required to use the tool

PopTools requires no knowledge of programming and is easy to use. However, the results of the analyses and the selection of appropriate statistical analyses require some existing knowledge of probability and statistics.

Data requirements

Depends on the probability distribution you have selected, and what question you want answered (see example in Table XI).

Example of using binomial distributions in PopTools

If we have five animals ($n = 5$), with a 10% *prevalence* ($p = 0.1$) of disease y, calculate the number of test positives (x) you are likely to get.

This is a simple scenario that will demonstrate how PopTools in Microsoft Excel can be used to generate an answer.

Strengths and weaknesses, when to use and interpret with caution

PopTools is a powerful tool and a great resource for those who cannot afford the program @Risk. Unfortunately, few resources exist to assist with learning how the programme works, and so becoming a competent user can take some initial trial and error, though familiarity with other modelling programmes such as MARK (http://warnercnr.colostate.edu/~gwhite/mark/mark.htm) will speed the learning process. Occasionally, when running simulations, PopTools can be slow, particularly when running on a Windows-based PC with a slow processor.

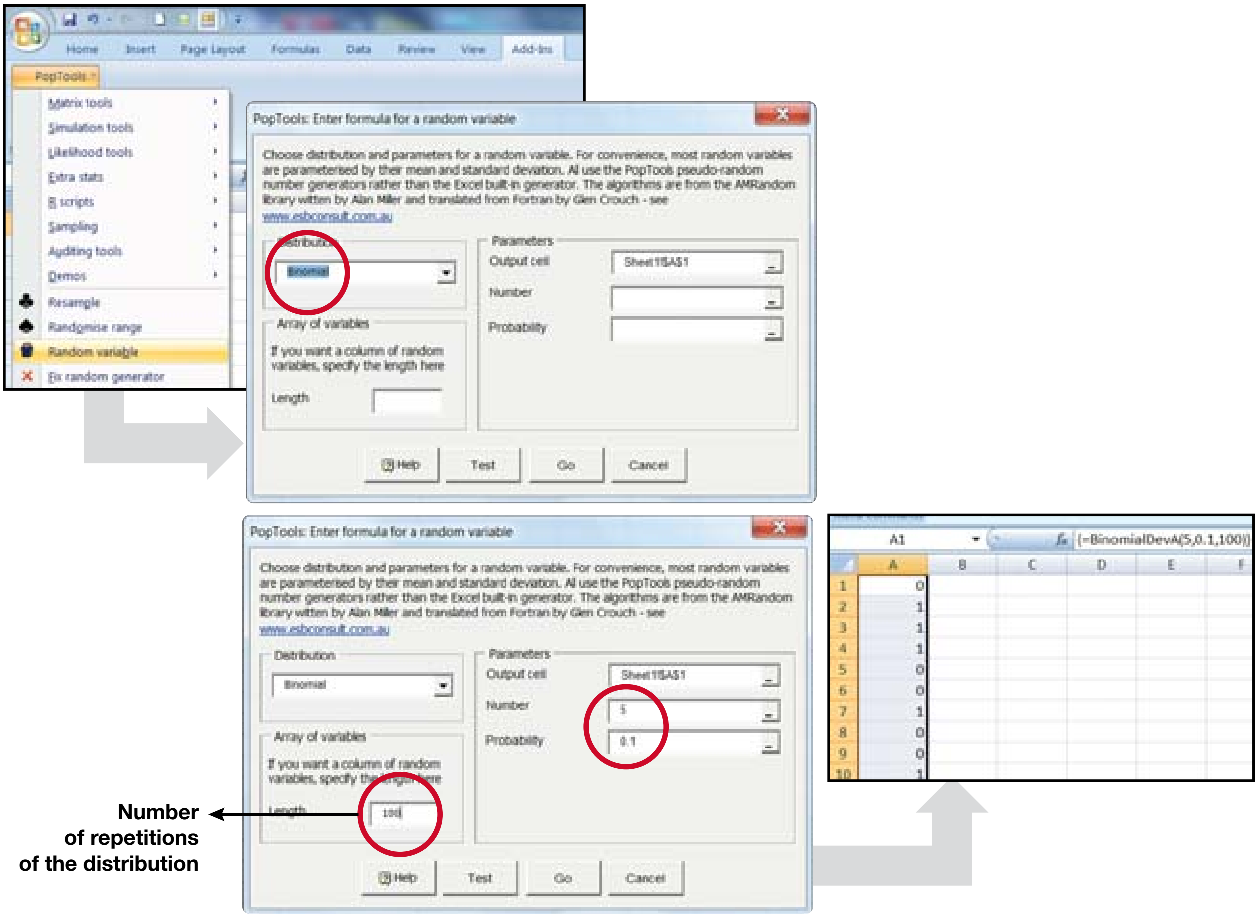
Case studies

More than 600 peer-reviewed references are listed at www.poptools.org/papers_all/, for example: Vose 2000; Murata *et al.* 2003; Murray *et al.* 2004; Budke *et al.* 2005; Di Stefano *et al.* 2007; Davis 2008; Hood *et al.* 2009.

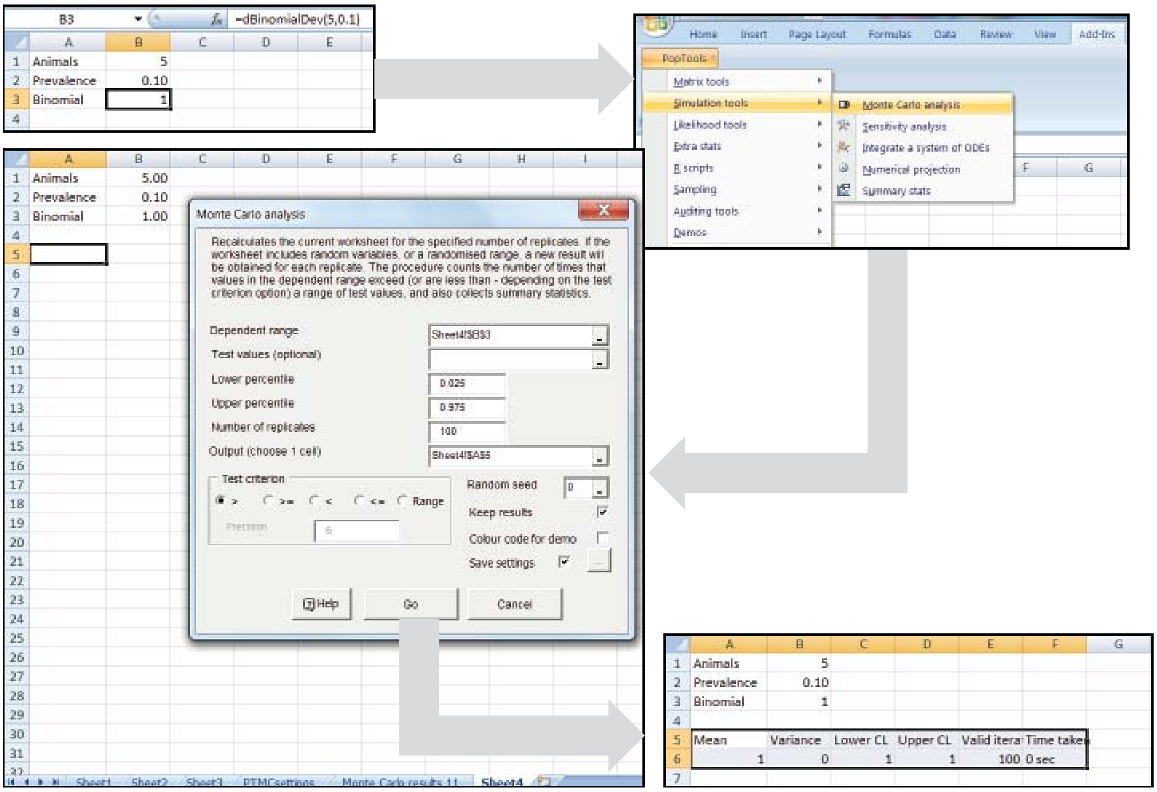
Table XI
Summary of probability distributions selected for modelling data

Probability distribution	Models for	Data required	Examples
Binomial	Successes (x)	n p	x = Binomial (n,p)
Beta	Probability of success (p)	n x	p = Beta (x + 1, n – x + 1)
Negative binomial	No. of trials (n)	x p	n = x + Negative binomial (x,p)

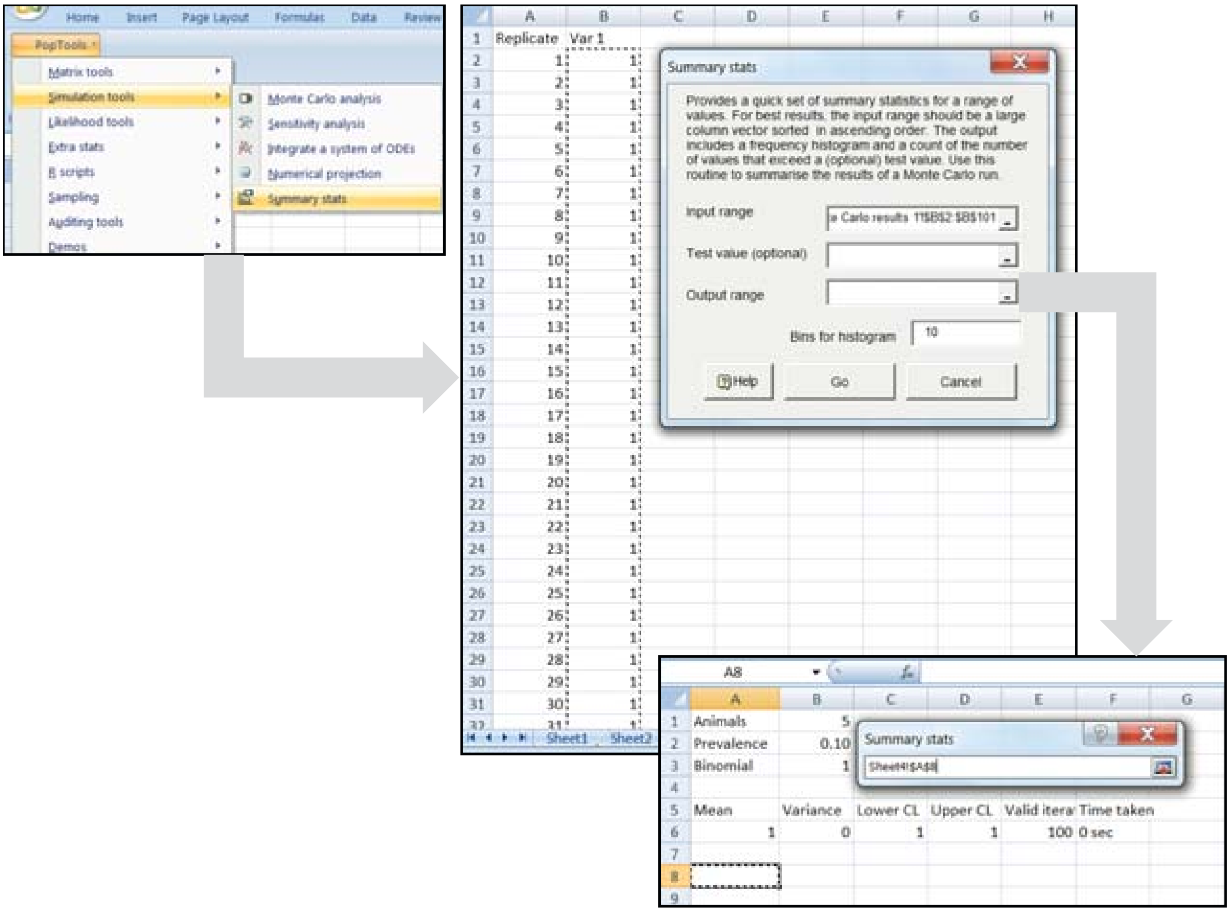
n= No. of trials; *p*= Probability of success; *x* = Successes



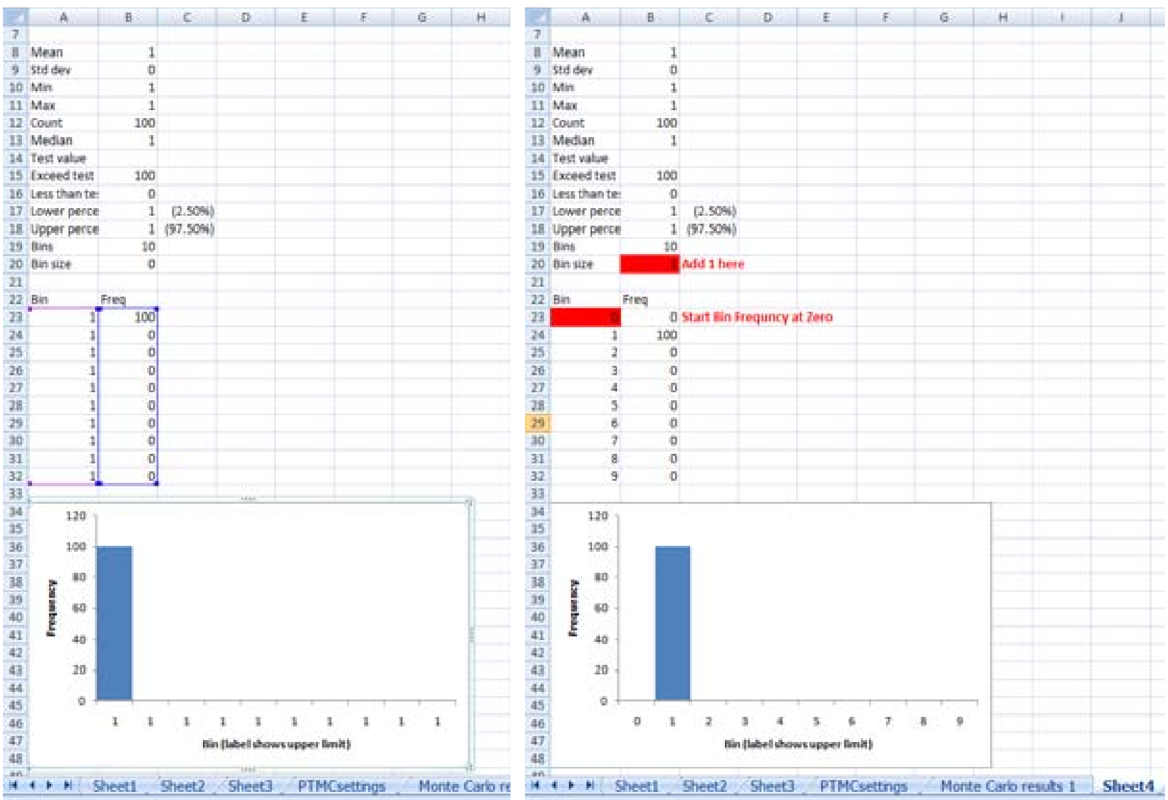
Binomial distribution in PopTools



Monte Carlo simulation with binomial distribution in PopTools



Monte Carlo simulation with binomial distribution in PopTools



Summary statistics of Monte Carlo simulation with binomial distribution in PopTools

Tool 17: Formal elicitation of expert opinion

S.C. MacDiarmid

In the *wildlife* conservation arena, expert opinion is most often sought on an informal basis. However there are times when a more formal approach is warranted. The following was developed for the Food and Agriculture Organization of the United nations (FAO) as a tool for eliciting the best expert judgements for numerical inputs. It avoids the process being dominated by a particular point of view and allows the combination of different experts' opinions into one probability distribution.

References

Vose 2000; Murray *et al.* 2004.

Source

Murray *et al.* (2004) and Vose (2000) provide instruction on the process of developing probability distributions through the elicitation and combination of expert opinion.

Cost

Completely dependent on circumstance and likely to be high.

Software requirements

In situations in which expert opinion is used to derive quantitative inputs, @Risk (Palisade Corporation) and Excel (Microsoft) are required (Gallagher *et al.* 2002).

Stage(s) of risk analysis when this would be used

In situations in which there is a paucity or absence of data, a subjective approach utilising expert opinion is appropriate in determining the probability distributions to be used as inputs into a *risk assessment*. The probabilities derived from elicitation of expert opinion may be quantitative (for example as in Gallagher *et al.* 2002) or qualitative (as in Gale *et al.* 2010).

Description of tool use

Elicitation and combination of expert opinion to generate inputs for a *risk assessment* are best conducted through a workshop approach using a modified Delphi process (Murray *et al.* 2004).

Murray and colleagues (2004) consider that 20 is the maximum number of experts that can be managed appropriately in a workshop. The choice of experts is crucial and each should be selected impartially through a consultative process based on their knowledge of the given subject. Experts should be selected from a variety of disciplines appropriate to the subject under consideration. It may be useful, however, to include subsidiary experts who do not necessarily have quite the same degree of expertise as the core group. Subsidiary experts may provide extreme values in their estimates, which can be used to generate discussion and provide evidence of overconfidence, overestimation or underestimation. Discussion of these extreme values can be used to reduce biases and obtain more accurate estimates from the second questionnaire (see below). It may be considered that it is not appropriate to include the estimates of subsidiary experts in the final analysis; such a decision should be made prior to the workshop.

The workshop method is conducted as follows[6]:

Introduction

- Explain the background to the project and aims of the workshop.
- Briefly introduce the discipline of *risk analysis* and the use of expert opinion and probability theory.
- Explain the questions to be asked, the definitions used in the questions and the assumptions made.

Conditioning the experts

- Explain the importance of accurate estimates, emphasising that this is an elicitation of opinion, not a test of knowledge.
- Provide in an easily understood format any data that may be available that is associated with the question(s) being asked.

Questionnaire 1

- Prior to the workshop, conduct a pilot questionnaire with a different group of individuals to ensure that each question is clear and to gauge how long it will take to answer.
- Ensure that the questionnaire is clear, easy to understand and not too long. Where possible, break the questions down into parts.
- Allow the questionnaire to be answered individually and anonymously.
- Ask the experts to provide estimates for the maximum and minimum values followed by a most likely value for each question. Asking for estimates in this order reduces anchoring bias.
- Ask the experts to provide percentage estimates rather than probabilities because percentages are conceptually easier to estimate.

6 Adapted with permission of the World Organisation for Animal Health (OIE) from Murray N., MacDiarmid S.C., Wooldridge M., Gummow B., Morley R.S., Weber S.E., Giovannini A. & Wilson D. (2004). – Handbook on import risk analysis for animal and animal products, Volume 2. Quantitative risk assessment. World Organisation for Animal Health (OIE), Paris. 126 pp.

– Provide aids such as computer software, graph paper or pie charts to help experts visualise percentages.
– Allow enough time during the workshop to complete the questionnaire.

Analysis 1

– Produce PERT (Beta-PERT) distributions (See Appendix 4, p. 103: Monte Carol modelling) to describe each expert's *uncertainty* around each question using the minimum, most likely and maximum values elicited.
– Combine the distributions from each expert regarding a particular question using a discrete distribution, appropriately weighted (if necessary) for each expert.

Results 1 and discussion

– Use a facilitator to ensure that all experts are included equally in the discussion so as to allow a free exchange of information between them.
– Discuss the combined distribution for each question in turn.

Questionnaire 2

Present the questionnaire to the experts again, ideally the next day, to allow them to amend their previous answers, if they consider it appropriate.

Analysis 2

– Analyse the answers to Questionnaire 2 as described for Questionnaire 1.
– Depending on what was decided before the start of the workshop, answers from subsidiary experts may or may not be included.

Results 2

– Provide the experts with preliminary results as soon as possible after the workshop and send out a validation questionnaire to ensure that results are reproducible.
– Provide the experts with the final results as soon as possible.
– Invite feedback on the usefulness of the results and the process itself.

Experience and expertise required to use the tool

A high degree of expertise is required in the formal elicitation of expert opinion. When quantitative inputs are derived from expert opinion, experience in their appropriate use and interpretation of probability distributions is essential.

Data requirements

Elicitation of expert opinion is used where there is a paucity or absence of data (Vose 2000).

Strengths and weaknesses, when to use and interpret with caution

Potential sources of bias and dealing with disagreement among experts need to be considered carefully (Murray *et al.* 2004).

Bias

A person's estimate of a distribution's parameters may be biased by a number of factors. People tend to:

– weight information that comes readily to mind
– be strongly influenced by small, unrepresentative sets of data with which they are familiar.

They may:

– be overconfident and estimate *uncertainty* too narrowly
– resist changing their mind in the face of new information
– try to influence decisions and outcomes by casting their beliefs in a particular direction
– state their beliefs in a way that favours their own performance or status
– knowingly suppress *uncertainty* in order to appear knowledgeable
– persist in stating weakening views simply to remain consistent over time.

Expert disagreement

In cases of expert disagreement, it is usually best to explore the implications of the judgements of different experts separately to determine whether substantially different conclusions are likely. If the conclusions are not significantly affected, one can conclude that the results are *robust* despite the disagreement among experts. In some cases, experts may not disagree about the body of knowledge; rather, they may draw different inferences from an agreed body of knowledge. In such cases one needs to make a judgement about which expert is more authoritative for the problem under scrutiny.

Choice of probability distribution

The PERT (Beta-PERT) distribution is used most commonly when eliciting quantitative estimates from experts (see Gallagher *et al.* 2002) although other distributions such as the uniform, general, cumulative or discrete may sometimes be used (Vose 2000; Murray *et al.* 2004). The uniform distribution is used in situations where experts are unable to propose a 'most likely' value but will propose a minimum and a maximum value. However, the uniform distribution is a very poor modeller of expert opinion and should be avoided if possible. It is very unlikely that an expert will be able to define a maximum and minimum value but have no opinion on a most likely value (Vose 2000). Individual PERT (Beta-PERT) distributions elicited from each expert are combined in a discrete distribution to produce the input value for each variable in the *risk assessment model* (Vose 2000; Gallagher *et al.* 2002).

Case studies

Gallagher 2002; Gale *et al.* 2010.

● Tool 18: Netica

M. van Andel

References

Dambacher *et al.* 2007; Walshe and Burgman 2009.

Source

www.norsys.com/download.html.

Cost

A limited version that can handle up to 15 decision points can be downloaded free of charge. For a version that can handle a network of larger than 15 decision points the costs are listed here: www.norsys.com/netica.html.

Software requirements

No specific requirement; Netica is a small programme that runs easily in a Windows environment.

Stage(s) of risk analysis when this would be used

Used in the *risk assessment* step and more specifically in the *risk evaluation* step.

Description of tool use

Bayesian belief nets (BBNs) describe our understanding of cause and effect. BBNs are being used more frequently in *risk assessment* with applications in public and environmental health. Like a conceptual map (see Cmap tool description), BBNs provide a graphical representation of beliefs and are based on concepts of cause and effect. BBNs can be used to describe links between actions and outcomes. In this way a series of conditional relationships can be represented.

An example of conditional probability is *diagnostic test* performance. The probability that an animal will test positive relies on the disease status of the animal. The probability that an infected animal will test positive is called the test sensitivity, and the probability that an animal that is not infected will test positive is one minus the test specificity.

A BBN consists of three elements:

– nodes representing key variables

– links that represent the cause and effect relationship between the nodes

– the probability that a node will be in a given state, given the state of the connected nodes.

Variables can be categorical (example of categorical data 0–5 deaths, 5–15 deaths above 15 deaths) or discrete (12 deaths).

Experience and expertise required to use the tool

Once the network is created elements can easily be updated and manipulated as information is received. Creation of the initial network is simple. Users of the tool do need to have an understanding of the relationships between different steps of the diagram to be able to interpret the results.

Data requirements

The probabilities of different events need to be known.

Strengths and weaknesses, when to use and interpret with caution

Incorrect probabilities entered into the programme will yield incorrect results at the end of the process. It is advisable that input values are consulted on by experts and agreed on.

BBNs cannot represent feedback loops. An example of what this means in an infectious disease setting is that the presence of *wildlife* infected with rabies may increase the *prevalence* of rabies in domestic animals and this may have the effect of increasing the *prevalence* of rabies in the *wildlife* population. This cannot be represented as a BBN. However the increase in *prevalence* in the domestic population due to the *wildlife* population can be represented as a BBN.

Case study

Pollino Carmel *et al.* 2007.

Tool 19: Precision Tree

P.S. Miller

Name: Precision Tree, a decision analysis software package for spreadsheets from Palisade, Inc.

Reference

Clemen and Reilly 2001.

Source

The software can be purchased and downloaded from Palisade's website at www.palisade.com/precisiontree/

Cost

Can be purchased as a stand-alone application or as part of Palisade's larger Decision Tools Suite. Prices can be obtained through the website.

Software requirements

Precision Tree requires a Pentium PC or higher processor, Microsoft Excel 2000 or higher, and Microsoft Windows 2000-SP4 or higher.

Stage(s) of risk analysis when this would be used

Precision Tree can be used in the *risk assessment* and *risk management* steps, where current and potential risks of disease introduction and *transmission* are evaluated across specific scenarios.

Description of tool use

Decision analysis provides a systematic method for describing problems. Taking into account the decision maker's preferences and beliefs regarding *uncertainty*, it is the process of modelling a problem situation in order to identify the decision that should be made. Decision trees, as opposed to influence diagrams, show all possible decision options and chance events with a branching structure. They proceed chronologically, left to right, showing events and decisions as they occur in time. All options, outcomes and pay-offs, along with the values and probabilities associated with them, are shown directly in the tree. There is very little ambiguity as to the possible outcomes and decisions the tree represents.

Precision Tree is an add-in to Microsoft Excel that allows the user to create influence diagrams and decision trees directly within a spreadsheet. A variety of diagram and tree nodes are available during construction, and values and probabilities are placed directly in spreadsheet cells, allowing the user to easily enter and edit decision *model* definition. Model results are used as pay-offs for each path through the decision tree, with calculation of payoffs occurring in real time as node values are edited. Model output reports provide information on statistical *model* summaries, risk profiles and policy suggestions. One- and two-way sensitivity analyses are easily created, with graphical results displayed within the spreadsheet. Another component of Palisade's Decision Tools Suite, @Risk, can be linked to any decision tree to quantify the *uncertainty* throughout the *model* using probability distribution functions. Monte Carlo simulation (Appendix 4, p. 103) is then used to evaluate the range of possible outcomes associated with a given decision.

Experience and expertise required to use the tool

Users should be familiar with the use of computer simulation *models* and the basics of decision analysis theory. While the software is rather simple to use at a basic level, expertise in the relevant biological and statistical fields is strongly recommended for proper use of the tool.

Data requirements

This is highly specific to the question being asked as part of the *risk assessment*. For a proper decision analysis, data on both the biological characteristics of the problem, as well as auxiliary factors that define the larger system (e.g. economic cost, impacts on other species, etc.) must be available in order to properly define and calculate pay-offs for each candidate decision.

Strengths and weaknesses, when to use and interpret with caution

Decision trees are designed to show a given decision problem in great detail, whereas influence diagrams are simplified depictions of the problem. This is both a strength and a weakness of the decision tree approach, as complex problems with many alternative decision pathways can very rapidly become difficult to view and properly interpret. As with any type of modelling tool, the accuracy of any specific outcome (decision) is greatly influenced by the detail of the information used as model input. However, if the overall decision analysis structure is *robust*, the relative value of a given decision is usually quite reliable.

Case study

Murayama *et al*. 2006.

Tool 20: Vortex

P.S. Miller

Name: Vortex, a stochastic simulation of the *wildlife* population extinction process.

Reference

Lacy R.C., Borbat M. & Pollak J.P. (2005). – Vortex: A Stochastic Simulation of the Extinction Process. Version 9.50. Chicago Zoological Society, Brookfield, Illinois.

Source

See www.vortex9.org for full details on the software, and to download an installation package.

Cost

Vortex is available to download at no cost from www. vortex9.org

Software requirements

Personal computer running Microsoft Windows 95, 98, 2000, NT 4.0 or XP, with at least 128MB of RAM.

Stage(s) of risk analysis when this would be used

Vortex can be used in the *risk assessment* and *risk management* steps, where current and potential risks of disease introduction and *transmission* are evaluated across specific scenarios.

Description of tool use

Vortex is an individual-based simulation model for population viability analysis (see Fig. 29 for an example data input interface and Fig. 30 for an example output screen). The package models population dynamics as discrete, sequential events (e.g. births, deaths, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modelled as constants or as random variables that follow specified distributions. Vortex simulates a population by stepping through a series of events that describe the typical life cycle of sexually reproducing, diploid organisms. The programme was written originally to model mammalian and avian populations, but its capabilities have improved so that it can now be used for modelling some reptiles and amphibians and perhaps could be used for fish, invertebrates or even plants, if they have relatively low fecundity or could be modelled as if they do.

In addition to single-population analysis, Vortex has the capacity to analyse complex metapopulation dynamics with dispersal among subpopulations. In addition, Vortex models loss of genetic variation in populations by simulating the *transmission* of alleles from parents to offspring at a hypothetical genetic locus. In this way, the demographic impacts of inbreeding depression can be included where appropriate. Density dependence in reproduction or mortality can be explicitly modelled, and management actions in the form of harvest, supplementation and translocation are included as well. Demographic parameters can be specified with greater complexity and specificity through the use of a built-in flexible mathematical function editor.

Multiple scenarios can be created within a single modelling project, allowing the user to quickly and easily create and review alternative *models* representing different management strategies, etc. Tabular and graphical output is available for a wide variety of model results, including population extinction risk, population abundance, mean or median time to extinction, mean inbreeding coefficient, population gene diversity (heterozygosity) and final population size. All input and output information for a set of analyses is stored within a project file, simplifying the process of scenario organisation.

As with other generic demographic modelling packages, disease is treated rather simply in Vortex, i.e. as a catastrophic event that is either totally absent or present and significantly affecting the population. The program's function capability allows for somewhat greater realism in modelling disease, but *epidemics* are not simulated as emergent events based on the underlying epidemiology of the disease. For greater realism in modelling disease dynamics, Vortex can now be physically linked to a disease dynamics *model* such as *OUTBREAK* (see p. 78) to create a metamodel, offering considerably greater realism.

Experience and expertise required to use the tool

Responsible Vortex users should have a thorough understanding of population demography and statistical methods for data analysis. The data input process is highly explicit, simplifying somewhat the process of analysing field data for use in the *model*.

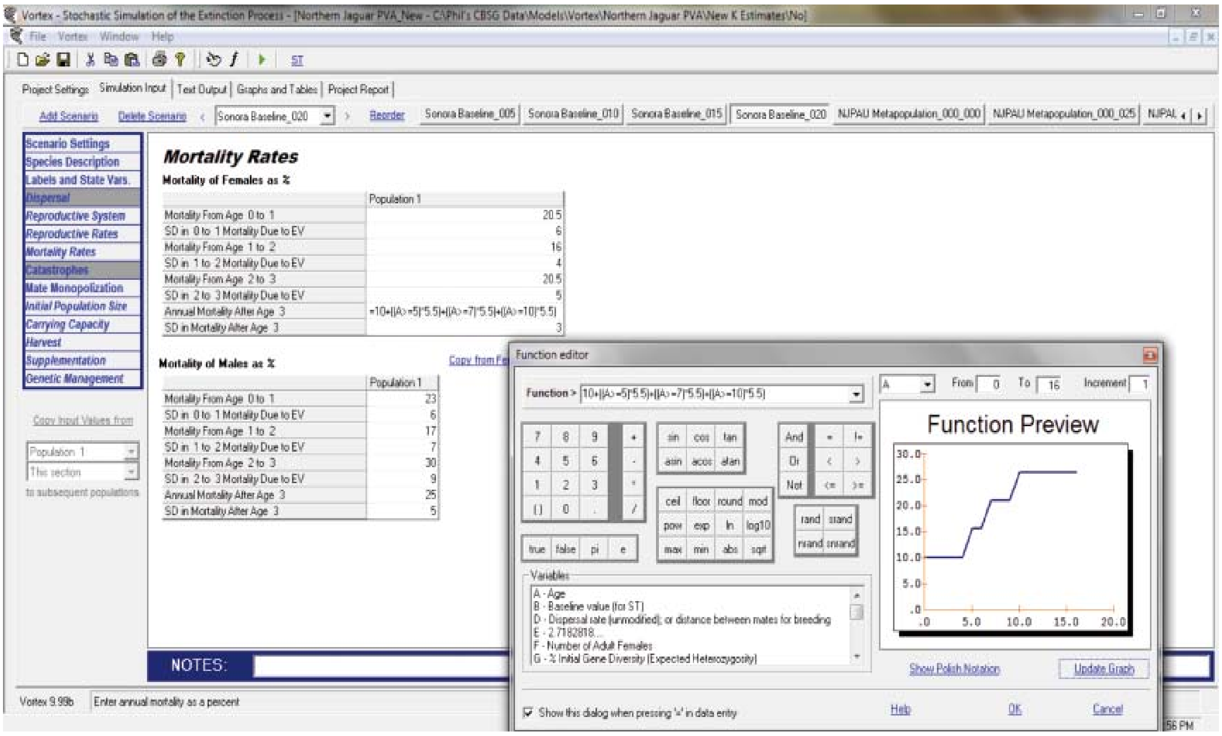


Fig. 29
Sample input screen in the Vortex simulation package, showing use of function editor interface

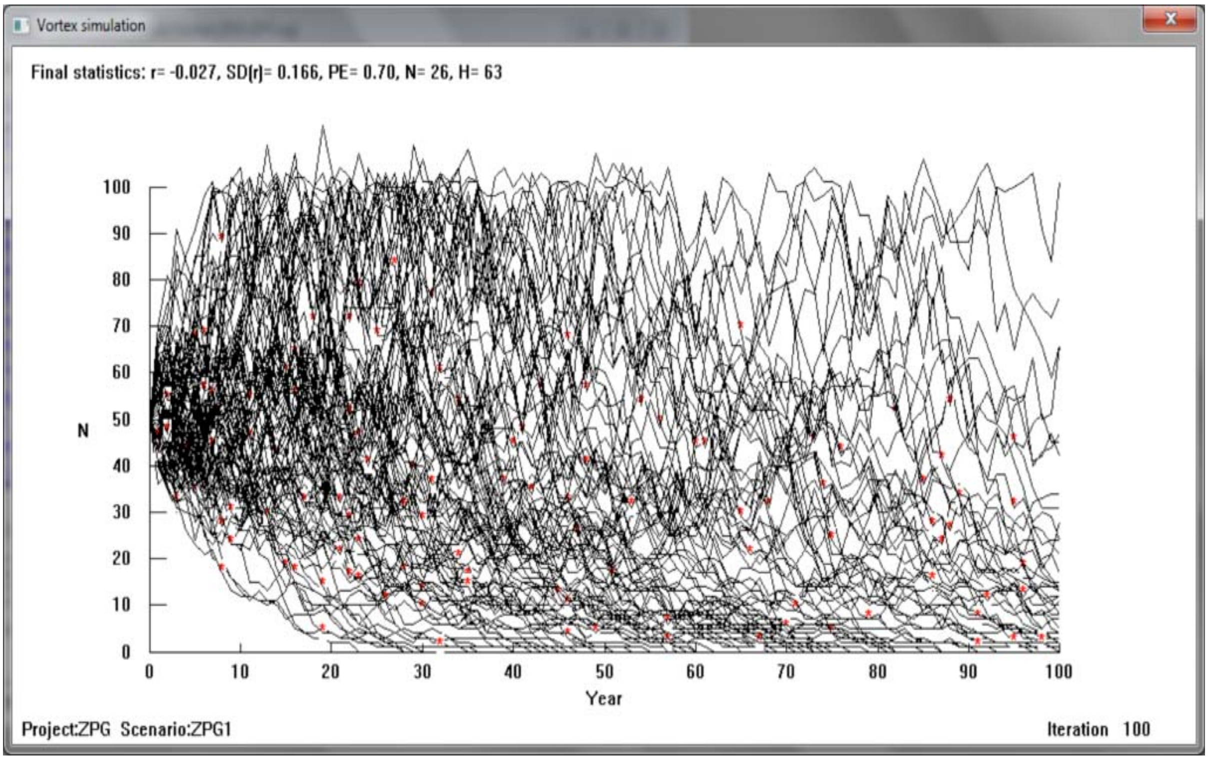


Fig. 30
Sample output from a simulation using Vortex

Nevertheless, careful attention to model structure and input is critical to developing a realistic and useful *model* for management decision making.

Data requirements

Realistic *models* of population demographic dynamics require considerable knowledge of population demographic rates (both mean and variance over time), and the ecological factors that affect them.

Strengths and weaknesses, when to use and interpret with caution

Since Vortex is an individual-based *model*, it is very useful for understanding and predicting the demographic dynamics of small populations that are subject to random fluctuations in birth and death rates brought about by environmental *variability*, etc. In the same way, the software can be very helpful for studying disease dynamics in *wildlife* populations, especially in a metapopulation context and when linked to an explicit disease *model* such as OUTBREAK. This same characteristic makes it unsuitable for studying large populations of *wildlife* (e.g. more than 30,000 individuals). As with any modelling package, specific interpretation of simulation output is a direct function of the accuracy and realism of the input parameters.

Case study

Bradshaw *et al*. 2012.

Tool 21: RAMAS

P.S. Miller

Name: RAMAS, viability analysis for stage-structured metapopulations

Reference

Akçakaya H.R. (2005). – RAMAS Metapop: Viability Analysis for Stage-Structured Metapopulations. Version 5. Applied Biomathematics, Setauket, New York.

Source

See www.ramas.com/ramas.htm for detailed descriptions of the software. The programme can be ordered from Applied Biomathematics, 100 North Country Road, Setauket, New York.

Cost

RAMAS Metapop – reduced student prices are offered for this and the RAMAS GIS application. See the website above for current prices and licence conditions.

Software requirements

IBM-compatible personal computer, running Microsoft Windows 95, 98, 2000, NT 4.0 or XP, with 30 megabytes of free hard disk space.

Stage(s) of risk analysis when this would be used

RAMAS can be used in the *risk assessment* and *risk management* steps, where current and potential risks of disease introduction and *transmission* are evaluated across specific scenarios.

Description of tool use

RAMAS Metapop is an interactive programme that allows the user to build matrix-based population demographic *models* for species that live in multiple patches. It incorporates the spatial aspects of metapopulation dynamics, such as the configuration of the populations, dispersal and recolonisation among patches and similarity of environmental patterns experienced by the populations. The programme can be used to predict extinction risks and explore management options such as reserve design, translocations and reintroductions, and to assess the impact of humans on fragmented populations. Features of RAMAS Metapop include age or stage structure for each population, random variation and temporal trend in vital rates (survivorships, fecundities) and carrying capacities of populations, several types of density dependence, age- or stage-specific dispersal rates and catastrophes. The programme produces a variety of output metrics for each *model*, including risk of population extinction or decline, median time to extinction, expected minimum abundance, metapopulation occupancy through time, and histograms of abundance at each time step for each life-history stage that is part of the *model*.

RAMAS GIS is designed to link a GIS with a metapopulation *model* for population viability analysis and extinction *risk assessment*. The software imports spatial data on ecological requirements of a species and creates a habitat suitability map with a user-defined functional *model*. The software then uses the habitat suitability map to find suitable habitat patches on the landscape and then combines the spatial information on the metapopulation with user-defined ecological parameters of the species to create a functional metapopulation *model* that is evaluated using the built-in RAMAS Metapop package.

As is typical for most generic population viability analysis packages, disease in animal populations is treated rather abstractly in RAMAS, usually as a catastrophic event that has a significant impact on the population(s) of interest when present but is otherwise absent from the environment. If a metapopulation structure is part of the model, RAMAS has a 'spreading catastrophe' feature that could simulate movement of the disease from one subpopulation to another via dispersing individuals.

Experience and expertise required to use the tool

Because of its flexible approach to model definition and construction, RAMAS users must be well versed in the fields of demographic data analysis, age- and stage-based population growth matrix theory, and statistical interpretation of population data. Navigation through the software is intuitive, but input and output data file management can be a bit cumbersome.

Data requirements

Realistic *models* of population demographic dynamics require considerable knowledge of population demographic rates (both mean and variance over time), and the ecological factors that affect them.

Strengths and weaknesses, when to use and interpret with caution

RAMAS is a very flexible package for analysing the viability of populations, suitable for animals, plants or insects. It is a population-based *model*, allowing the user to study very large populations without computational limitations. On the other hand, its flexible matrix-based approach requires the user to have a more advanced knowledge of population demographic processes and data analysis than with some other population viability analysis software packages. Its treatment of disease is comparatively implicit, but with expertise and care RAMAS can provide useful insights into the impacts of disease processes on animal populations (with its application to plants less well defined). As with any modelling package, specific interpretation of simulation output is a direct function of the accuracy and realism of the input parameters.

Case study

Akçakaya and Atwood 1997. (Does not include disease, but demonstrates the general use of RAMAS in population viability modelling.)

Tool 22: Risk communication plan template

R.M. Jakob-Hoff

Name: Risk communication plan template.

Reference

Modified from Armstrong *et al.* 2003.

Source

As above.

Cost

Free – reproduced as Table XII, below.

Software requirements

Can be used with pen and paper or with Microsoft Word or Microsoft Excel.

Stage(s) of risk analysis when this would be used

Risk communication.

Description of tool use

The information captured within this template (Table XII, p. 92) should be gathered at the beginning of the DRA process and reviewed frequently as the DRA progresses. The template is designed to capture essential information on the stakeholders, experts and decision makers for a specific *wildlife* DRA. This tool is designed to be used in consultation with these individuals to establish their information needs and preferred methods and frequency of communication. The template can readily be modified to include full names and contact details of each person listed and to accommodate additional or alternative communication needs.

Experience and expertise required to use the tool

No specialised expertise required

Data requirements

Names and contact details of DRA participants and contributors, their information needs and preferred methods and frequency of communication.

Table XII
Risk communication plan template

Group	Stakeholder name	Information needs	Communication method(s)	Frequency	Contact details
Stakeholders					
Experts					
Decision makers					

Strengths and weaknesses, when to use and interpret with caution

This is a simple and easily modified template. Its main value is in prompting for the capture of the most basic information needed to enable effective communication among DRA stakeholders, experts and decision makers. An individual must be assigned responsibility to capture this information and to maintain and frequently review the communication plan to ensure that it remains current.

Case studies

See the example in Table III in the 'Risk communication' section of this *Manual*.

Appendices

Appendix 1
Sources of information for wildlife disease risk analysis[7]

R.M. Jakob-Hoff and S.C. MacDiarmid

Information to assist in identifying hazards, assessing likelihoods of release, exposure and consequences and exploring options to manage risk can be found in a variety of sources including scientific journals, textbooks and websites devoted to diseases of *wildlife* and zoo animals, aquatic animals and livestock. Specific examples are:

Key textbooks

Friend M. (2006). – Disease emergence and resurgence: the wildlife–human connection. Circular 1285, US Department of the Interior and US Geological Survey, Washington, District of Columbia.

Hudson P.J., Rizzoli A., Grenfell B.T., Heesterbeek H. & Dobson P. (eds) (2006). – The ecology of wildlife diseases. Oxford University Press, Oxford, United Kingdom.

Kaner S., Lind L., Toldi C., Fisk S. & Berger D. (2007). – Facilitator's guide to participatory decision making. 2nd Ed. Jossey-Bass, San Francisco, California.

Ostfield R.S., Keesing F. & Eviner V.T. (eds) (2008). – Infectious disease ecology: effects of ecosystems on disease and of disease on ecosystems, Princeton University Press, Princeton, New Jersey.

Salman M.D (ed.) (2003). – Animal disease surveillance and survey systems Methods and applications. Iowa State Press, Ames, Iowa.

Thrusfield M. (2007). – Veterinary epidemiology, 3rd Ed. Blackwell Publishing, Oxford, United Kingdom.

Vose A. (2008). – Risk analysis, a quantitative guide, 3rd Ed. John Wiley and Sons, Chichester, United Kingdom.

Wobeser G.A. (2006). – Essentials of disease in wild animals. Blackwell Publishing, Oxford, United Kingdom.

Wobeser G.A. (2007). – Disease in wild animals: investigation and management, 2nd Ed. Springer, Berlin.

Key journals

Journal of Zoo and Wildlife Medicine (http://zoowildlifejournal.com/)

Journal of Wildlife Diseases (www.jwildlifedis.org)

EcoHealth (www.ecohealth.net/aboutus.php)

Wildlife websites

Avian reintroduction and translocation database – Lincoln Park Zoo (www.lpzoo.org/conservation-science/projects/avian-reintroduction-and-translocation-database)

FAO Scientific Taskforce on Wildlife and Ecosystem Health (http://wildlifeandecosystemhealth.org/)

IUCN SSC Conservation Breeding Specialist Group wildlife disease risk analysis (DRA) tools (www.cbsg.org/cbsg/risk/)

IUCN SSC Invasive Species Specialist Group database (www.issg.org/database/welcome/)

IUCN SSC Reintroduction Specialist Group (www.iucnsscrsg.org)

IUCN SSC Wildlife Health Specialist Group (www.iucn-whsg.org)

OIE Working Group on Wildlife Disease (http://web.oie.int/wildlife/eng/en_wildlife.htm)

Health Risk Analysis in Wildlife Translocations (www.ccwhc.ca/wildlife_health_topics/risk_analysis/rskguidintro.php)

7 Section based on Brückner *et al.* 2010

Wildpro, the electronic encyclopaedia and library for wildlife (http://wildpro.twycrosszoo.org)

Wildlife data integration network (www.wdin.org)

Data from disease *surveillance* and *monitoring* and investigations of outbreaks (see below)

OIE website (www.oie.int/):

- official country disease status
- animal disease information sheets
- *Terrestrial Animal Health Code* (www.oie.int/international-standard-setting/terrestrial-code/)
- *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*
- *Aquatic Animal Health Code*
- *Manual of Diagnostic Tests for Aquatic Animals*
- publications and documentation including the *Scientific and Technical Review*, *World Animal Health* and the *Bulletin*
- World Animal Health Information Database (WAHID) (http://web.oie.int/wahis/public.php?page=home)

FAO/WHO Health Standards – Codex Alimentarius (www.codexalimentarius.net/web/index_en.jsp)

FAO EMPRESS (www.fao.org/ag/AGAinfo/programmes/en/empres/home.asp)

The joint FAO/OIE/WHO global early warning system for major animal diseases including *zoonosis* (GLEWS) (www.glews.net)

Emslie R.H., Amin A. and Kock R. (eds) (2009). – Guidelines for the in situ reintroduction and translocation of African and Asian rhinoceros. IUCN Species Survival Commission African Rhino Specialist Group and Asian Rhino Specialist Group and Wildlife Health Specialist Group (www.rhinoresourcecenter.com/pdf_files/123/1236876187.pdf)

IUCN/SSC African Elephant Specialist Group. Guidelines for the in situ translocation of the African elephant for conservation purposes (www.african-elephant.org/tools/trnsgden.html)

Conservation and Development Interventions at the Wildlife/Livestock Interface – Implications for Wildlife, Livestock and Human Health. To download this IUCN/SSC Occasional Paper from the Animal and Human Health for the Environment and Development (AHEAD) Program go to: www.wcs-ahead.org/wpc_launch.html.

Published wildlife disease risk analyses

One should ascertain whether or not these have been adequately peer reviewed; more weight can be given to a peer-reviewed analysis. Care must be taken to ensure that the circumstances pertaining in one situation are relevant in another.

Assistance and advice

Assistance and advice can also be sought from a variety of specialists including other *wildlife* specialists, ecologists, entomologists, climatologists, epidemiologists, veterinary pathologists, virologists, microbiologists, parasitologists, laboratory diagnosticians, livestock industry specialists, agricultural economists and field veterinarians. If it is decided to undertake a *quantitative risk analysis*, advice should probably also be sought from mathematical modellers and statisticians.

In situations in which information is scarce or lacking, a subjective approach utilising *expert opinion* is appropriate for release, exposure and *consequence assessment*s. However, care must be taken when eliciting expert opinion to avoid bias and to deal with disagreement among experts. Appropriate methods for eliciting and combining expert opinion have been described (Vose 2000; Murray *et al.* 2004). Psychological research has shown that it is hard to elicit good subjective probability judgements; bias may be introduced both by the methods used to elicit the judgements and by the means by which these are modelled. Murray and colleagues (2004) outline a modified Delphi technique that has proven useful in many situations.

Appendix 2
Surveillance, monitoring and outbreak investigations as a source of information

S.C. MacDiarmid

In general, *surveillance* is aimed at demonstrating the absence of disease or infection, determining the *prevalence* or distribution of disease or infection, or detecting new or emerging diseases as soon as possible (OIE 2010).

Surveillance is the systematic ongoing collection, collation and analysis of information related to animal health and the timely dissemination of information to those who need to know so that action can be taken. *Monitoring*, on the other hand, is the intermittent performance and analysis of routine measurements and observations, aimed at detecting changes in the environment or health status of a population. Both are valuable sources of information for *hazard identification* and *risk assessment*.

Surveillance may be carried out for a number of reasons (Thrusfield 2007; OIE 2010). Specific examples include:

– early detection of disease outbreaks

– assessment of the health status of a defined animal population

– identification of new and emerging diseases

– identification of priorities for disease control and prevention

– evaluation of disease control programmes

– confirmation of the absence of a specific disease

– gathering information on disease occurrence for research or *risk analysis* purposes.

Domestic animals and *wildlife* may be susceptible to the same diseases, but infection in one does not necessarily mean that it also present in the other. It is intrinsically more difficult to monitor diseases in *wildlife* than in domestic animals and *surveillance* for diseases in *wildlife* presents challenges that may differ significantly from those encountered in *surveillance* in domestic animals (Mörner *et al.* 2002; OIE 2010).

Disease *surveillance* may be based on many different data sources and can be classified in a number of ways (OIE 2010). For example:

– the means by which the data are collected ('active' versus 'passive' *surveillance*)

– the disease focus (*pathogen*-specific versus general *surveillance*)

– the manner in which units for observation are selected (structured surveys versus non-random data sources).

Passive *surveillance* is that based on reports of laboratory diagnosis, results of routine slaughterhouse or game packhouse inspection, statutory notification of disease, etc. The data obtained from passive *surveillance* are often biased, because they are dependent on voluntary submission of samples to laboratories, and they usually lack denominator values. Passive *surveillance* thus cannot give unbiased estimates of disease *prevalence*. However, it can be carried out at a lower cost than active *surveillance* and has the advantage that it is the first stage in identifying new and emerging diseases, which active *surveillance* cannot do, as one cannot target *surveillance* at a disease not yet identified (Thrusfield 2007).

Active, or targeted, *surveillance* collects specific information about a particular disease so that its *prevalence* in a defined animal population can be measured or its absence demonstrated. It is often planned using appropriate statistical sampling theory and commonly focuses on populations that are at increased risk of being affected by the disease under consideration, thus increasing the efficiency of detection (Thrusfield 2007; OIE 2011). However, for certain diseases likely to be present at very low *prevalence*, statistical sampling may be inappropriate because of the very large numbers that would be required to be sampled. Hugh-Jones and colleagues (2000) observed that 'Beyond a certain very small *prevalence* or risk, one must abjure statistics and use epidemiological common sense. At this point, one employs disease 'traps'. When one is poaching rabbits, one does not spread snares all over the countryside but only in those few places where the most rabbits are most likely to be running. Similarly, when one has a disease *surveillance* system that has actively watched these sites and found nothing over a reasonable period of time, the disease does not exist'.

Serological *surveillance*, or sero-*surveillance*, is the identification of patterns of current and past infection using serological (antibody) tests (Thrusfield 2007).

Surveillance may be aimed at an entire animal population in a defined area or country. However, an alternative approach may be sentinel *surveillance* in which attention is restricted to certain species that act as 'sentinels' for a much broader population. For example, eastern equine encephalitis is a mosquito-borne virus disease of horses and other vertebrates, including humans, the *reservoir* of which is wild birds. A *surveillance* programme for eastern equine encephalitis may, therefore, include the regular serological testing of sentinel chickens which are kept inside but to which mosquitoes have access (Thrusfield 2007).

Specimens for disease *surveillance* in *wildlife* may be obtained from sources such as hunters and trappers, road kill, wild animal meat markets, sanitary inspection of hunted animals and game packhouses, morbidity and mortality observations by the general public, *wildlife* rehabilitation centres, *wildlife* biologists and government *wildlife* agency field personnel, farmers and other landholders, naturalists and conservationists. It may seem that a disease case collected by such passive *surveillance* represents merely a record in a laboratory database. However, such acquisitions may provide insights into the occurrence of important disease processes in wild animal populations (Mörner *et al.* 2002; OIE 2010).

Investigations into outbreaks of disease or mortalities in *wildlife* can provide useful *surveillance* data. In a discussion on *surveillance* for *wildlife* diseases, Mörner and colleagues (2002) point out that while many factors should be taken into consideration during a disease investigation, they consider it 'impossible' to prepare a comprehensive list of all the factors that should be investigated. Nevertheless, Bengis and colleagues (2002) list several techniques that can maximise the *surveillance* information gained from the investigation of disease outbreaks. Examples listed include:

– active investigation of any reports of abnormal *clinical signs*, mortalities or a sustained increase in vulture activity in a given area

– necropsies on all carcasses that become available on an *ad hoc* basis; collection of road kills or examination of hunters' kills can substantially increase the number of carcases examined

– veterinary inspections at all *wildlife*-culling operations

– veterinary supervision of protected area systems for disease *monitoring*

– veterinary examination of all animals captured for any reason including translocation, clinical assistance, fitting radio transmitters or removal of problem animals

– veterinary supervision at all wild animal holding facilities and game sales

– dedicated serological surveys.

Bengis and colleagues (2002) emphasise that in all these situations, sample collection, including body fluids, tissues and excretions should be maximised and serum samples should be banked for possible future retrospective studies.

Additional indirect *surveillance* techniques may include:

– rodent trapping for serological surveys, such as for arboviruses and cardioviruses, or for *pathogen* isolation

– *vector* trapping for distribution studies (for example, for *Glossina* spp. and *Culicoides* spp.) or virus isolation (for example, for orbiviruses and phleboviruses) and xenodiagnosis.

Appendix 3
Screening tests: selection, interpretation, and sample size calculator

B.A. Rideout

The use of screening tests to identify the presence or absence of *pathogens* is an important feature of the *disease risk analysis* process described in this volume, and a valuable tool for some of the *surveillance* techniques described in the previous appendix. There are a number of pitfalls and challenges associated with any screening effort and in a large, multidisciplinary DRA it may be useful for all contributors to have a basic knowledge of these. This appendix provides an introduction to three important areas:

– test selection

– test interpretation and use in decision making

– calculating sample sizes for pathogen screening.

Note that while the text here is intended for use by non-specialists, consultation with veterinary experts is recommended for the design, implementation and interpretation of any pathogen screening effort.

Screening test selection

In most cases, the goal of screening will be to rule out the presence of a disease agent of concern (identified in the *hazard identification* step), so that appropriately healthy animals can be selected for movement. If it has been determined that screening for the *pathogen* of concern is warranted, an appropriate test needs to be selected. Factors that determine test selection include the host species, the estimated *prevalence* of the agent in the population, the sensitivity and specificity of the test, the number of individuals to be tested, the nature of the agent, whether it causes acute or chronic disease, whether the goal is detecting exposure or active infection, the cost and availability of the test, the volume and nature of the samples needed, and the sample handling requirements (See 'Explanation of factors influencing test selection' on page 98). Table XIII lists the characteristics of the most widely available tests for animal diseases.

Before deciding on the optimum testing method, it is important to consider the host species being tested and whether the test has been validated for that species. Test validation is an important but often overlooked subject. Validation of a test ensures its accuracy (that the test will reliably identify the agent if present, will only identify that agent and will not identify the agent if it is absent). It also ensures that the test results are reproducible (the same result is produced each time a particular sample is tested) and responsive (that the positive result goes away if the agent goes away).

Unfortunately, very few tests have been validated for use in any *wildlife* species. In spite of this, the pitfalls of using an unvalidated test can be minimised by avoiding tests that are species specific. For example, many enzyme-linked immunosorbent assays (e.g. indirect antibody ELISAs) require labelled antibodies that recognise the antibodies of a specific domesticated animal species. It should *not* be assumed that such tests will work on a *wildlife* species (i.e. bind its antibodies with the same affinity and avidity) simply because it is of the same taxonomic group as the domesticated animal for which the test was developed. Some tests, such as those that directly detect the agent, do not rely on species-specific reagents and would therefore be better choices. Although conventional polymerase chain reaction (PCR) is one such test, most commercial laboratories use these tests in a species-specific way by interpreting a band of appropriate molecular weight on a gel as being a positive test result. When using conventional PCR tests in *wildlife*, it is important to confirm any positives by DNA sequencing or Southern blots of these bands. False-positive test results are common. Non-species-specific tests are listed in Table XIII, and should be preferred options.

Table XIII
Intrinsic (analytical) characteristics of tests

Serological (antibody) tests	Usefulness in wildlife	Sensitivity
Competitive inhibition ELISA	High	High
Protein A or G ELISA	High	Moderate
Virus neutralisation	High	Moderate
Haemagglutination inhibition	High	Moderate
Complement fixation	High	Moderate
Agar gel immunodiffusion	High	Low
Direct immunofluorescence	High	Moderate
Indirect antibody ELISA	Low	High
Indirect immunofluorescence	Low	High
Western blot	Low	Moderate
Agent or antigen detection tests		
TaqMan/real-time PCR	High	High
Bacterial or fungal culture	High	Moderate
Virus isolation	High	Moderate
Necropsy/biopsy/cytology	High	Variable
Conventional PCR for agent DNA	High*	High
Conventional PCR for agent RNA	High*	High
Direct antigen capture ELISA	Moderate	High

*If positive results confirmed

The sensitivity of a test refers to its ability to correctly identify the agent when it is present. Since the goal in most cases will be ruling out the presence of a disease agent of concern, choosing a test with the highest possible sensitivity is important. However, since the test sensitivity is seldom available, a practical alternative is to choose a testing method with a high intrinsic (or potential) sensitivity, such as PCR or a non-species-specific ELISA. Running two different tests in parallel will also increase the sensitivity.

It is also important to choose a laboratory with appropriate experience with the testing methods and the species being tested. Ideally, the laboratory staff should have experience in developing and validating tests, understand the pitfalls of applying tests to new species and settings, and have a willingness to work collaboratively to maximise the value of the testing.

Screening test selection can be viewed as a multi-step process:

1. Based on the nature of the agent of concern, determine whether it is best detected directly (e.g. by PCR or culture) or indirectly by measuring the host's immunological response to the agent (e.g. an antibody test for an agent that causes life-long infections).

2. Based on the number of animals to be tested and the sample handling requirements, identify the most sensitive, logistically feasible and cost-effective test available. If little is known of the sensitivity of the specific test, choose a method with high intrinsic sensitivity and consider running two different tests in parallel to maximise sensitivity.

3. Based on the host species to be tested, identify the most appropriate validated test, or one that is not species specific.

4. See 'Test interpretation and using test results for decision making' on p. 99.

Case study

A group of three juvenile California condors (*Gymnogyps californianus*) was scheduled to be transferred from a breeding facility in southern California, United States, to a release site in Baja California, Mexico. The birds were required to be test negative for highly pathogenic H5 and H7 avian influenza within 30 days of transfer. We were asked to test the birds for antibodies to H5 and H7 avian influenza types by agar gel immunodiffusion (AGID).

At the time of the testing request, the United States was declared free from highly pathogenic avian influenza, so *pathogen prevalence* was expected to be zero. Based on the nature of the agent and host, we would expect any *subclinical infection*s to have been cleared within 2–3 weeks but for antibody titres to persist for an unknown but potentially lengthy period. Because of this, the best choice of test would be one that detects only active infection, has the highest possible specificity (to minimise false positives), and is not species specific.

Although AGID is a non-species-specific test, it is a poor choice in this situation because it is an antibody test with the potential to detect past exposure to a low *pathogenicity* H5 or H7 avian influenza strain, resulting in a positive test and an erroneous interpretation that the bird has an active infection with a high *pathogenicity* avian influenza strain. Because of this concern, we were allowed to use a real-time PCR assay specific for highly pathogenic H5 and H7 avian influenza strains instead. Real-time PCR is also a non-species-specific test and has the advantages of only detecting active infection and being more sensitive and specific than AGID. Although real-time PCR assays are expensive, this test method was still the most cost-effective available because the number of birds involved was small and the consequences of a false positive were significant. The plan called for confirmation of any positive tests by virus isolation. All birds were test negative for H5 and H7 by real-time PCR and were transferred successfully.

Explanation of factors influencing test selection

Host species
If the host species is a domesticated animal, a validated species-appropriate test should be selected. If the host is a *wildlife* species, there are very few validated tests available, so a test with low species specificity should be selected (see Table XIII). If the host species is CITES[8] listed or sample movements are otherwise regulated, tests that are readily available in country might be preferred.

Agent prevalence
If the *prevalence* of the agent is expected to be low in the population, the most sensitive test available should be selected to increase the probability of detection. However, when *prevalence* is low, the probability of false-positive test results increases dramatically. As a result, any positive tests should be followed with a confirmation test that has the highest possible specificity (and is therefore different from the *screening test*). When agent *prevalence* is high in a population, a test with the highest possible specificity should be chosen to increase the probability of correctly identifying the uninfected individuals. However, when *prevalence* is high, the probability of false negatives increases dramatically (see, for example, case scenario 2 in the test interpretation tool). As a result,

8 Convention on International Trade in Endangered Species of Wild Fauna and Flora.

long *quarantine* periods and repeated testing might be required to ensure that an individual is free of the agent. See the test interpretation tool for additional discussion of this topic.

Sensitivity and specificity
Sensitivity refers to the ability of a test to correctly identify the presence of the agent, while specificity refers to the ability to correctly identify the absence of the agent. When sensitivity is high, there will be fewer false negatives. When specificity is high, there will be fewer false positives. While these test characteristics are important, they are seldom available for any given test. Because the goal of screening in most cases will be to rule out the presence of the agent, we will generally want to maximise sensitivity (thereby minimising the possibility of a false negative). Even if the sensitivity of the available tests is unknown, certain test types have higher intrinsic sensitivity (see Table XIII), which will make them preferred choices for screening purposes. In addition, the available sensitivity for any testing scenario can be maximised by running two different tests simultaneously.

Number of individuals to be tested
If the population is large and the agent *prevalence* is expected to be low, a large number of individuals will need to be tested to ensure the absence of the agent. In this situation, the cost and sample handling requirements become increasingly important. See the sample size calculation tool for additional discussion of this topic.

The nature of the agent
Agents that are present in very low numbers in the host or have the capability of causing latent or slowly progressive infections are inherently more difficult to detect and therefore require more complex screening strategies. Certain agents may be difficult to detect because they are labile (e.g. RNA viruses can be rapidly degraded by RNases if samples are not carefully handled using RNA preservation protocols), or because they are difficult to isolate. Tests need to be chosen carefully based on the agent characteristics in order to optimise the chances of detection. Consultation with professionals in the chosen laboratory, or other experts, is recommended.

Detecting exposure versus active infection
In cases where the agent of concern causes latent or chronic infections, detecting exposure might be a practical alternative to detecting infection (because exposure is nearly synonymous with infection). In most other situations (e.g. agents causing acute infections with relatively short *incubation periods*), the goal will be to detect active infection. Test selection will obviously differ in these two scenarios.

Cost and availability of the tests
Cost and availability of tests become obvious matters of concern with increasing sample numbers and more remote geographic locations.

Samples and handling
The size and nature of the host species might limit the availability of certain types of samples (e.g. blood samples), and the geographic location or skill of the operators may limit the complexity of sample handling that can be accommodated. Table XIII can aid with test selection in these situations.

Note
Analytical sensitivity reflects the potential performance of a test in ideal circumstances and may not necessarily reflect the actual diagnostic sensitivity in real-world scenarios. Table XIII can be a starting point for test selection, but consultation with experts is highly recommended.

Test interpretation and using test results for decision making

Diagnostic or *screening test*s should be used in *risk assessment*s only if the results will contribute to decision making. Testing for the sake of curiosity only causes confusion and *uncertainty* in the *risk assessment* process. Any decisions that will be based on test results should be determined in advance through careful planning, with an understanding of how tests perform in real-world situations. When it comes to test performance, there is a widespread misperception that laboratory test results are always reliable, particularly when they provide a concrete answer such as ‘positive’ or ‘negative’. In order to properly interpret a test result and use it for decision making, we need to understand some basic principles of test performance.

Test refers to the ability of a test to correctly identify the presence of a disease agent, while **specificity** refers to the ability to confirm the absence of an agent. As important as these test parameters sound, they have little practical value when it comes to interpreting test results or using results for decision making. We seldom know the sensitivity or specificity of a test, and, if we did, those values would only be relevant to the extent that our test population exactly matches the study population on which those values were originally calculated. More importantly, sensitivity and specificity are essentially fixed characteristics of a test and do not help us understand variations in test performance. The more practical parameter is the *predictive value* of a test, which tells us the probability that a result is correct. In most real-world situations, when we receive a test result what we really need to know is whether or not the result is true, because we will be making important decisions based on that result. The positive *predictive value* gives us the probability that a positive test result is true, while the negative *predictive value* gives us the probability of a negative result being true.

Unfortunately, calculating the actual *predictive value* requires not only knowledge of the sensitivity and specificity of the test but knowledge of the *prevalence* of the agent in the population as well (see Example 1 below for a *predictive value* calculation). Although we will seldom have the data needed to calculate the *predictive value*, we can use some basic principles of test performance to generate simple rules for estimating *predictive value*. The estimated *predictive value*s can then be used as a guide for interpreting test results and making decisions.

The simple rules we are about to develop are based on a qualitative estimate of the *prevalence* of an agent in the population being tested (low, medium or high *prevalence*). Even with a highly sensitive and specific test, when agent *prevalence* is low the positive *predictive value* will also be low. This means that any positive test result will have a high probability of being a false positive. Because of that, when *prevalence* is low we need to be suspicious of any positive test results and have a plan in place to confirm them. The confirmatory test should be different from the *screening test* (repeating the *screening test* would probably only generate another false positive and create more confusion). Although the positive *predictive value* is low in this situation, the negative *predictive value* will be correspondingly high. This means that we can generally trust a negative test result when the *prevalence* is low.

As agent *prevalence* increases, these relationships reverse: the positive *predictive value* increases (so we can trust a positive result), while the negative *predictive value* decreases (we can no longer trust a negative result because there will be a high probability of false negatives). Confirming negative test results is more difficult and could require extended *quarantine* and repeated testing over time.

Example 1: a low-prevalence situation

In this hypothetical scenario, the plan is to translocate 1,000 frogs from one area to another. The chytrid fungus (*Batrachochytrium dendrobatidis*) has been identified as a concern during the *hazard identification* process. The source population has been monitored and is thought to have a very low *prevalence* (2%). The goal is to create a chytrid-free cohort of frogs from the source population that can be used for this translocation. Let us assume that our *screening test* is very good and has a sensitivity of 95% and a specificity of 90%. If the actual *prevalence* is 2% in the population we would expect 20 individuals to be truly positive. Given our test sensitivity and specificity, we can expect the following results after testing 1,000 frogs:

Test result	Agent present	
	Yes	No
Positive	19	98
Negative	1	882

Presenting our results in this 2 x 2 table enables us to see that our test has correctly identified 19 of the 20 truly infected individuals, which is very good and reflects the high sensitivity of the test. However, the test has also incorrectly identified 98 frogs as being test positive when in fact they did not have the agent. If we calculate the positive *predictive value* it turns out to be the following:

Positive *predictive value* =
19/(19 + 98) = 0.16 = 16%.

What this means is that any positive test result from this population has only a 16% chance of being correct. If our predetermined plan was to euthanise any test positive frogs, we would have a high probability of unnecessarily euthanising healthy frogs because of these false-positive test results. That is why it is important to have a plan in place to confirm any positive results, using a test of a type different from the original *screening test*. If we use the same data to calculate the negative *predictive value*, we find that it is extremely good:

Negative predictive value =
882/(882 + 1) = 0.999 = 99.9%

This demonstrates that in a low-*prevalence* situation, positive results should be viewed with suspicion and confirmed by follow-up testing using a different test, while negative results can generally be trusted.

Example 2: a high-prevalence situation

In this hypothetical scenario, the plan is to rescue 1,000 frogs from a wild population that is suffering a chytridiomycosis outbreak. The goal is to identify the chytrid-negative frogs so that we can establish a chytrid-free reserve population for breeding and eventual release back into the wild. We are using the same test, with a sensitivity of 95% and a specificity of 90%, only now the *prevalence* is very high (90%). With this *prevalence*, we would expect 900 frogs out of 1,000 to be infected and 100 to be free of the agent. If we again put our test results in a 2 x 2 table, we get the following:

Test result	Agent present	
	Yes	No
Positive	855	10
Negative	45	90

Our test has correctly identified 90 of the 100 uninfected frogs, which reflects the high specificity of the test. But our test has also incorrectly identified 45 frogs as being test negative when in fact they had the agent. If we calculate the negative *predictive value* we get the following:

Negative predictive value =
90/(90 + 45) = 0.67 = 67%

What this means is that, for any negative test result, we have only a 67% probability that the result is correct. In other words, 33% of the frogs we are using to establish our chytrid-free colony are actually infected, so our effort will inevitably fail. However, in the same situation our positive *predictive value* would be very good:

Positive predictive value =
855/(855 + 5) = 0.99 = 99%

This example demonstrates that in a high-*prevalence* situation, we cannot trust a negative test result and would need to have a plan for extended *quarantine* and repeated testing, but a positive test result can generally be trusted.

Caution

Test interpretation is a complicated subject and is influenced by many more variables than we have presented here, such as stage of infection, the presence of concurrent diseases, the immunological competence of the individual, the experience of those performing the test, sample handling requirements, and the cut-off values used to establish a positive test. It is always preferable to consult appropriate individuals with expertise in diagnostic test interpretation when carrying out surveillance testing and interpreting results.

Sample size calculator for pathogen surveys

When conducting *pathogen* surveys on small target populations (100 or fewer individuals), sampling 100% of the animals is the preferred option because it provides the greatest population-level *pathogen* detection sensitivity, and with appropriate confirmation testing allows decisions to be made at the individual animal level.

However, when the target population is large or resources are limited, it will be necessary to select a subset of animals for testing. In this situation it is important to choose an appropriate number of animals from the target population for testing so that acceptable levels of risk (or confidence limits) can be maintained, as determined by the *risk evaluation* process. When only a subset of animals is being tested, it is essential to make resulting decisions at the population level. The goal is to detect the presence of the *pathogen* in the population so that a decision can be made about whether the entire population is eligible or ineligible for movement or other management action.

Alternatively, if the *pathogen* of concern is detected in the population, an individual animal testing strategy could then be developed and implemented to allow decision making at the individual animal level.

In order to calculate the appropriate number of animals to test we need to know:

- the total population size
- the sensitivity of the test
- the minimum *prevalence* level we want to be able to detect, and
- our desired probability of detecting infection if the true *prevalence* meets or exceeds our minimum *prevalence*.

In the simplest scenarios we assume 100% specificity of the test, which although unrealistic makes the calculations much simpler. Decision makers sometimes expect *pathogen* surveys to provide proof of freedom from disease (i.e. 100% probability of detecting the *pathogen* if present), but it is important to clearly convey throughout the *risk communication* process that this is an unattainable goal. It would at minimum require testing 100% of the animals no matter how large the population and the use of a test with consistently perfect sensitivity and specificity.

In the simplest scenarios we also assume that any infected animals would be randomly distributed throughout the population so that randomly selecting individuals for testing will have the best chance of detecting the agent if it is present. Truly random selection of the individuals to be tested requires the use of a random number generator or a table of random numbers (such as the table of random numbers, p. 432, in Thrusfield 2007). In some situations it might only be possible to approximate truly random sample selection, but it is important to avoid bias in the selection process.

It is also important to ensure that this random distribution assumption is valid for the agent and population under consideration. In some situations, disease agents might be spatially segregated within a population (creating clusters of infected individuals) or could be stratified by age class. If the assumption of random distribution of infected individuals is likely to be violated, it is worth consulting an epidemiologist or other specialist in *pathogen* survey design, as the calculations can become quite complicated.

Example scenario

A translocation of 200 wild frogs is being planned to repopulate an area from which they have been extirpated. The disease risk assessment has determined that testing for the chytrid fungus (*B. dendrobatidis*) is warranted and that our level of risk tolerance requires that we be 95% confident that we can detect the agent even if the *prevalence* is as low as 5%. Our test has an expected sensitivity of 95%, we assume 100% specificity, and we have previous survey data suggesting that the agent, if present, would be randomly distributed in the population. If we enter these numbers into the sample size calculator on the 'Epitools' section of the Ausvet.com.au website (http://epitools.ausvet.com.au/content.php?page=FreedomFinitePop), we find that we would need to test 55 of the 200 animals if we want to be 95% confident of detecting the agent if the true *prevalence* is 5% or greater. If we have a much lower risk tolerance and desire 99% confidence that we can detect the agent even if the *prevalence* is as low as 2%, our sample size requirement increases to 144, which reveals how dramatically the sample size requirement increases as our risk tolerance decreases.

If the online sample size calculator is not available, the following formula can be used:

$$n = [1 - (1 - p)^{1/d}]\,[N - d/2] + 1$$

where n is the required sample size, p is the probability of finding at least one infected animal in the sample, N is the population size, and d is the minimum number of infected animals expected in the population (derived from the minimum *prevalence* we want to be able to detect).

So in the above case scenario where our minimum *prevalence* is 5%, we would expect at least ten animals in the population of 200 to be infected. We have set our desired probability of detecting at least one infected animal at 95% (or 0.95), so our calculation becomes:

$$n = [1 - (1 - 0.95)^{1/10}]\,[200 - 10/2] + 1$$

$$n = [1 - 0.74]\,[195] + 1$$

$$n = 52$$

This value closely approximates the sample size derived from the online calculator.

Strengths and weaknesses, when to use and interpret with caution

Screening animal populations for diseases of low *prevalence*, which is the most common scenario, is a complex task. Test selection, design of survey protocols, and interpretation of test results must be approached with caution. Consult with experts whenever possible.

References

Thrusfield (2007).
See also: http://epitools.ausvet.com.au/content.php?page=home

Appendix 4
Monte Carlo modelling for risk assessment

N. Murray

1. The use of Monte Carlo simulation in a risk assessment

As discussed by Murray *et al.* (2004), while a *qualitative risk assessment* is suitable for the majority of *risk assessment*s, there may be some situations in which it can be useful to adopt a quantitative approach to gain further insights, identify critical steps, assess the impact of *uncertainty* in more detail or compare risk mitigation strategies. Quantification involves the development of a mathematical *model* that links the various steps in the risk pathway. In its simplest form a deterministic or point estimate approach is undertaken whereby each of the inputs, such as disease *prevalence* and test sensitivity or specificity, is represented by a single value such as the 'best guess', 'least likely' or 'worst case'. These values, in turn, may have been derived from a statistical table where the 'best guess' is the average or expected value and the 'least likely' and 'worst case' are associated with the lower and upper confidence limits.

For very simple *models* with only a few inputs, a deterministic approach may be reasonable as there will be only a limited number of possible scenarios to explore. However, as more inputs are added there will be a rapid escalation in the number of potential combinations or 'what if' scenarios. For example, if we had just four inputs, each with a mean and upper and lower 95% confidence limits, we would have 34 or 81 possible scenarios. Such an approach obviously has significant drawbacks. It can rapidly become impractical to interpret the results meaningfully as there is no relative weighting for each combination of values. Fortunately, we can overcome these limitations by undertaking what is commonly referred to as a Monte Carlo simulation.

If we have information about the range of values and the likelihood of each value, we can assign a probability distribution to each input. They can now be described as random variables as they can take on a different value as a result of a random process. The resulting *model* is called a stochastic *model*, and we can calculate the combined impact of the variation in each of the *model's* input distributions to determine a probability distribution of the possible model outcomes. The simplest way to do this is to perform a simulation using computing software such as @Risk (Palisade Corporation, Newfield, New York – see Tool 14, p. 78). This involves randomly sampling values from each distribution and combining the values generated, according to the mathematical logic of the *model*, to produce a result for a particular scenario. This process is repeated many times and the results from each scenario, which are also known as iterations, trials or realisations, are combined to produce a probability distribution of possible model outcomes.

Sampling values from probability distributions is most commonly undertaken by Monte Carlo sampling, a technique first used by scientists working on the atomic bomb. It was named after the resort town of Monte Carlo in Monaco, renowned for its casinos. The Monte Carlo method is based on simple random sampling from the entire distribution, which represents the sampling frame for each iteration. It is essentially sampling with replacement, as it is possible for the same values to be selected more than once.

Latin hypercube sampling is an alternative method that involves stratified sampling without replacement. The range of the distribution is divided up into a number of intervals, equal to the number of iterations to be performed and a simple random sample is then chosen from within each interval. Since each interval is selected only once during a simulation, Latin hypercube sampling ensures that values from the entire range of the distribution will be sampled proportionally to the probability density of the distribution. Fewer samples are usually required to reproduce the probability distribution so it is more efficient than Monte Carlo sampling for the same number of iterations. It is generally the preferred method of numerical simulation since fewer iterations are required for a particular level of accuracy.

Although Latin hypercube sampling may be the default sampling method in software products such as @Risk, the overall stochastic process is referred to as Monte Carlo simulation. This is an extremely useful modelling technique and underpins many *quantitative risk assessment*s.

2. Differentiating variability and uncertainty

Before turning our attention to some examples of the types of distributions commonly used to model biological processes it is important to distinguish between *uncertainty* and *variability* as these terms have often been used interchangeably, leading to a degree of confusion.

Uncertainty reflects a lack of understanding or incompleteness of one's knowledge or information about a particular thing. *Variability*, on the other hand, reflects the heterogeneity or variation that exists naturally within any biological system, whether we have a good understanding of that system or not. So, while *uncertainty* is reduced as knowledge increases, *variability* remains the same. In most, if not all, situations, it is likely that the varying degrees of *uncertainty* that exist at different points in the risk pathway will be of more concern than *variability*. How then can we determine the impact of these uncertainties on the final risk estimate? Fortunately, *risk analysis* provides us with a technique that enables the inevitable uncertainties to be considered in context. For example, it could turn out that, while considerable *uncertainty* exists at one point in the risk pathway, its overall contribution to the final risk estimate is inconsequential. In such circumstances, it is important not to overemphasise the *uncertainty* that exists but to provide appropriate perspective.

3. Defining a distribution

There are basically two families of distributions, discrete and continuous, which are defined by the characteristics of their respective random variables. Discrete variables can take on only a limited number of values, whereas continuous variables can take on any value within a given range. Distributions can be further specified as either parametric or non-parametric. In the statistical sense, a parameter refers to a numerical descriptive measure that characterises a population, such as the mean and standard deviation, as well as the minimum, maximum or most likely values. As far as distributions are concerned, parameters are values that define their shape and range, either in combination with a mathematical function, in the case of a parametric distribution, or directly for non-parametric distributions. Examples of parametric distributions include the normal, binomial, Poisson and beta distributions while non-parametric distributions include the uniform, triangular, discrete and general distributions.

4. Guidelines for developing a simulation model

Before turning attention to some specific examples of distributions used to model biological processes in a *quantitative risk assessment*, it is worthwhile emphasising that a number of important steps must be worked through in a systematic manner when developing a simulation *model*. These steps include:

– ensuring that the scope of the assessment is adequately characterised by identifying the population of interest and clearly and explicitly stating the question to be answered

– providing a graphical outline of the biological pathways considered in the *model* to identify the variables, their relationships and information requirements as well as ensuring that there is a logical chain of events in space and time leading to the appropriate estimate being calculated

– keeping the *model* as simple as possible to represent as accurately as necessary the system of interest

– documenting the assumptions, evidence, data and uncertainties for each variable to ensure that an appropriate distribution is chosen

– verifying that each iteration of the *model* is biologically plausible and that unexpected or counter-intuitive results are not ignored.

For further elaboration of these and a number of other important guidelines the reader is referred to Murray *et al.* (2004).

5. Some examples of distributions used to model biological processes

As discussed by Murray *et al.* (2004) there are essentially two sources of information from which a distribution can be developed to represent a variable in a *risk assessment model*; empirical data and expert opinion. While a large number of probability distributions is available to the risk analyst, caution is warranted. Unless careful consideration is given to the theoretical basis and underlying assumptions, particularly for parametric distributions, an inappropriate choice may be made that could lead to significant flaws in the assessment. It is important to ensure the distribution selected is biologically plausible and not just simply selected arbitrarily or because it provides a 'good fit' to the data. Several techniques, which are beyond the scope of this book, are available to assist in developing an appropriate distribution. They include fitting empirical data to a distribution using either parametric or non-parametric techniques, a purely subjective approach using expert opinion, and, a combined approach that incorporates empirical data and expert opinion using Bayesian inference. For further details the reader is referred to other texts, including those of Murray *et al.* (2004) and Vose (2008).

Rather than simply listing the various distributions and their characteristics, the following sections focus on the amount and type of information available followed by the distribution relevant under those circumstances. Throughout this text, probability distributions will be described in terms of functions used in the *risk assessment* computing software @Risk, for example, Binomial, Beta, and Uniform.

5.1 Distributions used to model expert opinion or to convert a set of data into a distribution

Non-parametric distributions provide a convenient means of modelling either expert opinion or converting a set of data into an empirical distribution as their parameters are intuitive and simple to use.

Depending on the circumstances either a continuous or a discrete distribution can be developed.

5.1.1 Minimum, maximum

For the most basic situation the amount of information available may simply cover a range of possible values without any relative weighting of one value over another. In such cases a uniform distribution defined by two parameters, a minimum and maximum value, would be appropriate as all possible values within the range have an equal probability of occurrence:

Uniform (minimum, maximum).

This distribution, which is a simple, continuous distribution, is commonly used to model expert opinion as well as those situations in which the available data are restricted to defining a range. It has a wide variety of applications from defining a distribution of disease *prevalence*, test sensitivity and specificity, *incubation period*, duration of viraemia, etc. Figure 31 provides an example of a uniform distribution, which is also known as a rectangular distribution. While it is the most maximally uninformed distribution of all, it is nevertheless useful in some circumstances.

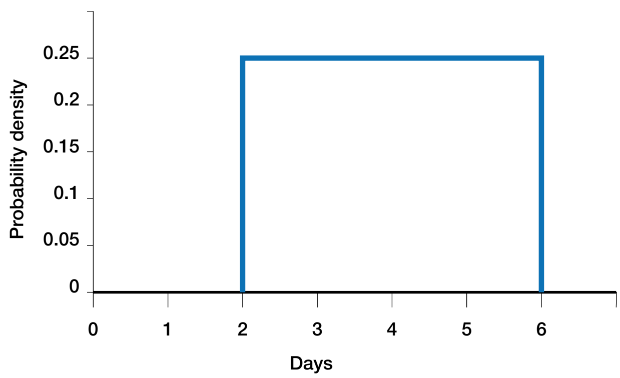


Fig. 31
A uniform distribution of the duration of viraemia where the range has been estimated to be from two to six days

5.1.2 Minimum, most likely, maximum

In addition to defining a range of possible values there may by some information or opinion that enables an estimate of the most likely value within the range to be obtained. The appropriate distribution to use here is either the pert or the triangular, which are both continuous distributions:

Pert (minimum, most likely, maximum)
Triangular (minimum, most likely, maximum).

The pert distribution is actually a modification of a specific type of parametric distribution, the beta distribution (discussed below). It provides a more 'natural' shape than the corresponding triangular distribution (Fig. 32). It is not as influenced by the extreme (minimum and maximum) values, particularly when the distribution is skewed. The main drawback of the triangular distribution is its unnatural shape, which rarely, if ever, provides a reasonable description of a biological process. As can be seen from Figure 32 it tends to overemphasise the tails and underestimate the shoulders relative to the pert distribution. Both the pert and triangular distributions have found widespread application for many biological processes.

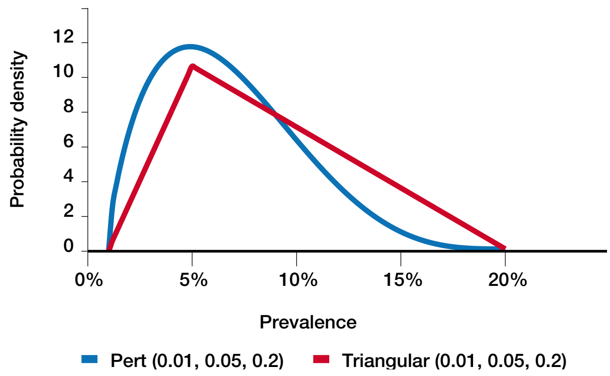


Fig. 32
Comparing a pert and a triangular distribution

The pert distribution can be easily and conveniently manipulated by applying a weighting factor to the mean of the distribution, enabling various shapes to be generated for the same values of the minimum, most likely and maximum. This can be particularly useful in refining the shape of the distribution when eliciting expert opinion, as shown in Figure 33. In this example, adapted from an import *risk analysis* on chicken meat undertaken by the Ministry of Agriculture in New Zealand, the age at which chickens are likely to become infected with infectious bursal disease (IBD) virus prior to being slaughtered at 49 days of age is depicted. Initially there was a great deal of *uncertainty*, so a uniform distribution, Uniform (1, 49) was used. Later some information became available indicating that they were most likely to become infected around 3 weeks of age. This was modelled as a Pert (1, 21, 49). After further enquiries the estimate was refined to 'most chickens become infected between 14 and 28 days of age'. This was interpreted as 90% of chickens being likely to become infected during this period. A modified pert with a corresponding weighting factor was used to model this new information. The same estimates for the minimum, most likely and maximum values were used as in the original pert distribution. For further details on this technique refer to Murray *et al.* (2004) and Vose (2008).

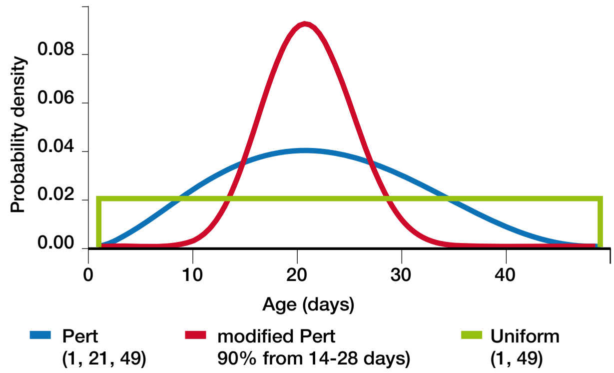


Fig. 33
A comparison of a uniform distribution, a standard pert distribution and a modified pert distribution of the age when a chicken is likely to become infected with IBD virus prior to slaughter at 49 days of age
From Murray *et al.* (2004)

5.1.3 Minimum, maximum with a specified number of equal length classes, each with a probability pi of occurring

The histogram distribution can be used to model a set of continuous data that is grouped into equal-length non-overlapping classes bounded by a minimum and a maximum class interval whereby each class has a certain probability *p*i of occurring. It is useful for replicating the shape of a set of data as shown in Figure 34.

Histogram (minimum, maximum, {pi}).

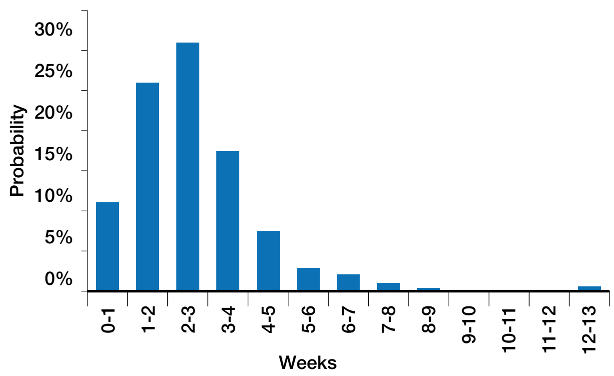


Fig. 34
A histogram probability distribution of the duration of viraemia in cattle naturally infected with bluetongue virus
From Murray *et al.* (2004)

5.1.4 Data grouped in specified (x_i, p_i) pairs

There are a number of situations when it may be convenient to group data into specific (x_i, p_i) pairs where each pair has a value x and a weight p which specifies the value's relative probability of occurrence. The underlying data may be discrete or continuous.

Two distributions are available to model discrete data; the discrete and discrete uniform (duniform):

Discrete ({x_i}, {p_i})
Duniform ({x_i}).

The discrete uniform distribution is a special form of the discrete distribution that can have one of several discrete values (x_i) each with an equal probability of occurrence.

These distributions can be used to define an empirical distribution directly from a data set that is organised into (x_i, p_i) pairs, particularly where there is an abundant amount of representative data. The discrete distribution can also be used to model a posterior distribution in a Bayesian inference calculation. The discrete uniform distribution can be usefully employed in a non-parametric bootstrap simulation to determine a sampling distribution for an uncertain parameter where there are few representative data. It is used to resample from the original data set. For further information on Bayesian inference and bootstrap simulation refer to Murray *et al.* (2004) and Vose (2008).

An important application of these discrete distributions is in modelling expert opinion where there are divergent views, in which case each expert's opinion would be captured by the x_i value with a corresponding weighting of p_i. In those situations where each expert's opinion is considered to be equally valid, the discrete uniform distribution would be appropriate.

For continuous data, two distributions are available: the general and cumulative distributions. The range of each distribution is defined by a minimum and a maximum value.

General (minimum, maximum, {x_i}, {p_i})
Cumul (minimum, maximum, {x_i}, {p_i}).

They can both be used to convert a set of data into an empirical distribution provided the data are continuous and cover a reasonable range. In the case of the cumulative distribution, the probability values (p_i) are the corresponding ascending cumulative probabilities (Fig. 35). While both distributions may be used to model expert opinion, special care should be taken when using the cumulative distribution, as small changes in a cumulative plot can lead to significant distortions in its corresponding relative frequency plot. The general distribution can be used to model a posterior distribution in a Bayesian inference calculation where the parameter being estimated is continuous.

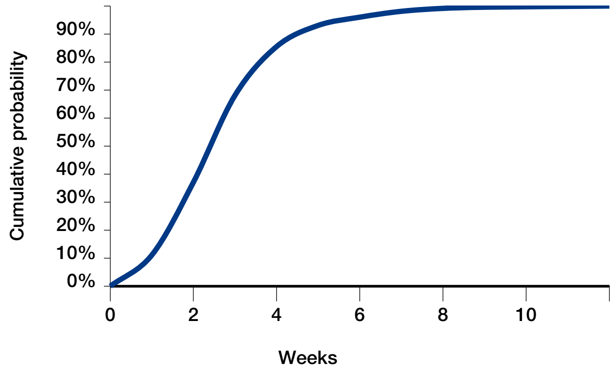


Fig. 35
A cumulative probability distribution of the duration of viraemia in cattle naturally infected with bluetongue virus
From Murray *et al.* (2004)

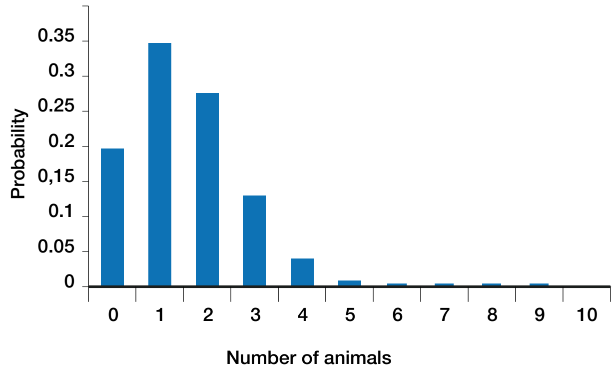


Fig. 36
A binomial distribution of the variation in the number of infected animals (x) likely to be in a sample (n = 10) drawn from a population with a disease prevalence (p = 0.15)
From Murray *et al.* (2004)

5.2 Distributions used to model a binary response

The outcome of interest in many *risk assessment*s is a binary response. That is, there are only two possible outcomes. For example: an animal is infected or it is not; when tested it is positive or it is not; a disease outbreak occurs or it does not. Such binary responses can be conveniently modelled as a binomial process, provided we can reasonably satisfy its underlying assumptions.

A binomial process consists of *n* identical trials each with the same probability of success (*p*). The variation in the number of successes (*x*) is modelled by the binomial distribution:

$$x = \textit{Binomial}\ (n, p).$$

Since the probability of success remains constant, a binomial process is effectively sampling from an infinite population with replacement. While this would obviously not be the case in practice, for example where a sample of animals is drawn from a particular population harbouring a certain disease, provided the size of the population relative to the sample size is large, it is reasonable to assume that the probability of sampling an infected animal remains constant. As a guide, if the size of the population is at least ten times the sample size, such an assumption is appropriate. In those situations where it is not reasonable to assume that probability remains constant, a hypergeometric process, discussed below, is applicable. Figure 36 provides an example of a binomial distribution modelling the number of infected animals (*x*) in a sample (*n*) drawn from a population with a disease *prevalence* (*p*).

In some situations we might be interested in estimating the number of animals that we would need to select before we included a certain number with a trait of interest (diseased, pregnant, etc.) in the sample. Since the negative binomial distribution *models* the number of failures likely to arise before *x* successes are observed, the variation in the number of animals that would need to be selected (*n*) before *x* successes is determined by:

$$n = \textit{Negbin}\ (x, p) = \textit{failures.}$$

If the level of interest is in estimating the number (*n*) that would need to be selected to include (*x*) successes in the sample, then:

$$n = x + \textit{Negbin}\ (x, p) = \textit{successes} + \textit{failures.}$$

As an example, in planning a survey and estimating costs it could be informative to determine the variation in the number of animals from an infected population that would need to be tested before identifying an infected individual; that is, the number of 'failures'. Figure 37 provides an example of the variation in the number of uninfected animals that are likely to be selected before an infected animal is included in a sample.

Under an empirical definition of probability, the number of events of interest (*x*) that occur in a number of identical and repeatable trials (*n*) is expressed as a ratio (fraction or proportion) of the total number of events that occurred. As a result, probability is a measurable property of the physical world and can never actually be observed.

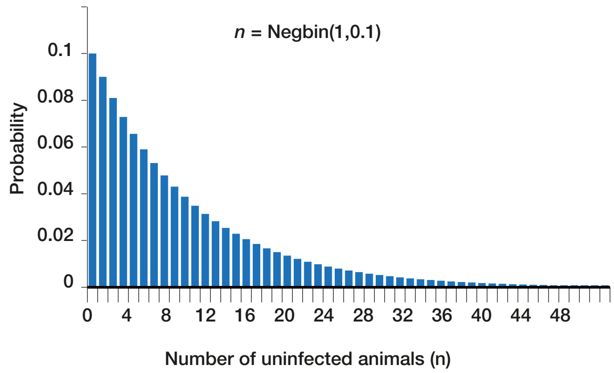


Fig. 37
A negative binomial distribution of the number of uninfected animals likely to be selected from a population with a disease prevalence of 10% before including an infected animal in the group

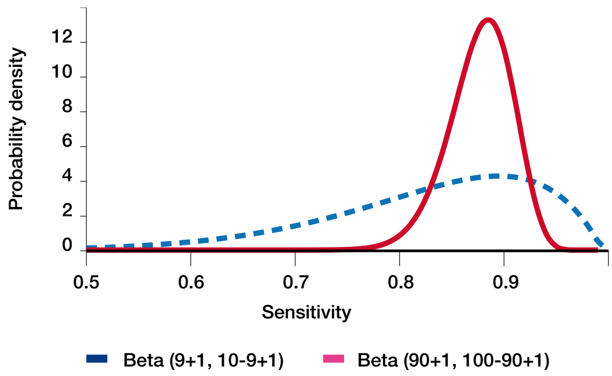


Fig. 38
Using the beta distribution function to model an uncertain parameter p, of a binomial distribution. In this case p represents test sensitivity

As *n* approaches infinity it is the limit of the ratio:

$$\lim_{n \longrightarrow \infty} \frac{x}{n} \cdot$$

In other words, we can be increasingly certain of its true value as more and more trials are undertaken. The level of confidence we have in an estimate of probability (*p*) after having observed *x* successes in *n* trials is embodied in the beta distribution, which provides a convenient way of modelling *uncertainty* about *p*:

$$p = Beta\ (x + 1, n - x + 1).$$

This particular formulation of the beta distribution is actually the posterior distribution that arises from using the beta distribution as a non-informative conjugate prior to a binomial likelihood function in a Bayesian inference (for further details refer to Murray *et al.* 2004 and Vose 2008).

Figure 38 provides an example of a beta distribution used to model test sensitivity. In this example, if nine out of ten animals known to be infected with a particular disease were positive to a serological test, the point estimate of the test's sensitivity would be 90%, that is, the probability that the test is positive given that an animal is infected. But, how confident can we be that this is a reasonable estimate, particularly considering that there were only ten animals in the trial? By inserting the appropriate values into the beta distribution function $p = Beta\ (x + 1, n - x + 1) = Beta\ (9 + 1, 1 - 9 + 1)$ and plotting the results we can readily assess the impact of *uncertainty*. As more information is gathered by testing more animals we would be increasingly confident of the test's 'true' sensitivity. In the end there is always a trade-off between obtaining a reasonable level of confidence and the cost and effort needed to acquire additional information.

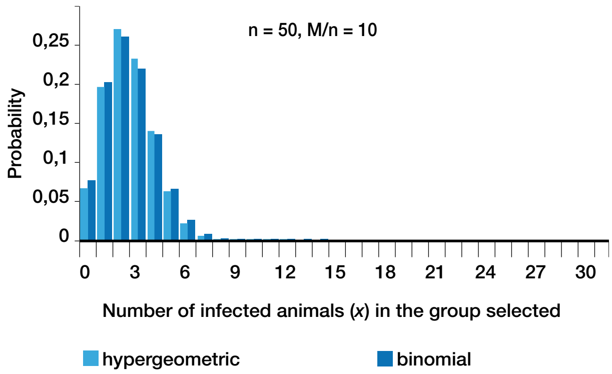
5.3 Sampling from finite populations: the hypergeometric process

As discussed earlier, since probability remains constant and the results from succeeding trials are independent under a binomial process, the binomial distribution is effectively modelling sampling with replacement from a very large (essentially infinite) population. However, in most, if not all, practical situations when modelling biological processes, sampling would be undertaken without replacement from finite populations. For example, in a group of 100 animals (M = 100) where there are five with a trait of interest (D = 5), the initial probability that an animal has the trait would be 0.05. If the first animal selected has the trait, then the probability that the next animal selected would also have the trait would be 4 ÷ 99 = 0.04, whereas, if it does not, the probability would be 5 ÷ 99 = 0.051. As a result the probability, measured by $D \div M$, changes depending on whether the previous animal had the trait or not. That is, the probability of success is no longer independent of the outcome of the previous trial.

Provided the population size is at least ten times the sample size, the probability of success remains more or less constant. However, as the ratio of population size to sample size diminishes, proper account needs to be taken of fluctuations in probability through the application of a hypergeometric process. The corresponding hypergeometric distribution *models* the number of successes (*x*) in a sample of size *n* from a population of size *M* where there are *D* individuals with the characteristic of interest:

$$x = Hypergeo\ (n, D, M).$$

Since the probability of success changes each time an individual is selected and removed from the population, the hypergeometric distribution is modelling sampling without replacement. As can be seen from Figure 39 it is not really until the population size in relation to the sample size (*M:n*) falls below about ten that important differences begin to emerge between the results generated from a binomial distribution and the hypergeometric distribution.



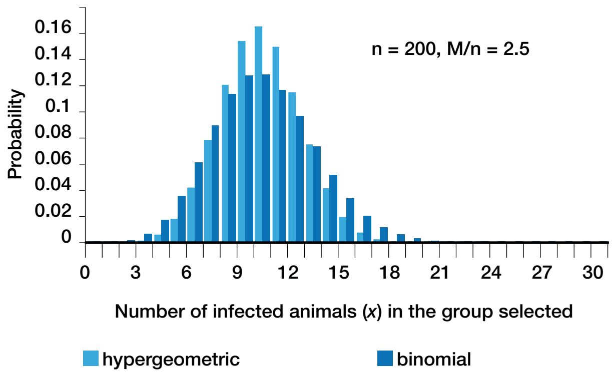


Fig. 39
A comparison of the hypergeometric and binomial distribution
For the number of infected animals (*x*) in a group *(n)* selected from a population (*M = 500*) with a number of infected animals (*D = 25*). For the hypergeometric distribution, *x = Hypergeo (n, D, M)*, while for the binomial distribution prevalence is calculated as *D/M* and *x = Binomial (n, D/M)*

5.4 Distributions used to model variables that are normally or log normally distributed

Many naturally occurring variables such as weight, height, viral titre in tissues, physiological characteristics, pH of tissues and fluids, and milk and egg production are normally distributed. Others are normally distributed following some sort of transformation of the data; for example, taking the logarithm of a set of data on the *incubation period* of a disease. The normal distribution has an extensive variety of applications ranging from statistical theory, where it is widely used in statistical inference and hypothesis testing, to the central limit theorem. This theorem establishes a relationship between the average of each of a set of samples drawn from any population, regardless of the shape of its underlying distribution, and the normal distribution. Since the averages are approximately normally distributed, there are a number of useful applications, including, for example, ensuring that proper account is taken of heterogeneity in a population (for further details refer to Murray *et al.*, 2004, Vose 2008).

The normal distribution is characterised by two parameters, the mean (μ) and standard deviation (σ):

Normal (μ, σ).

It is an unbounded continuous distribution that extends from minus infinity to plus infinity and has a bell-shaped curve. Since it is unbounded, we may need to impose a restriction on its limits if we are to avoid implausible values. This is done by truncating it using the Tnormal (μ,σ, *minimum, maximum*) function where *minimum* and *maximum* define the minimum and maximum of the plausible range of values.

The log normal distribution often provides a good representation for data that extend from zero and are positively skewed, that is, data that have a longer right hand tail, such as herd size and disease *incubation periods*. In addition, the outputs from computer simulations involving the multiplication of two or more distributions are often distributed log normally.

The log normal distribution is characterised by two parameters, the mean (μ) and standard deviation (σ):

*Lognorm (*μ*, σ).*

It is an unbounded, continuous distribution extending from zero to plus infinity that is used to model a variable (*x*) the natural log of which (ln(*x*)) is normally distributed. The parameters *μ* and σ are the actual mean and standard deviation of the log normal distribution. Alternatively, the log normal distribution may be specified by the mean and standard deviation of the normal distribution of ln(*x*).

Since the log normal distribution extends from zero to plus infinity we may need to truncate it to avoid implausible values:

Tlognorm (μ, *σ, minimum, maximum*).

5.5 Distributions used to model events in space or time

The Poisson, gamma and exponential distributions can be used to model events in space or time provided we can satisfy the underlying assumptions of a Poisson process that there is a constant, continuous probability of an event occurring in a particular interval (*t*). It is essentially a memory-less system, as the number of events occurring in any one interval is independent of the number in any other interval, regardless of whether an event has only just been observed or there has been a considerable amount of space or time between them.

The Poisson process is characterised by one parameter lambda (λ), the average number of events per unit interval (t) of space or time. The interval t is measured in either space (per litre, per kilogram, per kilometre, etc.) or time (per second, per hour, per day, per year, etc.). The reciprocal of (λ) is the mean interval between events (β) so that

$$\lambda = \frac{1}{\beta}\cdot$$

5.5.1 The number of events in an interval

The Poisson distribution is used to model the *variability* in the number of events (x), in an interval (t):

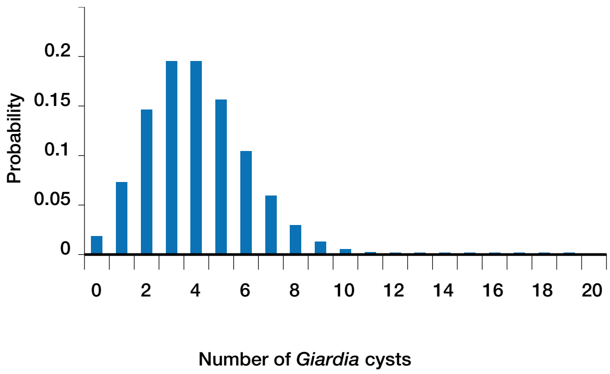
$x = Poisson\left(\lambda \times t\right)$, *or in terms of* ($\beta$),

$$x = Poisson\left(\frac{t}{\beta}\right)\cdot$$

It is worth noting that in @Risk the Poisson function is expressed as Poisson (lambda), where lambda actually equals either

$$\lambda \times t \quad \text{or} \quad \frac{t}{\beta}$$

not just simply λ, unless, of course, t equals one. Although, theoretically, there can be any value between zero and an infinite number of events in a specific interval, in practice this is almost never a restriction. For example, if there are four *Giardia* cysts per litre of contaminated drinking water on average, Figure 40 demonstrates that the probability of more than 20 cysts is vanishingly small.



where λ = 4/litre, t = 1 litre

Fig. 40
A Poisson probability distribution of the number of *Giardia* cysts per litre of water

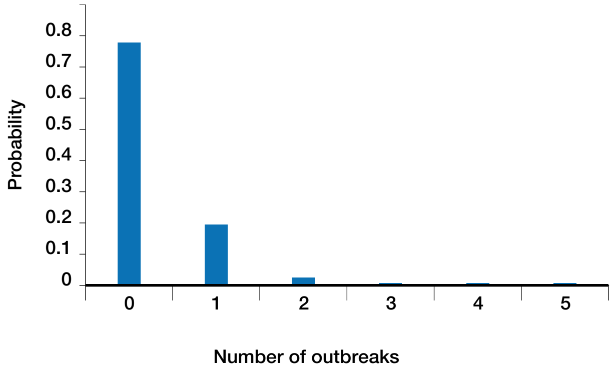


Fig. 41
A Poisson probability distribution of the number of disease outbreaks expected during the next time interval t,
where t = 6 months and the mean interval between events (β) is 24 months.

Provided we can satisfy the assumption that there is a constant and continuous probability of a disease outbreak over a certain period, we could estimate the number of outbreaks expected during, say, the next 6 months, given that historical information indicates an outbreak occurs on average every 24 months. In this situation the mean interval between events (β), would be 24 months so that λ is 1/24 outbreaks per month. The number of outbreaks in the next six months could then be modelled as Poisson (6/24) as presented in Figure 41. Of course, given that *risk factors* may change over time through varying levels of exposure as well as the result of intervention strategies on population immunity, etc., it might not be reasonable to assume that a Poisson process applies.

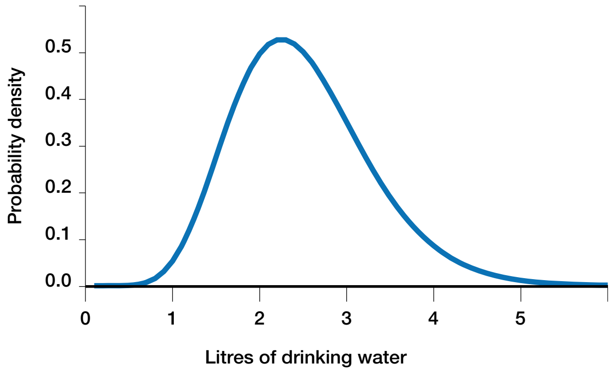
5.5.2 Estimating the amount of space or time until the next (x) events have occurred

The gamma distribution can be used to model the variation in the space or time until the next (x) events have occurred:

$$t_x = Gamma\left(x, \frac{1}{\lambda}\right)$$

or in terms of β, $t_x = Gamma\left(x, \beta\right)$.

If it has been determined that an infectious dose for *Giardia* is ten cysts, we can estimate the amount of contaminated drinking water with an average of four cysts per litre that would need to be ingested before becoming ill. Figure 42 plots a distribution of the volume of water that would need to be ingested in order to be exposed to ten cysts.



t_{10} = Gamma (10, 1/4)

Fig. 42
The amount of contaminated drinking water that would need to be ingested in order to consume ten *Giardia* cysts

5.5.3 Estimating the average number of events per unit interval λ

The gamma distribution can be used to model *uncertainty* about λ as we can never actually be sure of its true value unless our observations extend over an infinite interval. However, we can be increasingly confident of its true value by collecting more data.

$$\lambda = Gamma\left(x, \frac{1}{t}\right).$$

For example, if we tested a one litre sample of contaminated drinking water and found four *Giardia* cysts we could estimate that the average number is two per litre. But how confident can we be that this is a reasonable estimate? We can use the gamma distribution to model the uncertainty surrounding λ as shown in Figure 43. If we sampled a larger volume of water and found 400 cysts in 100 litres we would be increasingly confident that the *true* value of λ is four cysts per litre (Fig. 43).

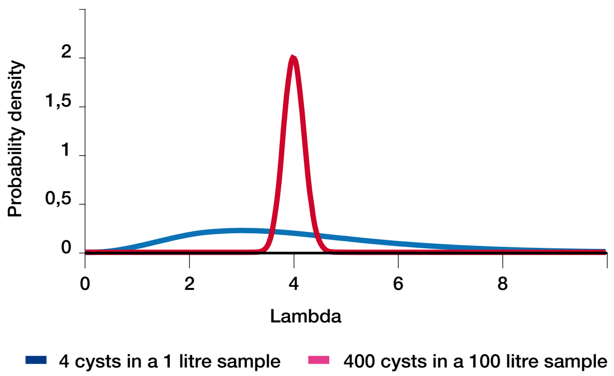


Fig. 43
Estimates of the average number of *Giardia* cysts

Per litre of contaminated drinking water (λ), using the gamma distribution,

$$Gamma\left(x, \frac{1}{t}\right)$$

where x = the number of cysts, t = the space (volume) of observation

Strengths and weaknesses, when to use and interpret with caution

Monte Carlo modelling is reasonably intuitive, relatively easy to implement and avoids the direct use of complex mathematical formulae. It provides a powerful technique whereby many biological processes can be conveniently incorporated into a *model* allowing the impact of various uncertainties that inevitably exist to be properly investigated. Critical steps along a particular biological pathway can be readily identified and various intervention strategies explored to access their relative impact on the outcome of interest. It can provide a useful adjunct to a qualitative assessment to gain further insights into particular aspect of the overall assessment.

Although Monte Carlo modelling involves numbers, it is not necessarily any more *objective*, nor are the results necessarily any more 'precise' than a qualitative assessment. Choosing an appropriate *model* structure, which pathways to include or exclude, the level of aggregation or disaggregation, the actual values used for each of the inputs and the types of distribution applied to them all involve a degree of subjectivity. The results themselves, which are expressed numerically, invariably present significant challenges in interpretation and communication.

Regardless of whether a qualitative or quantitative approach is adopted it is important to appreciate that all *risk assessments* inevitably include a degree of subjectivity. The personal opinions and perceptions of the analyst, experts and decision makers are inescapable. As a result, in order to ensure that a reasonable level of objectivity is attained, it is important to transparently document all the data, assumptions, uncertainties, methods and results. It addition, the conclusions reached must be supported by a well-reasoned and logical discussion. As with any *risk assessment* it should be fully referenced and subjected to peer review.

Case studies

Paisley 2001; Pharo & MacDiarmid 2001.

References

Vose 2000; Murray *et al*. 2004

Software options

Excel (www.microsoft.com) together with Excel-based software that enable simulation modelling to be undertaken: @Risk (www.palisade.com); Crystal Ball (www.oracle.com); Model Risk (www.vosesoftware.com). Refer to the relevant website for details concerning costs, licensing agreements and trial versions.

Appendix 5
A guide to planning a DRA workshop

R.M. Jakob-Hoff, T. Grillo, A. Reiss, H. Hodgkin & R. Barraclough

As noted above, many *wildlife* DRA exercises are likely to be conducted by one or two individuals who may or may not consult others with relevant knowledge or expertise. However, where a DRA workshop is possible, the following is provided to assist in the planning.

Planning a wildlife DRA workshop

Increasingly workshops are used for *wildlife* DRAs, in which the subject matter attracts significant public (and therefore political) interest, is associated with contentious issues such as public health or changes in land use or the results of which have impact on a diverse group of stakeholders. For those who are convening or participating in such a workshop, some understanding of group dynamics will help preparation.

Understanding people in groups

The psychology and behaviour of human beings is well beyond the scope of this *Manual*. However, a basic understanding of some group dynamics that can influence the success of a collaborative enterprise is of value and can be used to anticipate, recognise and appropriately respond to behaviours that reflect the group's stage of development.

Synergy
An increased effectiveness achieved by a number of people working together (Chambers Concise Dictionary).

An ideal DRA team brings together a relatively small group (8–15) of individuals with well-matched skill sets. Over time, a team functioning at its full potential can develop a synergy that produces results far superior to those that could be produced by any one individual (see Box 7). To gain the full benefits of such teamwork, the workshop leader must pay attention to establishing a collaborative culture in which each member feels valued and is able to contribute fully.

The characteristics of the stages are:

Stage 1 – Forming
This occurs when a team is formed *and* when it encounters changes, including changes in group members. There is a high dependence on the group leader for guidance and direction during this stage. Individual roles and responsibilities are unclear, and people need to get to know each other and the task. The leader must guide discussion about the group's purpose, objectives and external relationships.

Box 7:
The four-stage model of team development

All groups go through stages of development and it is useful for workshop convenors and participants to be aware of them. There are numerous *models* of this but a common one is Tuckman's four-stage *model* of team development (Tuckman 1965). In this *model*, groups go through four stages termed 'Forming', 'Storming', 'Norming' and 'Performing' (Fig. 44). As shown by the double arrows in this figure, a group may find itself repeating any part of the cycle if significant changes occur.

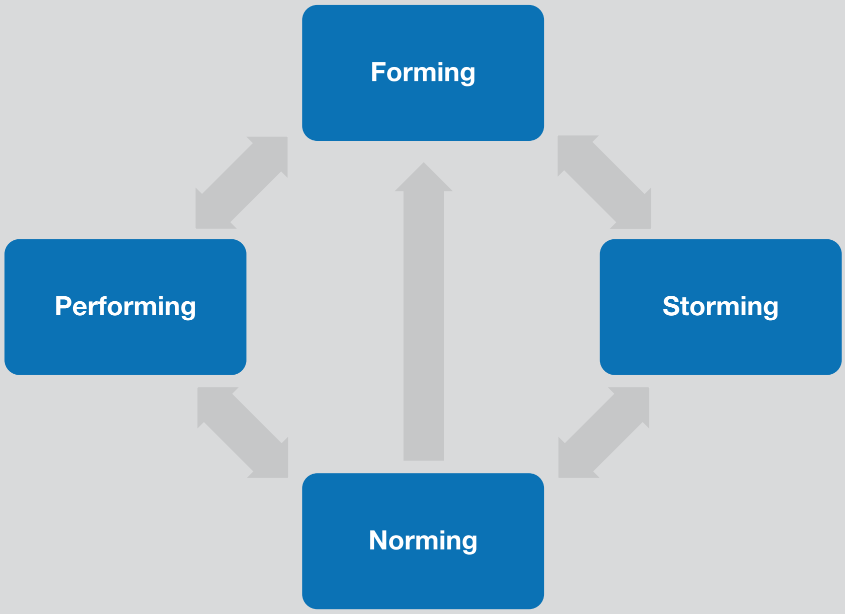


Fig. 44
Stages of team development

Stage 2 – Storming
Boundaries are tested and decisions do not come easily within the group during this stage. Group members vie for position as they attempt to establish themselves in relation to other group members and the group leader, who might receive challenges from group members. Clarity of purpose increases but plenty of uncertainties persist. Cliques and factions may form and there may be power struggles. The team needs to be focused on its goals to avoid becoming distracted by relationships and emotional issues. Compromises may be required to enable progress. Leadership is needed to help move through this stage productively.

Stage 3 – Norming
Roles and responsibilities become clear and accepted and there is agreement on how decisions are made and how the group operates. Norms of behaviour develop, both formal and informal. Smaller decisions can be delegated to individuals or small teams within the group. Commitment and unity is strong. The group may engage in fun and social activities. The group discusses and develops its processes and working style. There is general respect for the group norms and for the leader and some leadership may be shared by the group. People start to feel they are a team.

Stage 4 – Performing
The group knows clearly what it is doing and why. It has a shared vision and requires less hands-on management from the group leader. There is a focus on achieving goals, and the group may develop a high degree of autonomy. Disagreements occur but now they are resolved within the group positively, and changes to processes and structure are made easily. Group members look after each other. Morale and performance are high.

Personal attributes of group members

In an effective group, the attitude of members is as important as skills and knowledge. Ideally, workshop group members are:

- able and willing to work in a team
- willing to listen to other points of view
- open to new information and ideas
- adaptable to a changing political situation
- empathetic to cultural needs and practices
- willing to share professional expertise and information freely within the team.

Working agreement

It is useful to clarify the need for these attributes when inviting individuals to participate in the workshop. One method for encouraging these behaviours is to suggest, at the beginning of the workshop, a working agreement to assist the group to use its time most effectively (see Box 8). It is important that the wording is discussed and understood by all participants and that group consensus on the terms of the agreement is reached. The written agreement can then be placed in a prominent site within the meeting venue where members can refer to it as needed. It is, of course, essential that the workshop leader consistently practices these behaviours as an example to others.

Box 8:
Example of a working agreement for a DRA workshop

- The focus is on the agreed workshop objective(s)
- All other business and agendas are put on hold
- We will be respectful of each other at all times
- Everything will be recorded on paper for the group memory
- Everyone participates; no one dominates
- All ideas, comments and opinions are openly shared
- All ideas are valid
- We will actively listen to each other without interruption
- Differences and problems will be acknowledged
- We will observe agreed time-frames
- Confidentiality is observed whenever requested

Assembling and developing a collaborative DRA team

A workshop will ideally be organised by a small core group that will meet to plan the workshop, organise logistics, assist in ‘running’ the workshop and meet again to debrief after the workshop. The planning group should include representatives of key stakeholders and decision makers. If this is not possible, keeping these people informed and inviting their input to establishing the workshop’s plans and goals will pay dividends.

Meetings

The particular circumstances of the DRA will determine the most appropriate and practical means of meeting with the team. There can be great benefit (in developing synergy, improved communication, relationship building and commitment) in face-to-face meetings. However, time and resources as well as concern for minimising carbon footprint mean that more frequently groups are using Internet and telecommunications technology to have 'virtual' meetings. Apart from the savings in time, money and carbon emissions, these have the advantage of bringing individuals together who are geographically separated by great distances.

Regardless of the meeting venue, considerable work needs to be done prior to each meeting. More often than not, those who agree to participate in the team will be doing so on a voluntary basis or on behalf of their organisation. Adequate preparation is therefore not only in the interests of getting maximum value from the meeting, but also acknowledges that the time and expertise being donated by participants to the DRA exercise is valued.

All good meetings have a clear, agreed purpose, agenda and time-frame and should conclude with an agreed action plan in which responsibility for each action has a clear deadline and is assigned to a specific individual. If the skills of a facilitator or evaluator are to be used, this is the time to begin working with them.

See Box 9 for a pre-workshop preparation checklist as an aid to the preparation of a DRA workshop. With the exception of venue preparation and catering, the items on the checklist are relevant to both face-to-face and 'virtual' workshops using the Internet.

Value of facilitators

As noted above, one of the values of skilful, independent facilitators, particularly during the early 'forming' and 'storming' phases, is their ability to focus on the process and dynamics of the group and to make timely interventions. A good facilitator will raise the group's awareness of group dynamics, mediate conflicts and bring attention back to the meeting's purpose. This frees the group up to focus on the topic of the meeting. In the absence of a trained facilitator (which is probably the most common situation) raising team awareness of the phenomenon of stages of group development at the outset (e.g. posting a diagram such as Figure 44 with its explanation on the meeting room wall or group website) can be a useful tool to provide context when conflicts arise.

Assembling a wildlife DRA team

For the purposes of this *Manual* the term 'team' refers to any group of two or more individuals collaborating with each other on a *wildlife* DRA. Depending on circumstances, the team may or may not meet face to face, regularly, intermittently or even at all. In many cases discussions may occur only at a distance using e-mail, telephone, the Internet, etc.

Box 9:
Pre-workshop preparation checklist

- Write a project outline for the DRA including all relevant background
- Complete a full literature review on the topic and include as much unpublished information as is available. (The aim is to provide all participants with sufficient background material to bring them on to an equal understanding of the issues, the information available to you and the key information gaps)
- If you are to use the services of a facilitator, an evaluator or a communications professional, meet with them early to seek input into the planning of the meeting and the evaluation and communications plans
- Using the evaluation planning template (Appendix 6, p. 118), draft the goal of the DRA and the specific objectives and methods to be used. These will be reviewed with the participants and the remaining fields completed during the meeting
- Use this *Manual* to select the appropriate DRA tools and ensure that you, or at least one of the other participants, is familiar with them
- Create a list of stakeholders and experts and prioritise according to:
  a) skills and expertise needed; and
  b) influence on communicating and implementing the DRA findings. Avoid inviting more than 10–12 participants but ensure that there is broad representation of experts and stakeholders
- Use the communications plan template (Table XII) to enter full contact details of attendees (title, organisation, mailing address, e-mail, telephone, fax). This plan will be completed during the first meeting. (Note: this register of attendees, with some minor adjustments, could also form the beginning of a skills register.)
- Develop a meeting budget and consider sources of funds including sponsors
- Circulate the project brief with an invitation to the preferred list of attendees
- Draft an agenda that will systematically step the meeting participants through the DRA process as outlined in this *Manual* using any tools chosen to assist. Circulate this prior to the meeting
- If necessary submit sponsorship applications
- Identify and book a suitable venue, if needed
- Organise food and drinks for participants and check if any have special dietary needs
- Check the venue is fully functional and set up for your needs – including comfortable seating, tables, clean, functional and accessible toilets, audiovisual equipment, white boards, etc. and adequate heating, cooling and ventilation
- Organise consumables such as paper, pens, rolls of paper, sticky tape, name tags, etc.
- Print and collate any printed materials for distribution before or during the meeting

As with any team, having the right mix of individuals is critical to the quality of its performance. The specific scenario and DRA questions your team is addressing (refer to the problem formulation step of the DRA process) will influence the range and types of expertise needed.

Members of a DRA team can be broadly categorised as either 'stakeholders' or 'experts'. Some individuals may fall into both categories. When considering the team's composition it is useful to make a list of relevant stakeholder groups and experts (Table XI), prioritise them and then consider specific individuals to contact to check their interest and availability.

Stakeholders

Stakeholders are those people and organisations that have a direct or indirect interest in, or will be affected by, the DRA process and its outcomes. A checklist of some potential stakeholder groups is provided in Table XIV. (A specific example is included as Table II).

Table XIV
Checklist of some potential wildlife DRA stakeholders

Biosecurity advisors or agencies
Captive breeding practitioners or organisations
Community conservation groups
Non-governmental organisations (NGOs), e.g. WWF, Greenpeace
Federal, state and local government agencies
Funding agencies and donors
Media/journalists
Hunting, fishing and other outdoor recreation organisations
Industry representatives, e.g. horse racing, mining, power generation, etc.
Wildlife conservation managers/rangers
Land owners and managers, including farmers, ranchers, property developers, etc.
Regulatory bodies including permit processing officers
Policy advisors/Politicians
Public health organisations
Researchers or universities
Volunteer wildlife groups – e.g. wildlife rehabilitation carers
Pet owners

When selecting stakeholders for the team, priority should be given to those who hold key information or skills and those who will have influence on the communication and implementation of recommendations arising from the DRA.

This list will also form the basis of the all-important communications plan (see risk communication step of the DRA process).

Experts

The level and type of expertise used is one of the most important factors influencing the outcome of the analysis. *Risk analysis* is not the exclusive domain of specialists. While expertise in *risk analysis* can contribute significantly to the process, people who are knowledgeable in appropriate areas of *wildlife* biology and relevant health sciences can carry out a credible assessment of disease risks (Leighton 2002). Each situation will require a specific mix of skills and expertise.

Using the social, political and technical dimensions discussed in the '*Planning and conducting a wildlife DRA*' section of this *Manual*, Table XV summarises a list of skills, attributes and professions that can be of value to those aspects of a *wildlife* DRA process. The wide range of professions listed is a reflection of both the complexity of *wildlife* disease scenarios and the value of taking a transdisciplinary approach.

As not all readers of this *Manual* will be familiar with the skills associated with all of the professions listed, a brief synopsis of the skill sets associated with a selection of them is provided below.

Wildlife managers

These are generally government or NGO (e.g. community conservation group) representatives responsible for coordinating management decisions for endangered or threatened species. They are able to provide context on current species management programmes and advice on requirements for government permits for *risk management* initiatives. Managers of *ex situ* (captive) and *in situ* (free-ranging) *wildlife* can also bring in-depth knowledge of the biology and behaviour of the *wildlife* species under consideration and the practicalities of working with them. They may also be able to access some of the resources available for research targeted at priority knowledge gaps and *risk management* implementation through their affiliated organisations.

Wildlife veterinarians

All veterinarians receive a broad training in the prevention, investigation, diagnosis and medical and surgical treatment of domestic animal ailments. Their training, which also includes specialist topics such as nutrition, animal reproduction and toxicology, focuses primarily on horses, cattle, sheep, goats, pigs, dogs, cats and poultry. *Wildlife* veterinarians have additional postgraduate training or experience in the application of veterinary skills to captive or free-living *wildlife*. They have a strong focus on disease prevention and, as such, have a good understanding of disease risk assessment and *risk management* (Fowler 1986; Franzman 1986). In addition, *wildlife* veterinarians may bring knowledge and skills in chemical and physical capture, restraint and transport of *wildlife*, disease *surveillance* and *monitoring*, diagnostic sample collection, storage and transport, interpretation of diagnostic results and the development of pre-translocation *quarantine* and health screening protocols.

Epidemiologists

Veterinary and medical epidemiologists study the patterns of disease occurrence in populations and the factors that influence these patterns. (Thrusfield 2007). They focus on investigating animal populations rather than individual animals and aim to:

- determine the origin of a disease the cause of which is unknown
- investigate and control a disease the cause of which is either unknown or poorly understood
- acquire information on the ecology and natural history of a disease
- plan, monitor and assess disease control programmes
- assess the economic effects of a disease.

They can therefore advise on disease event patterns in a population and the factors that influence their occurrence. They can also identify *risk factor*s for disease and determine optimal treatment and management options, advise on the use of methods to compare the impacts of different *risk management* options and provide guidance on outbreak investigation, study design, data collection and analysis and documentation of results.

Table XV
Skills and attributes that can be of value to a wildlife DRA process

	Skill or attribute	Who might have these skills
Social	Working with communities	Social scientists
	Group facilitation	Facilitators
	Cultural understanding	Cultural advisor
	Communication	Communications practitioners (e.g. employed in media, public relations, marketing)
	Project review	Evaluator, auditor
Political	Influence	Individuals whose opinions are likely to influence stakeholders e.g. community leaders (councillors, heads of pertinent local organisations or cultural groups, politicians, prominent scientists and spokespeople?)
	Policy, regulations and guidelines (national/ international)	Policy advisor
	Legal advice	Environmental lawyer
	Up-to-date knowledge of relevant legislation, permits (e.g. CITES), etc.	Government agency representatives
	Understanding of transboundary disease issues	Government agency representatives, e.g. in the areas of customs and biosecurity
Technical	Wildlife management, biology and ecology	Ecologist, biologist, wildlife manager
	Wildlife health and disease including diagnostic tests and their interpretation	Wildlife veterinarian Epidemiologist Laboratory scientist (e.g. pathologist, virologist, microbiologist, toxicologist, etc.)
	Zoonotic diseases	Veterinarian Public health doctor Epidemiologist
	Disease risk analysis	Risk analyst Statistician
	Disease modelling	Disease modeller, Climatologist Population biologist Geneticist Reproductive biologist

Wildlife ecologists
Ecologists study the relationships between organisms and their environments. An ecologist can provide insight into the interactions between organisms within the study site and between them and their habitat. A number of specialist disciplines have arisen from the subject of ecology. For instance, some ecologists specialise in reintroduction biology, the process of translocating populations to re-populate previous habitat from which they have been eliminated, establishing populations in 'safe' locations, or supplementing depressed populations. They bring experience in logistical and animal handling approaches to maximise survival of translocated animals. A disease ecologist can provide insight into factors affecting the *transmission*, rate of spread and maintenance of disease within a population and the dispersal and density of the population (Animal Health Australia 2011).

Public health doctors
The discipline of public health focuses on the prevention of diseases and the promotion of health in people and forms part of the training of both medical and veterinary practitioners. Of value to *wildlife* DRA is their understanding of zoonotic diseases, i.e. diseases naturally transmitted between humans and other vertebrate species, e.g. rabies and psittacosis. Given the widespread and growing interaction between people and *wildlife*, most *wildlife* DRAs should include consideration of zoonotic disease transfer risks. Individuals with this training can provide advice on measures available to manage these risks.

Given their potential value at the planning, problem formulation and implementation steps of the DRA, two further skill sets are described: those of evaluation and facilitation.

Evaluators
Evaluation is 'the process of determining the merit, worth or value of something or the product of that process' (Scriven 1991). Trained evaluators bring a broad range of data-gathering, critical thinking and analytical skills. Where possible, it is valuable to involve an evaluator when developing an evaluation framework at the outset of planning the DRA (Appendix 6, p. 118). A good evaluator will greatly assist the clarification of research questions during the problem formulation step and ensure that data to be gathered to answer the review question 'How will I know if I have succeeded?' is identified and planned for. The inclusion of an evaluation plan (Appendix 6, p. 118) as part of the DRA process and its implementation will provide the basis for the *monitoring* and review stage of *risk management*. This, in turn, will provide the basis of an adaptive management process (Fig. 8) enabling the need for adjustments to the *risk management* programme and improvements to future DRA processes to be identified.

Facilitators
In a DRA workshop setting, a neutral, experienced facilitator can be a valuable resource for the team. Facilitators help groups to clarify their goals and ensure full participation and mutual understanding while fostering inclusive solutions and cultivating shared responsibility (Kaner *et al.* 2007). While it can be an advantage for the facilitator to be familiar with the meeting's subject matter, he or she must remain neutral to the content and focus on the group's processes. This is vital given the passion and strongly held views often aired at *wildlife* DRA workshops, and the occasional need to resolve conflicts! To be effective, facilitators need to be involved during the earliest stages of planning the DRA process.

Appendix 6
Evaluation planning

R.M. Jakob-Hoff

In a DRA project there are two aspects that should be subject to formal evaluation:

– the DRA process itself, and

– the outputs of the process that are the *risk management* actions.

Consequently an evaluation plan should be developed during the problem description step and additional evaluation questions developed as part of the *risk management* step. In both cases goals and strategies are formulated and, for each one, the question asked 'How will success be measured?'.

Table XVI provides an example of an evaluation plan (sometimes referred to as a 'programme logic model') used in planning a DRA for Tasmanian devils within a Conservation Breeding Specialist Group (CBSG)-facilitated conservation planning workshop. This is a tool that can be used to clarify, document and establish a common understanding of the project and to ensure the reasons for pursuing a particular course of action are open and transparent for all involved. The DRA team should collaboratively develop an evaluation plan during the problem formulation step of the DRA project.

Developing and using this framework can involve considerable discussion among team members, and tends to lead to a much clearer and more realistic DRA plan than one drawn up in isolation. *Time must be allowed for this participatory process*. The more participatory the process, the more it can help to ensure common understanding of the project among all participants. In line with the adaptive management approach, evaluation plans are living documents and should be continuously refined as new information comes to hand. They require careful review and, often, several revisions.

An explanation of the steps in developing an evaluation plan follows.

1. Initially the goal for the DRA, as agreed to in the problem description step, is noted above the table. All subsequent objectives are developed as a means of achieving this goal.

2. The first column of Table XVI lists the specific objectives of the *risk analysis*. As far as possible, you should formulate SMART objectives – which are specific, measurable, achievable, realistic and time dependent.

3. The second column of the table explains the reason or rationale behind each objective, i.e. why this objective is important. This is a 'clarification' step and, when discussed, will often lead to a refinement of the objective.

Table XVI
Evaluation plan for a Tasmanian devil DRA workshop (excerpt)

Goal To establish an evidence-based disease risk management plan for Tasmanian devils within the context of an insurance population management plan using the best available information, analytical tools and expertise.

Specific objectives (What?)	Rationale (Why?)	Strategies (How?)	Evaluation questions	Sources of data
By 7 July 2008, to review and analyse the disease risks associated with management of an insurance population of devils	Management of an insurance population will involve *ex situ* management and periodic movement of animals between metapopulations Identification and analysis of associated disease risks will enable appropriate risk mitigation measures to be established	Follow a structured *disease risk analysis* process Involve key stakeholders, experts and decision makers in DRA	Was a structured DRA process followed? Were an appropriate group of stakeholders, experts and decision makers involved in the DRA? If key individuals or groups were not involved, who were they and why were they not involved?	Organiser's evaluation Organiser's and participant's evaluation Participant's evaluation questionnaire and organiser's follow up with missing individuals
Within the same timeframe, to develop a disease risk management plan that is integrated with the insurance population management plan	A disease risk management plan as an integral component of the insurance population management plan is needed to ensure that disease risks are appropriately and consistently understood and applied by all relevant participants.	Conduct the DRA within the broader framework of a CBSG insurance population planning workshop for Tasmanian devils	Was the DRA included as part of a CBSG insurance population planning workshop for Tasmanian devils	Organiser's evaluation Workshop report

4. The third column states the inputs (activities, processes and resources) to be used to attain the objective. This list is the action plan for the DRA. It is important to be as detailed as possible with this step and to take into account any assumptions made in step 2 above.

5. The fourth column lists the questions that will be needed to monitor and evaluate the effectiveness of the strategies used, the extent to which outcomes were achieved and the extent to which each objective has been met. Both qualitative and quantitative measures are valid and important and should be applied as appropriate.

6. The final column lists the sources of the data needed to answer the evaluation questions and this becomes the DRA monitoring plan. Defining these at the outset will ensure that appropriate processes are put in place to collect relevant data in a format that lends itself to *robust* analysis.

Box 10 lists some possible measures of success for a *wildlife* DRA.

Box 10:
Some possible measures of success for a wildlife DRA

In the context of a wildlife DRA, key measures of success could include:

– The best available data have been used
– Data gaps were identified and prioritised for future research
– Data analysis was as robust as possible (i.e. stands up to peer review) given the levels of uncertainty (assumptions are explicitly stated) and the available tools, resources (time, funds, technology, etc.) and expertise.
– Risk management recommendations were supported by key stakeholders and decision makers
– Risk management actions have been, or are being, implemented, monitored, reviewed and refined over time.

These measures could be framed as the objectives for a DRA exercise and used to generate suitable evaluation questions to anticipate and avoid any potential obstacles to success.

Appendix 7
Example wildlife DRA summaries

B. Rideout

As this *Manual* is the first published articulation of the application of *disease risk analysis* from a specific biodiversity conservation perspective, it has not been possible to locate existing publications that follow the format outlined in this *Manual*. The following case studies have been compiled retrospectively from the author's personal experience and are included here to illustrate how a wide variety of DRAs could be summarised following the format outlined in this *Manual*. Given that the examples are based on retrospective material not all components of a full DRA were completed. This in itself provides insight into the potential value of each of the sub-steps of the process as illustrated in Figure 4.

We encourage others who choose to follow the systematic process described in this *Manual* to publish their work and increase the case studies available as examples to colleagues around the world.

Example 1: Interruption of California condor (*Gymnogyps californianus*) release programme

References

Unpublished conservation programme documents.

Risk communication

Stakeholders involved in the *risk analysis* and decision making included our clinical veterinarians, California condor breeding programme managers, and US Fish and Wildlife Service California condor recovery programme staff.

Problem description

Context
The California condor is one of the most endangered birds in North America. By 1987, only 27 birds remained, all in captivity. The recovery programme involves captive propagation in several isolated and relatively *biosecure* facilities, with release at several locations in the south-west United States and Baja California, Mexico. By locating the breeding facilities near the release sites and keeping the breeding flocks relatively isolated from other birds, releases can occur with minimal disease screening (because the wild populations would be exposed to the same pathogens as the captive breeding flocks, neutralising any disease risks). The primary disease surveillance tool is routine health *monitoring* of the population and thorough post-mortem examinations

on all birds that die. Although the mortality rates in the captive breeding flocks are very low, one facility experienced the unexpected loss of a parent-reared nestling at three months of age. A thorough post-mortem examination revealed that the chick died from a poxvirus infection that had spread through all of the internal organs. Poxviruses more typically cause self-limiting skin infections. This type of systemic virus spread had not been seen in any captive or free-ranging California condors in the past and raised questions about the source and significance of the virus. Until these questions could be resolved, no further releases were allowed from this facility. Because the breeding programmes operate at maximum capacity, there is little space to house juvenile birds if releases are interrupted, so this situation created a serious management problem due to lack of holding space for the birds originally destined for release.

Goals, scope and focus
The goal of the recovery programme is to maximise the population of California condors and eventually re-establish self-sustaining populations in the wild. The goal of this risk assessment was to answer the following questions:

1. Was this poxvirus a newly introduced virus in the region that might pose a threat to the wild population or just a low-risk endemic agent that for unknown reasons caused an overwhelming infection in this nestling?

2. What is the normal host for the virus, and would that host probably already be a natural source of exposure for wild California condors?

Assumptions and limitations
The chief limitations with this approach are that it requires a rapid and technically challenging response, and it assumes that in a reasonable time-frame we can characterise the virus and determine its normal host.

Discussion of acceptable levels of risk
The risk tolerance is low for this project because the California condor population size is still low and the geographic range is very restricted. Any introduced disease that could limit the ability to establish self-sustaining populations in the wild would be devastating.

Hazard identification

Hazard list
The only hazard of concern at this point is an unidentified avian poxvirus.

Hazard categorisation (infectious/non-infectious)
Infectious.

Initial hazard prioritisation (identification of hazards of concern for full risk assessment)
Avian poxvirus.

Graphic depiction (e.g. scenario tree) of the biological pathways leading to exposure of the susceptible animals or people to each the hazards of concern)
Not used.

Risk assessment

Release assessment
Although avian poxviruses are not known to cause *latent infections*, there is a possibility of chronic or inapparent infections that could result in release (assuming that this agent is not already present in Condor release areas). In addition, the persistence of the agent in the environment increases the risk of release through mechanical or fomite transmission.

Exposure assessment
Condors frequently congregate at carcases and water sources in the wild, which results in high potential for exposure if release of a novel poxvirus were to occur.

Consequence assessment
Systemic poxvirus infections are normally a rare and isolated occurrence. If this virus has a higher potential to cause systemic infection, the consequences could be significant, such as causing sufficient mortality to prevent the establishment of self-sustaining populations in the wild.

Risk estimation
The risk estimation concluded that the questions above needed to be addressed before releases from this captive breeding population could continue.

Risk management

Option evaluation
Based on the above analyses, the risk mitigation plan required the sequencing of portions of the poxvirus DNA to determine the strain type and then conducting surveillance for this strain in wild birds that would be sympatric with California condors.

Implementation

Action planning
The Wildlife Disease Laboratories at San Diego Zoo Global were responsible for poxvirus sequencing and opportunistic surveillance of wild birds.

Monitoring and review

The highest prevalence of poxvirus infections in wild birds in this geographic region was seen in common ravens (*Corvus corax*) and California towhees (*Pipilio crissalis*). The DNA sequence of the common raven virus did not match the sequence of the California condor virus. However, the sequence of the California towhee virus was a 100% match with the California condor virus. This California towhee poxvirus has also been seen in other native birds throughout North America, indicating that it is an endemic virus in this part of the world. Since California towhees are abundant in California condor release areas, the conclusion was that exposure of the wild population had probably already occurred. Releasing additional California condors from the affected facility would not pose any additional disease risk to the wild population. Releases therefore resumed and no additional problems have been seen.

Example 2: Identification and mitigation of the cause of *Gyps* spp. vulture declines in Asia

Risk communication

Stakeholders involved in the *risk analysis* and decision making included veterinarians, biologists, representatives of NGOs, political officials and government agency representatives in several Asian countries. However, the process was not structured as a formal risk assessment and communication plan, but rather evolved as research results became available and public awareness increased.

Problem description

Context

The oriental white-backed vulture (*Gyps bengalensis*), long-billed vulture (*G. indicus*) and slender-billed vulture (*G. tenuirostris*) were once among the most common birds across south Asia, but a catastrophic decline beginning in the 1990s resulted in a population decline of greater than 95%. This decline has had tremendous conservation, cultural and public health significance, since these vultures are the primary means of carcase clean-up from the agricultural industry and are also important in some human funeral ceremonies.

Goals, scope and focus

The goals were to identify the cause(s) of the decline and implement effective mitigation strategies as rapidly as possible.

Assumptions and limitations

A diverse array of assumptions and limitations made the task very difficult. The pattern and spread of the population declines were assumed by many to be consistent only with transmissible causes (Cunningham *et al.*, 2003), so initial investigations focused primarily on viruses and other infectious agents. The investigations were challenging in part because of the difficulty in obtaining fresh carcases for post-mortem examinations, the lack of local expertise in field investigation of *wildlife* diseases, a lack of rapidly available funding, and the number of countries and government agencies involved. Whatever the cause of the decline, it was assumed that government intervention would be required to address the problem, so conclusive findings and clear risk communication were expected to be critical.

Discussion of acceptable levels of risk

The risk tolerance for mitigation failure was low because of the rapidity of the decline, the expected slow recovery of such a long-lived and slowly reproducing species, and the public health ramifications of accumulating carcases (such as the expansion of the feral dog population and associated increases in the rabies risk).

Hazard identification

Comprehensive hazards list:

The group that identified the cause of the decline began with a very broad list of potential hazards based on a case definition arising from the field investigations. The hazard list included infectious agents such as novel viruses, mycoplasmas, other bacteria, natural and man-made toxins and environmental conditions.

Hazard categorisation (infectious/non-infectious)

Both infectious (transmissible) and non-infectious hazards were considered.

Initial hazard prioritisation (identification of hazards of concern for full risk assessment)

Because of the broad nature of the hazard list, all categories of causes remained high priorities for investigation. A decision was made to proceed with parallel investigations of:

- toxic aetiologies (causes) through tissue analysis for organic and inorganic toxins,
- a transmission study involving captive birds inoculated with material from affected birds to determine if an unidentified infectious agent was involved.

Ultimately the cause of decline was determined to be the contamination of cattle carcases with the veterinary drug diclofenac (Oaks *et al.* 2004). Birds feeding on carcases of cattle treated with diclofenac experienced acute kidney damage and died rapidly from secondary renal gout.

Graphic depiction (e.g. scenario tree) of the biological pathways leading to exposure of the susceptible animals or people to each the hazards of concern)
Graphic representations were not used, but once diclofenac was identified as the apparent cause of the population declines, a modelling study confirmed that the observed prevalence of diclofenac in cattle carcases was sufficient to explain all of the observed population declines (Green *et al.* 2004). This helped rule out other avenues of exposure, such as water contamination.

Risk assessment

Release assessment
Shortly after the identification of diclofenac as the cause of the vulture's decline, the prevalence of the drug in domestic cattle carcases was assessed and found to be high (Green *et al.* 2004). 'Release' had already occurred on a large geographic scale, requiring high-level government intervention to prevent ongoing release and exposures.

Exposure assessment
Exposure required only a single feeding on a contaminated carcase. Bioaccumulation does not occur in the food chain or the environment, so mitigating exposure required only prevention of exposure to carcases of treated cattle.

Consequence assessment
The consequences of ongoing exposure included the probable extinction of several *Gyps* vulture species, an increasingly unsanitary environment due to accumulation of decomposing carcases, and rapid increases in other scavenger populations, such as feral dogs, with an increased risk of human rabies and other *zoonoses* (Markandya *et al.* 2008).

Risk estimation
The consequences of widespread diclofenac exposure were already being felt by the time the drug was identified as the cause of the vulture's decline, so it was obvious that continued population declines and all of the associated negative outcomes would occur unless there was effective mitigation of the exposure risk.

Risk management

Option evaluation
The only option that could be implemented on a sufficiently large scale and rapid timeline was a government ban on the use of diclofenac in animals.

Implementation

Action planning
Meetings with appropriate stakeholders and government officials led to bans on the veterinary use of diclofenac in India and Pakistan by 2006. In order to improve compliance with the ban, additional research by several groups lead to the identification of non-toxic alternative drugs, as well as the identification of other non-steroidal anti-inflammatory drugs that were as toxic to vultures as diclofenac (Swan *et al.* 2006).

Monitoring and review
Monitoring the effectiveness of the diclofenac ban reveals that the prevalence of contaminated carcases has dropped dramatically, but enough contaminated carcases remain to cause ongoing population declines of approximately18% per year (Cuthbert *et al.* 2011). Obstacles to success include the fact that diclofenac is easy to manufacture and there are hundreds of small factories continuing to produce it, the drug is sold on the human pharmaceutical market without prescription, so it continues to be available to farmers and veterinarians in pharmacies, and the non-toxic replacement drug is perceived as being less effective. A number of NGOs continue to work on improving the effectiveness of the mitigation strategies.

Example 3: Pacific island psittacine translocation

References

Unpublished conservation programme documents.

Risk communication

Stakeholders involved in the *risk analysis* and decision making included agriculture and *wildlife* officials at the national and local government levels for the source and destination islands, as well as independent experts reviewing the plans.

Problem description

Context
A small psittacine species is listed as CITES Appendix II because its distribution is limited to one small South Pacific island and is therefore vulnerable to extinction from a variety of catastrophic events, such as a typhoon.

Goals, scope and focus
The goal of the project is to translocate a small group of these psittacines from the source island to a destination island within its original historical range in order to establish a second population as a hedge against extinction.

Assumptions and limitations
A major assumption in the *risk analysis* was that the sole remaining population of the target species has remained isolated from unnatural disease exposure due to the remoteness of the source island and the historical lack of an airstrip or tourist activities. In addition, the lack of other psittacines on the destination island reduced the list of diseases of concern to those that have a broad host range (beyond psittacines).

In order for the translocation to be acceptable and successful, the destination island had to meet the following limiting criteria:

– be within the original historical range of the species
– be free of other psittacine species
– be free of introduced ship rats (*Rattus rattus*), which are known to have extirpated other native psittacines, and
– have the support of the local people.

Discussion of acceptable levels of risk
Although the risk of significant disease introduction to the destination island is low, the risk tolerance is also very low. This is because there are other endangered avian species on the destination island that would be vulnerable to a catastrophic disease outbreak, and the destination island is under the governance of a different country than the source island.

Hazard identification

Comprehensive hazards list
There was no available disease surveillance data for the population, but historical evidence suggested that the population had been stable and without any documented disease outbreaks or mortality events for at least several decades. The comprehensive hazards list was developed from the global scientific literature on psittacine diseases, but the task was problematic because most of the agents of concern were documented in birds from the global pet trade rather than from wild populations.

Agents of concern with potentially broad host ranges included polyomaviruses, paramyxoviruses, herpesviruses, circoviruses, avian influenza, haemoparasites, gastrointestinal parasites and ectoparasites.

Hazard categorisation
(infectious/non-infectious)
The only non-infectious hazard of concern was mortality associated with holding for *quarantine*. Because of this concern, and the long history of isolation on the small source island, there was no strict quarantine period. The translocation plan called for birds to be released in two weeks or less, with daily health *monitoring* during the holding period.

Initial hazard prioritisation (identification of hazards of concern for full risk assessment)
The following hazards were determined to be the highest priority based on expert opinion and the literature regarding their broad host range, transmissibility and potential population-level effects.

– paramyxoviruses
– circoviruses
– avian influenza viruses (H5 and H7 strains owing to regulatory concerns)
– ectoparasites.

Graphic depiction (e.g. scenario tree) of the biological pathways leading to exposure of the susceptible animals or people to each the hazards of concern
Not used.

Risk assessment

Release assessment
The likelihood that the hazard was present or would be released was considered low for paramyxoviruses and avian influenza because recent exposure was considered unlikely, the agents do not survive long in the environment and they do not cause persistent infections.

The likelihood of presence or release was considered low to moderate for polyomaviruses, herpesviruses and circoviruses, and high for haemoparasites, gastrointestinal parasites and ectoparasites (see exposure assessment).

Exposure assessment
The likelihood of exposure for most viral agents was considered low to moderate because close contact would be required. Close physical interaction with other avian species on the destination island was not expected and the target species would be the only nectar and pollen specialist on the island, so exposure at shared feeding sites was considered unlikely. Exposure to haemoparasites was considered likely because comparable arthropod vector populations were present on both the source and the destination islands. Exposure to gastrointestinal parasites and ectoparasites was also considered likely because of the environmental persistence of the infective stages of some agents.

Consequence assessment
For paramyxoviruses, the biological consequences were considered potentially significant if there was a host-adapted virus that was non-pathogenic in the psittacines but had unknown potential to spill over

into other species and cause disease. The likelihood of this was considered low, however. There was also a concern over the regulatory consequences of any positive test results because of potential confusion with exotic Newcastle disease.

The consequences of establishing a novel circovirus or polyomavirus on the destination island were considered significant because of the potential for these agents to cause population-limiting disease, survive for extended periods in the environment and cause persistent infections.

The consequences of avian influenza virus establishment were largely a regulatory concern because a variety of avian influenza strains are probably present already in aquatic birds on both the source and destination islands.

The consequences of establishing new ectoparasites, such as blood-sucking mites, were considered potentially significant. Some ectoparasites can cause lethal infections in individuals, and disrupt nesting behaviour in populations.

The consequences of establishing haemoparasites on the destination island were considered relatively low because any agents present would probably be distributed through all the islands in the region.

Risk estimation
The risk estimation concluded that screening for viruses and parasites with a potentially broad host range was warranted.

Risk management

Option evaluation
Based on the above analyses, a risk mitigation plan was developed that involved testing cloacal swabs by PCR for the viruses of concern (polyomaviruses, circoviruses, paramyxoviruses, and avian influenza H5 and H7 strains). PCR was determined to be the best testing option because it does not rely on species-specific reagents and in this case did not require blood sampling.

The mitigation plan for ectoparasites involved careful inspection of captured birds and treatment with insecticide spray.

However, the birds could not be safely held in quarantine until test results were available. Consequently the mitigation plan called for release of the birds as soon as possible after capture and ectoparasite treatment, but with lethal removal of the released birds if test results later came back positive (and were confirmed by additional testing).

Implementation

Action planning
Consensus on the risk assessment and mitigation plan was achieved with all of the stakeholders. Implementation fell to the *wildlife* disease specialist on the translocation team and the in-country regulatory veterinarians.

Monitoring and review
There were no mortalities or other adverse outcomes during the translocation. PCR testing for the agents of concern was negative in all birds. Feather mites were present on all birds and were treated with insecticide spray. No other ectoparasites were found. Subsequent DNA sequencing data from the feather mites revealed that they were probably a novel host-adapted species. Other birds sharing the same habitat on the source island, such as *Acrocephalus* sp. reed warblers and domestic poultry, had their own unique feather mite species, so it appears that host switching is not common with these ectoparasites.

Post-release *monitoring* was the responsibility of the project leader and assigned staff on the destination island. *Monitoring* has been ongoing since the release, with success determined by the growth of the released population and the absence of negative impacts on other native bird species. Periodic project updates have been submitted to the government agencies overseeing the project.

Appendix 8
DRA example: Mountain gorilla, using Stella™ software

(From Unwin and Travis 2009)

Participants

Laura Hungerford, Patty Klein, Mike Cranfield, Genevieve Dumonceaux, Barbara Corso, Mark Atkinson, Shelley Alexander, Dominic Travis, Tom Meehan, Jim Else, Sue Brown.

Step 1 – Tell the story

Bwindi Park gorillas. Trackers and guides are the source. Scabies originates from the local community and is one of the few diseases that does *not* stem from the trackers and guides. The disease of most concern for the gorillas is measles (affects the population for a few months) and tuberculosis (continually affects the population)

Step 2 – Define the questions

Risk of transmission of disease to the gorillas (from the identified sources).

What is the likelihood of introducing scabies into the habituated gorilla population?

What is the likelihood of introducing cryptosporidia into the habituated gorilla population?

What is the likelihood of introducing measles into the habituated gorilla population?

The species of concern are:

- humans
- gorillas
- other (habituated) primates.

Step 3 – Map the pathways (Fig. 45)

Procedures done at all points:

- In the tracker and guide/community/agricultural activity area: community health programmes (basic) and basic veterinary care
- In the staging/health-screening area: educational programme

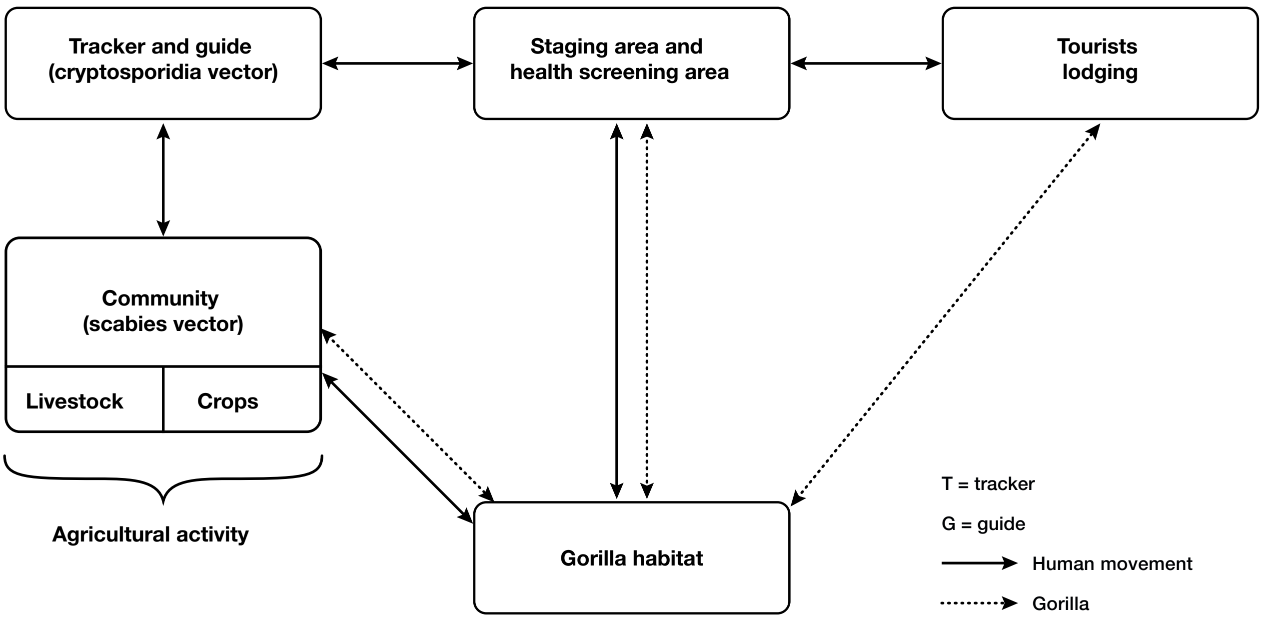


Fig. 45
Step 3 – Map the pathways

Step 4 – Identify all potential sources

a) Scabies transmission pathways (Fig. 46)

Identify all potential sources for scabies transmission

Source point	Hazard risk assessment
Trackers and guides	Low
Local community	High
Livestock/crops	None
Staging/health screening area	Low
Tourist lodging	None
Gorilla habitat	High

Assumptions and conclusions

The probability of transmission from trackers and guides is low.

The critical control point (CCP) is gorilla movement to and from the community.

CCPs are within the community, gorilla to gorilla within the habitat, and community to gorillas.

b) Cryptosporidia transmission pathways (Fig. 47)

Identify all potential sources for *Cryptosporidium* transmission

Source point	Hazard risk assessment
Trackers and guides	High
Local community	Low
Livestock/crops	High
Staging/health screening area	Low
Tourist lodging	Low
Gorilla habitat	High

Assumptions and conclusions

Not critically significant.

The four CCPs are: gorilla to livestock; livestock to trackers and guides; staging area to gorillas; trackers and guides to gorillas.

c) Measles transmission pathways (Fig. 48)

Identify all potential sources for measles transmission

Source point	Hazard risk assessment
Trackers and guides	Low (>0)
Local community	Low (>0)
Livestock/crops	None
Staging/health screening area	Low (>0)
Tourist lodging	Low (>0)
Gorilla habitat	None

Assumptions and conclusions

The probability of transmission from trackers and guides or tourists is extremely low, but the effect if it occurs is really bad.

The risk of transmission is extremely low.

The CCP is within the gorilla population.

There is a need to modify the destination population.

d) Tuberculosis transmission pathways (Fig. 49)

Identify all potential sources for tuberculosis transmission

Source point	Hazard risk assessment
Trackers and guides	Medium to moderate
Local community	Medium to moderate
Livestock/crops	Low
Staging/health screening area	Medium to moderate
Tourist lodging	Low
Gorilla habitat	None

Assumptions and conclusions

There is an extremely low risk of transmission.

There is no effective treatment, and it is a significant health problem in terms of morbidity/mortality.

The CCPs are within the community and gorilla to gorilla.

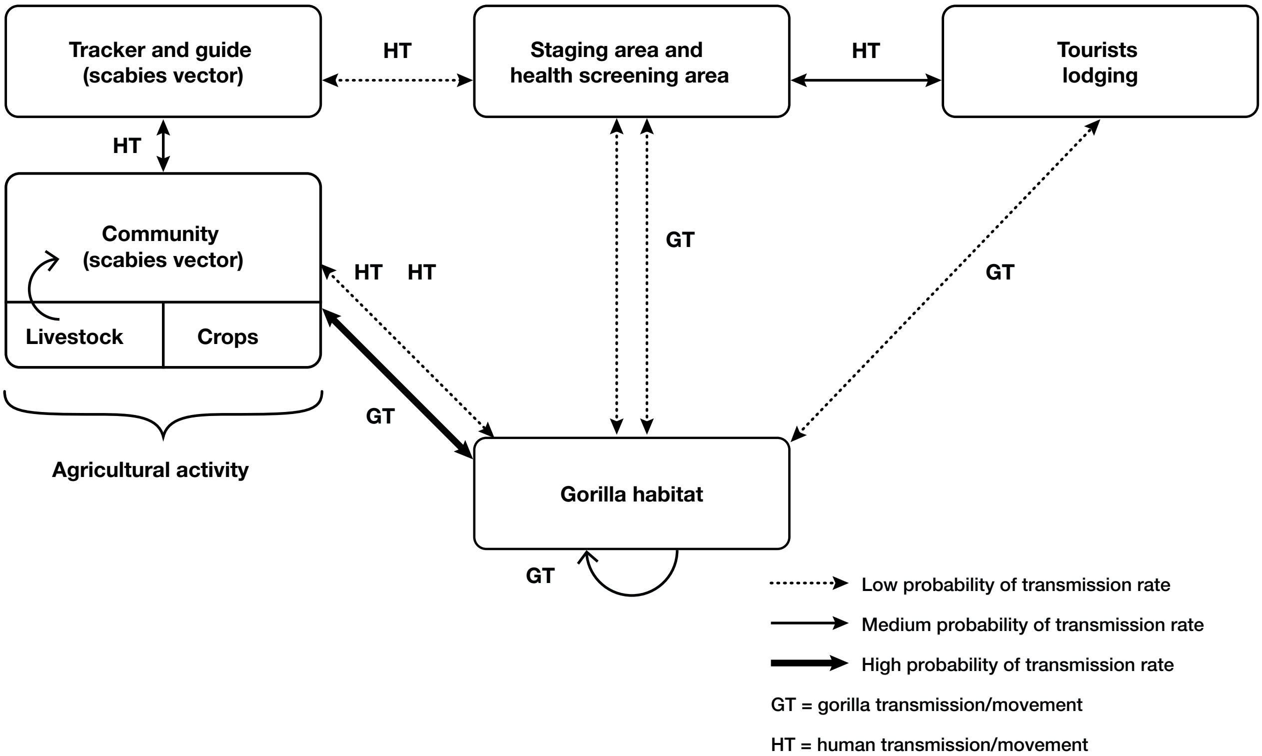


Fig. 46
***a)* Scabies transmission pathways**

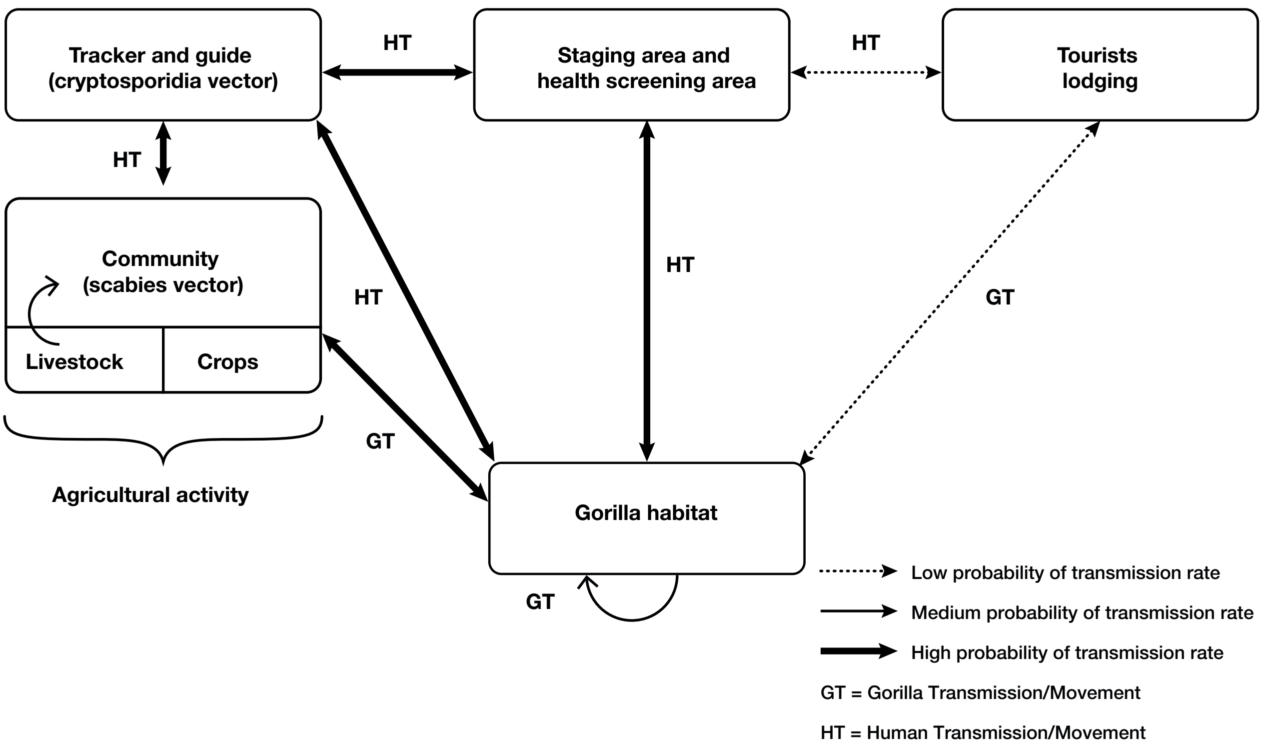


Fig. 47
b) Cryptosporidia transmission pathways

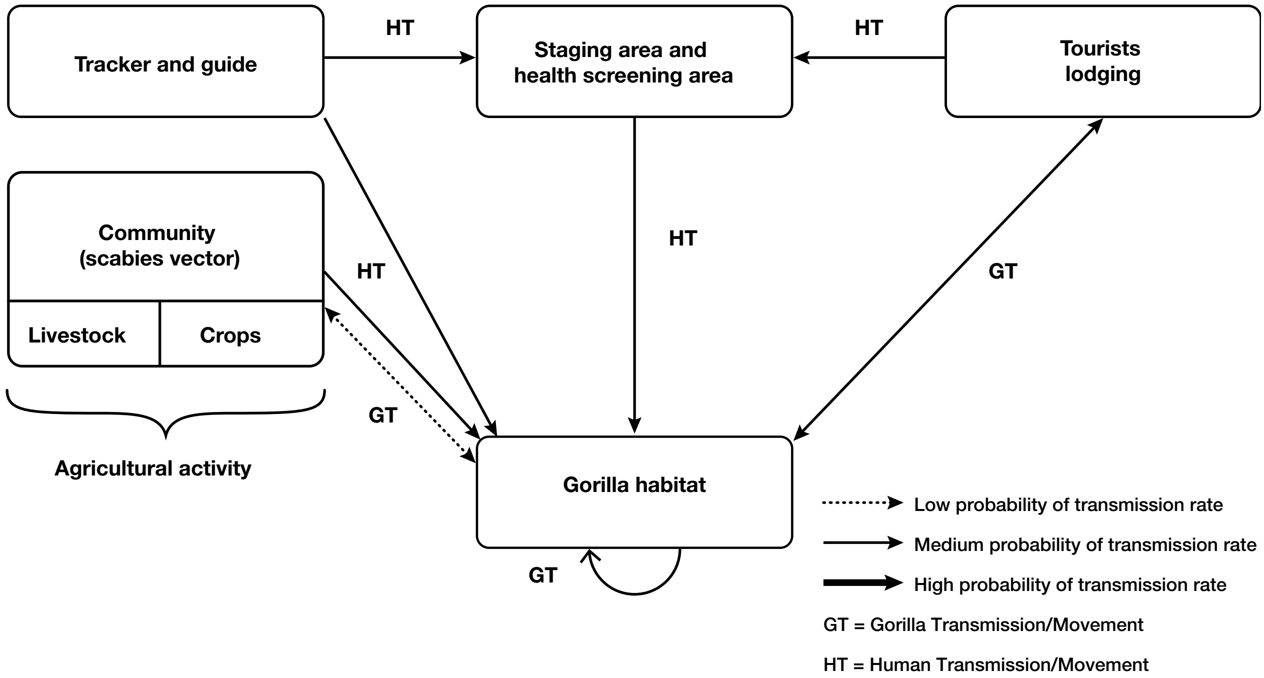


Fig. 48
***c)* Measles transmission pathways**

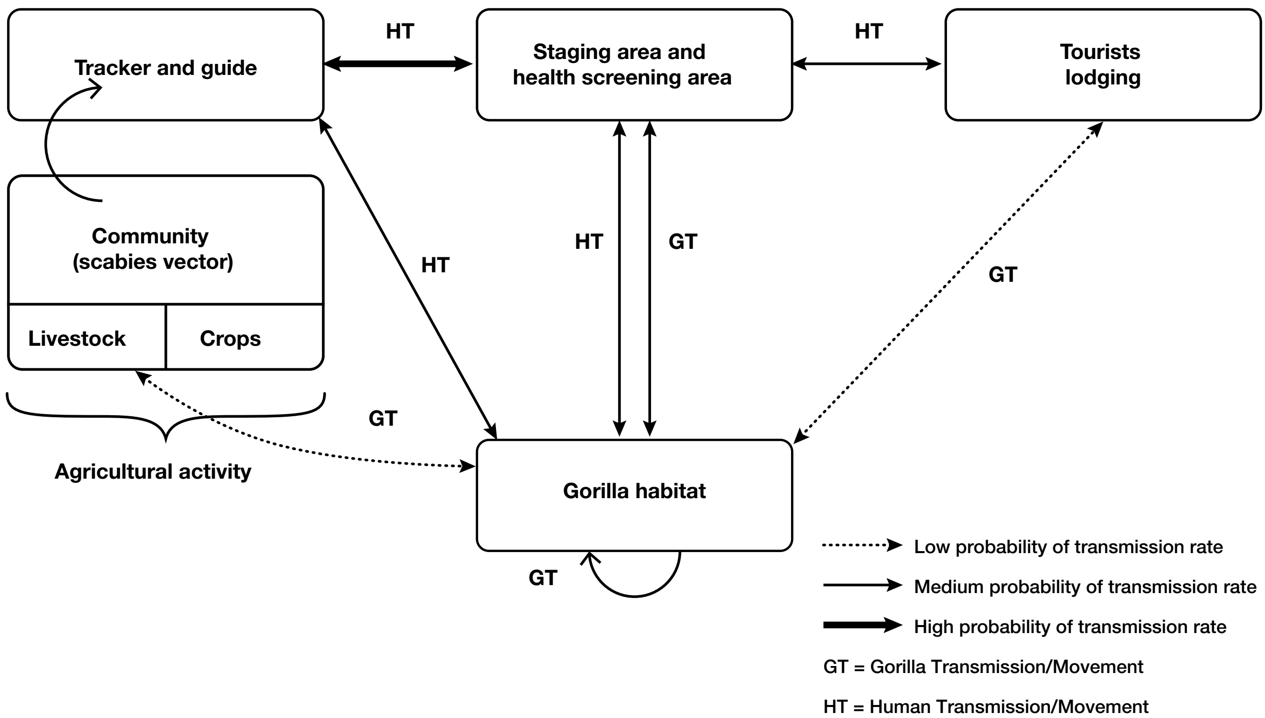


Fig. 49
***d)* Tuberculosis transmission pathways**

Actions

Community control point

- Increase community and public health programmes/education.
- Employee health programmes.
- Increased livestock health programmes/education.
- Create buffer zone.

Staging area control point

- Tracker and guide personal hygiene.
- Tourist personal hygiene.

Habitat control point

- *Vaccination* programme.
- Treatment.

Stella™ Software (www.iseesystems.com)

Working group summary of diagram

The Stella programme is designed to see patterns in dynamic situations. We developed this *model* as a working draft to allow the group to become familiar with the Stella programme.

Set up:
Modelled as transmission of disease among gorillas, transmission among children of trackers, transmission among other children in the village, trackers used as route of exposure of measles to the gorillas.

Assumptions:
gorillas contract measles (from humans and each other)

- humans act as *fomites* for the measles virus
- trackers developed immunity to measles as adults
- naive populations = all but trackers
- negligible impact of transmission tracker to tracker.
- closed populations
- random contacts
- random dispersal
- human adults that are not trackers are irrelevant (only trackers have contact with gorillas)
- all people infected recover and gain immunity.

Identifying data:
other children= 5,000

- trackers' children= 700
- trackers = 110
- gorilla population = 320
- non-contact gorillas = 60
- contact gorillas = 260
- vaccine programmes have 98% efficacy for gorillas and people
- contact rate sick child to child is 1:10
- contact rate for trackers to gorillas in contact groups is 1:20
- contact rate for non-contact gorillas to contact gorillas is 1:2

Run and evaluate scenarios

1. Measles goes through the population.
2. Vaccinate just the trackers children.
3. Vaccinate all children.
4. Vaccinate gorillas only.

Results of simulations

Vaccinating the gorillas only was the most effective way to minimise the incidence of measles in the gorilla population.

Re-evaluate *model* again, and again and again …

Summary

Process of developing the model
Identification of the problems to address. Assemble a group of individuals with diverse experience and training. Employ someone who has knowledge of Stella. Begin to draw a conceptual picture of the problems you are addressing. Develop assumptions.

Determine the CCPs of the *model*.

Input data into the *model* (if possible use real data, otherwise best estimates). Run the *model*.

Evaluate the data, *model* and graphs resulting.

Re-evaluate the appropriateness of the data entered and the relationships created. Continue to refine and improve the *model* (to infinity).

Question: Does this approach provide benefit in exploring a complex problem?

Answer: Yes, it allows you to visualise the process, to identify CCPs, identify relationships that may not have been obvious and get a clearer idea of the information you need to acquire.

Question: Can this approach give you a quantitative answer?

Answer: With more refinement and enough good data it may give you quantitative answers.

Decision tree cost analysis for human–gorilla measles

Description and interpretation

Three scenarios were assessed. The first involved an assumed prevalence in the in-contact human population of 10% and screening for the disease in these individuals conducted by cursory inspection and observation of clinical signs only. The sensitivity of this method was assumed to be 50%. The cost was assumed to be zero.

Scenario 1: Physical inspection of trackers

In the second scenario the screening test method used was a hypothetical PCR of clinical samples from every in-contact human. The sensitivity of this method was assumed to be 99%. Specificity was assumed to be 75%. Additional assumptions were that positive in-contact humans were excluded from the workforce. Based on this specificity the probability of a false-positive individual is 0.225. This created the requirement for an additional 25 (rounded) individuals on the workforce with resulting labour cost increases. This was also based on a daily application of the method (which may not be realistic at all). The effect of the frequency of PCR testing (daily, weekly, quarterly, annually) on the sensitivity value of the method (not of the test) must be considered. The costs incurred were the test costs and the labour costs. The probability of disease (agent) introduction into the gorilla population was reduced to 0.00005 in this *model*.

Scenario 2: PCR testing of trackers

Assumptions
100 trackers/guards at USD 3/day

PCR test cost = USD 20. Increased sensitivity of PCR increases false-positive rate so that $p = 0.225$, therefore workforce required increases.

The third scenario implemented *vaccination* of the in-contact humans. Vaccine efficacy was assumed to be 99% and therefore prevalence dropped to 1%. Testing was limited to inspection for signs and therefore 50% efficacy was assumed. This approach dropped cost to a one-time investment of USD 2.00 per vaccination or an initial outlay of USD 200 outlay. The risk probability was 0.000025.

Scenario 3: Vaccination of trackers

Assumptions
Vaccine cost = USD 2/dose.

100 trackers/guards vaccinated.

Vaccination reduces prevalence to 1%.

Scenario 1: Physical inspection of trackers

COST?	Parameter	p	Value (USD)	Comment
–	Prevalence	0.1	0	
+	Test	0.5	0	Cursory observation for signs of infection
–	Viability	0.01	0	
–	Transmission	0.5	0	
TOTAL		0.0002	0	

Scenario 2: PCR testing of trackers

COST?	Parameter	(p)	Value (USD)	Comment
–	Prevalence	0.1	0	
+	Test	0.01	25 x 100	PCR oronasal swab
–	Viability	0.01	0	
–	Transmission	0.5	0	
TOTAL		0.00005	2,500	Per test application; need to factor in change in sensitivity due to change in testing frequency

Scenario 3: Vaccination of trackers

COST?	Parameter	p	Value (USD)	Comment
–	Prevalence	0.01	200	Vaccine efficacy reduces prevalence to 1%
+	Test	0.5	0	Inspection for signs
–	Viability	0.01	0	
–	Transmission	0.5	0	
TOTAL		0.00025	200	One time cost

Recommendations

Based on these data and *models* it is clearly more cost beneficial to vaccinate the in-contact humans; however, the use of PCR as a screening test reduces the risk of measles introduction five-fold. These conclusions appear to differ from those obtained using the Stella model. However, this disparity may be due to the complexity of the Stella model, that is, the addition of temporal considerations and additional variables which may affect the outcome.

Risk management/mitigation

Blood sample – minimum 10 mL (6 mL serum, 4 mL whole blood in EDTA [ethylenediaminetetra-acetic acid]), plus enough for at least three blood smears and several drops on filter paper. All samples to be duplicated.

This is a living document and will need to be updated on a regular basis. The samples here are a minimum. All sanctuaries must have access to blood collection and storage equipment and formalin as a bare minimum. Training in the correct use of this equipment will also be required for several sanctuaries.

Notes for on-site veterinarian, in-house laboratory: this refers to the apes only. A second sheet for monkeys will need to be completed.

Table XVII of this section shows part of a disease management chart, this one an example from Limbe Wildlife Centre. For each disease of concern, diagnostic methods and potential management strategies are given, both what is done, and what is ideal. Collation of this data is helpful so risk can be managed, (in this case, across the Pan African Sanctuary Alliance), by highlighting, for example, what everyone considers important to test for, and potential laboratories to assist in investigating those pathogens.

Risk management strategies can be prioritised by creating a risk matrix (Table XVIII). For example, for the new Gorilla Rehabilitation Centre near the Tayna Nature Reserve in the Democratic Republic of Congo, the likelihood of Ebola virus at the centre might be considered medium or high, and the severity would also be high, based on what we know about the pathology of this disease. Therefore it is a disease of high concern. However, if this matrix was at Chester Zoo in the United Kingdom, although the severity for Ebola would still be very high, the likelihood would be very low (we do not currently import animals from areas where Ebola virus is known to exist!). There is software available to assist in the development of risk matrices. For now, it is enough to know that risk matrices exist, and they may be a useful tool in risk management.

Table XVII
Part of a disease management chart – Limbe Wildlife Centre

Disease category	Aetiology (those in bold for inclusion in quarantine disease special interest)	Species	Relative risk	Clinical signs	Diagnostics	If blood samples, what tube, what volume?	For each sample, way and period of conservation	Who can test? (red current)	Treatment if possible/ required	Husbandry	References/ comments	Test as part of normal protocol (T), test in face of outbreak (S)
Viral	Hepatitis A, B, C	All	L	Various – liver associated	Serology	Serum (plain) and plasma (EDTA) 0.5 mL	Freezing, months	JHI, Pasteur/ GAHMU			Not a disease issue, but may need to test for legal reasons?	T (Hep A and B only)
	Encephalomyocarditis virus	All	**M**	Sudden Death	Histopathology	N/A	Formalin, months	JHI/ GAHMU	N/A	Rodent control, cockroach control	More information required?	S
	SIV/ HIV	Chimps	L	Usually asymptomatic	Serology	Serum (plain) and plasma (EDTA) 0.5 mL	Freezing, months	JHI, Pasteur/ GAHMU	N/A		Humans raise antibodies	T
	STLV	Chimps	L	Usually asymptomatic	Serology	Serum (plain) and plasma (EDTA) 0.5 mL	Freezing, months	JHI, Pasteur/ GAHMU	N/A			T
	Ebola/ Marburg	All	**M**	Sudden Death	Serology	Serum (plain) and plasma (EDTA) 0.5 mL	Freezing, months	CIRMF/ GAHMU	N/A			S
	Measles (morbillivirus)	All	L	Maculopapular exanthema	Clinical signs, virus isolation, seroconversion	Serum (plain) and plasma (EDTA) 0.5 mL	Freezing, months	JHI, Pasteur/ GAHMU	N/A		Vaccination?	S
	Polio (enterovirus)	All	L	Asymptomatic or, CNS	Clinical signs	Serum (plain) and plasma (EDTA) 0.5 mL	Freezing, months	JHI, Pasteur/ GAHMU	N/A		Vaccination?	S

GAHMU, Great Ape Health Monitoring Unit
JHI, John Hopkins Institute, Cameroon

Table XVIII
Risk matrix for various primate diseases

Likelihood		Severity: Very low	Severity: Low	Severity: Medium	Severity: High
	High	Non-pathogenic Escherichia coli		Gastrointestinal parasite infections	Ebola virus
	Medium			Introduction of anthelmintic-resistant strains of helminths	
	Low	Exotic strains of non-pathogenic organisms		Stress-induced secondary infections following move	Introduction of human metapneumo-virus
	Very low				

Contingency planning – being prepared

The focus of our contingency planning is to keep the sanctuary operational and avoid entry of the disease, disease in staff, culling animals or closure of the sanctuary.

Example: Tuberculosis

First assess the risk to determine if a contingency plan is required.

Risk assessment: hazard
Infection with tuberculosis complex (human/ bovine):

- primates
- hooved stock.

Legislation/statutory control of tuberculosis:

- OIE
- Public health (country dependant)
- Public perception of human health risk.

Risk assessment: likelihood
Infection of sanctuary animals with tuberculosis:

- currently increasing
- constantly changing.

Legislation to control tuberculosis imposed by government/OIE:

- Often non-existent.

Public perception of human health risk:

- high
- influenced by media coverage.

Likelihood x hazard = risk
Likelihood currently moderate but increasing.

Hazard/stakes – very high:

- limited control of source of infection and potential human health risk.

= Contingency planning necessary …

Aim
To decrease the likelihood of introduction of tuberculosis to, or dissemination from, a sanctuary.

Principles
Control measures are designed to reduce the risk of transmission. The routes of possible transmission and contingencies undertaken are listed below.

Main routes of transmission	Contingencies to reduce risk of transmission to/from sanctuary animals
Wildlife and domestic animals	**Aim – to reduce contact between wild animals and sanctuary animals:** – Domestic cattle around the sanctuary can be vectors – Wildlife mammal vectors are likely and will vary between sanctuaries **Preventative measures:** – Prevent contact between primate's enclosures and domestic cattle, not allowing them to graze in the same area – Minimise contact between wildlife mammals and primates as much as is practical
New arrivals	**Aim – to prevent the introduction of infected animals** **Control measures:** If possible, ask for certified diagnostic test before arrival. Obtain as much history on tuberculosis in all populations, from the area of origin, as is possible **Quarantine:** – Different animal care staff from the sanctuary should administer quarantine – Length: 90 days to identify classic symptoms – Intradermal skin test: two tests to be undertaken during quarantine, 42 days apart, using mammalian old tuberculin, avium and bovine tuberculin – Utilise serology rapid test (Stat-pak) if available – Thoracic radiology, if possible – Sputum and tracheal lavage, if possible. Definitely take tracheal lavage for culture if other testing reveals a possible positive
Food	**Aim – to prevent entry of the disease in infected food products. Food items are not a common source of tuberculosis** **Control measures:** – Controlled origin of the food, specially the green feed that we often offer to our animals
Fomites (vehicles, equipment, crates, clothing and shoes etc.)	**Aim – to prevent disease being transferred to animals, their food or anything they may come in direct contact with** **Control measures should disease be widespread (outbreak):** – Footwear disinfected and all trucks and cars (wheels and wheels arches) that enter the quarantine and sanctuary area
Faeces, waste food, **soiled bedding, etc.**	**Control measures in the event of outbreak:** – Waste products from suspected animals or enclosures must be packed and sealed carefully and separately from all other items – Daily disinfection of soil with approved products recommended for mammalian tuberculosis
Infected humans	**Aim – to prevent the transfer of a disease strain that can infect both humans and animals:** – We would like to make a difference between working staff and visitors – Efforts should concentrate on keeping staff healthy **Recommendations for visitors:** – In the event of an outbreak restrict access to the centre – Always wear facial masks when entering the centre – A short questionnaire on health status is to be undertaken – Prevent visitor access if exhibiting respiratory symptoms – Not less than 10–15 metres between animals and visitors **Recommendations for staff:** – Prophylactic health programme: *in vitro* quick test and Mantoux test – Work wearing facial masks and gloves

Additional points

These contingency measures (Table XIX) are liable to revision as the threat changes and our knowledge of the disease and its control develops. They will be reviewed on a regular basis (minimum monthly).

The contingency of how we would operate and provide care for our animals in the event of a human pandemic is also not covered within this document.

Risk communication

The most important step in the risk analysis process is communication of the risk to all interested parties (your manager, your staff, other veterinarians, your government, peer-reviewed journals, news media, etc.) *and* encouraging dialogue between them. Risk communication is particularly important because the perception of risk by people who do risk analyses can often vary from that of the general public (such

Table XIX
Summary contingency plan

Measures in place (date)	– Test of intradermal reaction against *M. tuberculosis* and *M. bovis* – Quarantine
Measures to be put into effect as quickly as possible **Timing to be supplied as soon as they are known**	Control measures – biosecurity: – Housing/exclusion of wild primates – Restrict human access – Aerosol minimisation – Graded biosecurity – citadel approach Sanctuary dependant
Measures to be put in place in event of outbreak	– Isolation of the sanctuary and positive animals – creation of epidemiological units (Fig. 50) – Stop animal movements – Check all of the collection with quick test and intradermal reaction (*M. tuberculosis*, *M. avium* and *M. bovis*) – Inform the authorities – Possible sacrifice of positive animals

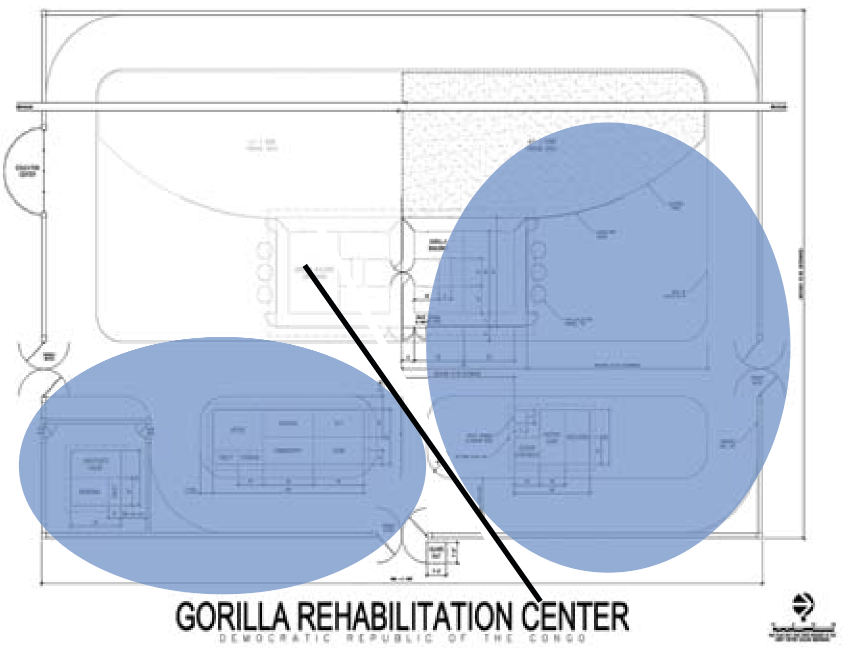


Fig. 50
Creation of epidemiological units
This highlights how your facility can be separated into areas, to prevent the spread of an outbreak to other areas of your facility.

as the local village elders) or your manager. The former (us) may argue that risk should be determined objectively by the 'data alone', whereas the latter may 'irrationally' colour their perception of risk by subjective factors, often called 'outrage factors'. Reality is usually somewhere in the middle.

Since society generally reacts more to outrage than 'mere hazard', an important part of risk communication is to make serious hazards 'more outrageous', and modest hazards less so. Gruesome graphic government campaigns highlighting the dangers associated with driving under the influence of drink or drugs, or some of the educational material used to inform on the transmission of Ebola virus (Fig. 51) are examples of increasing outrage. The extent to which the 'public' accepts risks is clearly related to the degree of outrage.

So, risk communication should not be an afterthought. Consideration of communication of the results of a risk assessment is essential in both defining the hazard and the risk question, as well as formulating the approach to the whole risk analysis. Otherwise the whole exercise will be rendered useless.

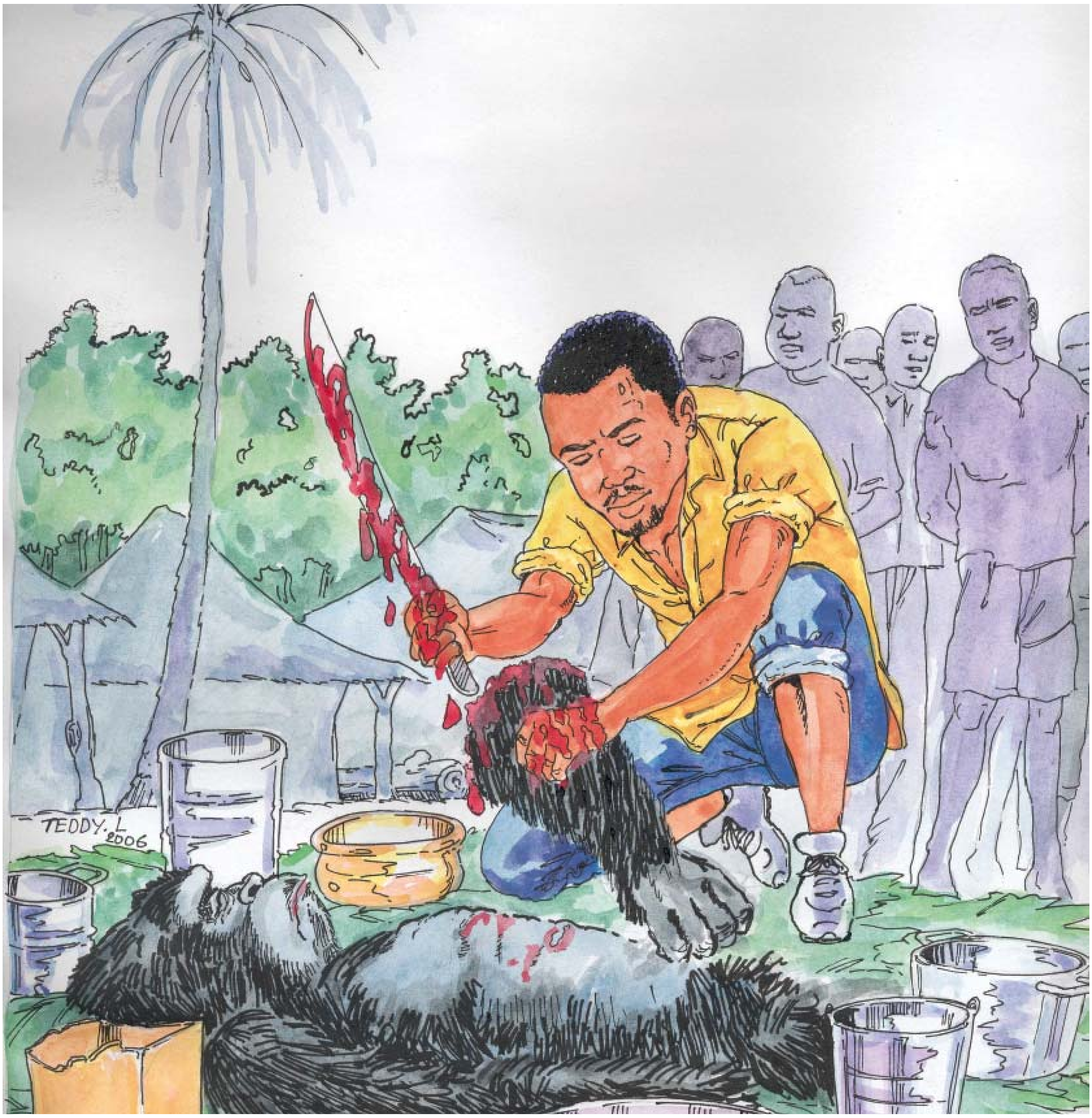


Fig. 51
Image from a series of educational cartoons on the spread of Ebola virus in the Democratic Republic of Congo
(Thanks to Ken Cameron, Wildlife Conservation Society Field Veterinarian)

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Glossary of terms

D. Travis, S.C. MacDiarmid, D. Tompkins, B. Rideout & C. Lees

This glossary has been assembled for this *Manual* only. It is not an attempt to standardise or prescribe terminology across the field of wildlife management. Rather the aim is to ensure that terms are used consistently throughout the *Manual* and to help users have a common understanding of what has been written. For instance the terms 'risk analysis' and 'risk assessment' are often used interchangeably. In this *Manual* we have followed the terminology used by the World Organisation for Animal Health (OIE) in using the term 'risk assessment' as a sub-component of 'risk analysis'. Italicised words within definitions refer to other words included in this glossary.

Acceptable risk	A level of *risk* that is so small in terms of likelihood of occurrence or consequences that, in comparison with the expected benefits, stakeholders are willing to accept it
Clinical sign	A behavioural or physical change from normal expressed by an individual when suffering from a *disease*
Consequence assessment	The process of describing the relationship between specified exposures to a hazard and the consequences of those exposures. A causal process must exist by which exposures produce adverse health or environmental consequences, which may in turn lead to socioeconomic consequences and consequences for conservation. The *consequence assessment* describes the consequences of a given exposure and estimates the probability of them occurring
Contagious disease	A *disease* caused by a *parasite* that is acquired directly or indirectly from other hosts without involvement of a *vector* (a subset of *transmissible diseases*; all *contagious diseases* are transmissible, but not all *transmissible diseases* are contagious)
Diagnostic test	Any procedure used to aid in the characterisation of the cause or nature of a *disease* (see *screening test*)
Disease	Any impairment of the normal structural or physiological state of a living organism resulting from its physiological response to a *hazard*
Disease risk analysis	The application of *risk analysis* to identify diseases that may enter a specified animal population to identify the likelihood of such introductions, assess their consequences and identify measures that may be applied to mitigate either the likelihood of introduction or the magnitude of consequences
Ecosystem	A community of organisms together with its physical environment, viewed as a system of interacting and interdependent relationships
Endemic	A disease or *parasite* the *prevalence* of which does not exhibit wide fluctuations through time in a defined location. The term 'enzootic' is sometimes applied when referring to non-human populations

Epidemic	A sudden, rapid spread or increase in the *prevalence* or *intensity* of a *parasite* or *disease*. An *epidemic* is often the result of a change in circumstances that favour parasite *transmission* such as a rapid increase in *host* population density or the introduction of a new parasite. Having an established baseline is essential for detecting *epidemics*. The term 'epizootic' is sometimes applied when referring to non-human populations
Exotic	In relation to disease, a *pathogen* not known to be present in a specified geographic area
Exposure assessment	The process of describing the biological pathway(s) necessary for exposure of animals and humans in a particular environment to the *hazards* (in this case the pathogenic agents) released from a given risk source, and estimating the probability of the exposure(s) occurring, either qualitatively or quantitatively
Fomite	Any inanimate object that is capable of harbouring *parasites* and thereby playing a role in the *transmission* of those *parasites*
Hazard	A biological, chemical or physical agent in, or a condition of, an animal or animal product with the potential to cause an adverse health effect. See also *disease*
Hazard identification	The process of identifying the pathogenic or hazardous agents that could potentially be introduced into a specified animal population or environment by the activity being considered
Holding	Confinement in a non-*biosecure setting* for purposes other than prevention of the acquisition or spread of *parasites* (see *quarantine*)
Host	Any animal that is capable of harbouring a *parasite*, regardless of whether it plays a role in the further *transmission* of the *parasite*
Incidence	The number of new health events (*infection*, *disease*, etc.) experienced by a given population over a specific period of time. (cf. *prevalence*, the total number, new and old, in a given population in a specified time period)
Incubation period	The time that elapses between *infection* with a *parasite* and the onset of *disease*
Infection	The entry and development or multiplication of a *parasite* in the body of a *host*, where it may or may not cause *disease* (see *infestation*)
Infectious disease	The debilitating effects of *infection* or *infestation* by a *parasite*. It is possible for a *host* to be infected by a *parasite* but to show no *clinical signs* of *disease*
Infectious period	Period during which the infected individual is able to transmit the *infection*
Infestation	Subsistence of a *macroparasite* on the external surface of a *host* regardless of whether the *infestation* results in *disease*
Intensity	The mean number of *parasites* within infected individuals of the *host* population. (A different usage is sometimes used: the mean *parasite* burden of the entire population. It is important to distinguish between these two usages)
Latent infection	A persistent *subclinical infection* in which the *parasite* is dormant but has the potential to become active and cause disease or be transmitted in the future
Latent period	The period when an individual is infected but not yet capable of transmitting the *infection*

Macroparasites	*Parasites* that in general do not multiply within their hosts but instead produce *transmission* stages (eggs and larvae) that pass into the external environment (e.g. the parasitic helminths (worms) and arthropods). Typically macroparasites are visible to the naked eye
Model	In the context of DRA, a graphical or computational representation of an actual system used to predict *disease* dynamics and impacts, and the effect of management interventions on those dynamics and impacts
Monitoring	The intermittent performance and analysis of routine measurements and observations, aimed at detecting changes in the environment or health status of a population
Objective	Considering or representing facts, information, etc., without being influenced by personal feelings or opinions
Parasite	An agent that lives on or within a host and that survives at the expense of the *host* regardless of whether a *disease* state follows. This definition includes both *microparasites* (e.g. bacteria, viruses) and *macroparasites* (e.g. helminths, arthropods)
Pathogen (pathogenic agent)	Any *disease*-causing *parasite*
Pathogen pollution	The human-driven (anthropogenic) movement of parasites outside their natural geographic or host species range
Pathogenicity	The degree to which a *parasite* tends to cause *disease* in its *host* and the severity of the *disease* caused
Predictive value	Used in describing the ability of a *diagnostic test* to correctly identify infected and uninfected individuals in a population. A positive *predictive value* is the proportion of individuals with a positive test who have a condition, and a negative *predictive value* is the proportion of individuals with a negative test who do not have the condition
Prevalence	The proportion of the host population with *infection, disease* or antibody presence, often expressed as a percentage. A measure of how widespread an *infection*, *disease* or exposure to an infectious agent is at a point in time
Qualitative risk assessment	An assessment in which the outputs on the likelihood of the outcome or the magnitude of the consequences are expressed in qualitative terms such as high, medium, low or negligible
Quantitative risk assessment	An assessment in which the outputs of the *risk assessment* are expressed numerically
Quarantine	Isolation and observation in a *biosecure setting* for a specified period of time to allow *diseases* of concern to be detected and treated, and to prevent all new exposures to *parasites* of concern
Release assessment	The process of describing the biological pathway(s) necessary for a particular activity to 'release' (that is, introduce) *hazards* into a particular environment or *ecosystem*, and estimating the probability, either qualitatively or quantitatively, of that complete process occurring
Reservoir	Any animate (humans, animals, insects, etc.) or inanimate object (plant, soil, faeces, etc.) or any combination of these serving as a habitat of a *parasite* that reproduces itself in such a way as to be transmitted to a susceptible *host*

Risk	The likelihood of the occurrence and the likely magnitude of the consequences (biological, economic, etc. as defined by a specific *risk analysis* question) of an adverse event or effect to animal or human health
Risk analysis	The process composed of problem description, *hazard identification*, *risk assessment*, *risk management* and *risk communication*
Risk assessment	The evaluation of the likelihood and the consequences of entry, establishment or spread of a pathogenic agent within a specified animal population or environment
Risk communication	The interactive exchange of information and opinions throughout the *risk analysis* process concerning risk, risk-related factors and risk perceptions among risk assessors, risk managers, risk communicators, the general public and other interested parties
Risk estimation	The process of integrating the results from the *release assessment*, *exposure assessment*, and *consequence assessment* to produce overall measures of risks associated with the *hazards* identified at the outset
Risk evaluation	The process of comparing the risk estimated in the *risk assessment* with the level of risk, determined through consultation with stakeholders that is acceptable
Risk factor	Factor associated with an increase in the probability of occurrence of an outcome of interest (e.g. *disease*, reduced fecundity, mortality, etc.)
Risk management	The process of identifying, selecting and implementing measures that can be applied to reduce the level of *risk*
Robust	In the context of *disease risk analysis*, will withstand strong intellectual challenge
Screening test	Any procedure used to aid in the identification of individuals in a population that have *subclinical infections*, so that appropriate action can be taken (see *diagnostic test*)
Sensitivity analysis	A technique commonly used in computer modelling that quantifies the proportional change observed in *model* outcome as a function of proportional changes in the value of any one *model* input parameter. Thus, the relative ‘importance’ of *model* input parameters for their contribution to *model* performance can be directly evaluated
Subclinical infection	An *infection* that does not result in *clinical signs* of *disease*
Surveillance	The systematic ongoing collection, collation and analysis of information related to animal health and the timely dissemination of information to those who need to know so that action can be taken
Transdisciplinary	The collaborative exploration of an issue or problem that integrates the perspectives of multiple disciplines in order to connect new knowledge and deeper understanding to real life experiences
Transmission	The process by which a *parasite* passes from a source of *infection* to a new *host*
Transparency	In the context of *disease risk analysis*, comprehensive documentation of all data, information, assumptions, methods, results, discussion and conclusions used in the *risk analysis*. Conclusions should be supported by an *objective* and logical discussion and the document should be fully referenced

Uncertainty	The lack of precise knowledge of the input values that is due to measurement error or to lack of knowledge of the steps required, and the pathways from hazard to risk, when building the scenario being assessed
Vaccination	The use of vaccines to stimulate antibody production for the prevention of specific diseases
Variability	A real-world complexity in which the value of an input is not the same for each case owing to fluctuations in parameter values among individuals, populations and species over time and space
Vector	An insect or any living carrier that transports an infectious agent from an infected individual to a susceptible individual or its food or immediate surroundings. The organism may or may not pass through a development cycle within the *vector*
Wildlife	Animals that have a phenotype unaffected by human selection and live independent of direct human supervision or control
Zoonosis	A *disease* naturally transmitted between humans and other vertebrate species

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and the International Union for Conservation of Nature (IUCN)

The IUCN–OIE *Manual of Procedures for Wildlife Disease Risk Analysis* provides a 'how-to' guide that will be useful to the growing and diverse range of professionals involved in assessment and management of wildlife-associated disease risk scenarios. This document has been co-written by 22 specialists in the fields of wildlife disease ecology, epidemiology, risk analysis, modelling, disease surveillance, diagnostics, wildlife management, research, teaching and conservation planning. These authors have pooled their knowledge and experience to make tools and processes at the cutting edge of wildlife disease risk analysis accessible to a broad global audience in an effort to ensure healthy ecosystems through better decision-making. This is a companion volume to the *Guidelines for Wildlife Disease Risk Analysis*.

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Guidelines
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1. Zebra and domestic animals share a grazing area near a local village in the buffer zone of Limpopo National Park, Mozambique. Photo courtesy of Michael Kock, 2010
2. From hunter to market table: animals throughout Asia and Africa are sought for human consumption. Photo courtesy of William B. Karesh, EcoHealth Alliance (right)
3. An elephant monitoring team patrols coastal forest in Gabon where elephants and other wildlife are prominent parts of the landscape. Photo courtesy of Michael Kock, 2004
4. Little red flying fox *(Pteropus scapulatus)*. Photo courtesy of Mdk572 Wiki Creative Commons (http://creativecommons.org/licenses/by-sa/3.0/)
5. Collecting samples for avian influenza diagnostic testing from a gull during a HPAI H5N1 outbreak in Mongolia. Photo courtesy of William B. Karesh, EcoHealth Alliance
6. A gas flare at the Rabi Kounga oilfields located in the Ogooué-Maritime Province of Gabon attracts birds and other wildlife seeking warmth and insects. Photo courtesy of Michael Kock, 2004
7. Collecting samples for avian influenza diagnostic testing from a whooper swan during an HPAI H5N1 outbreak in Mongolia. Photos courtesy of William B. Karesh, EcoHealth Alliance
8. Gujarati cows: cows throughout India are often treated with diclofenac, a veterinary drug that reduces pain and inflammation. Photo courtesy of Richard Kock, Royal Veterinary College of London
9. Waterfowl on the Hakaluki Haor, a protected wetland in eastern Bangladesh. Photo courtesy of Parviez Hosseini, EcoHealth Alliance
10. Green-eyed tree frog *(Litoria genimaculata)*. The green-eyed tree frog is one of several species threatened by chytridiomycosis, a disease that has been associated with declines in amphibian populations worldwide. Photo courtesy of Lee Skerratt, James Cook University, Townsville, Australia, 2005

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Contents

Contributors

The IUCN/OIE *Guidelines for Wildlife Disease Risk Analysis (DRA)* (hereafter '*Guidelines*') was compiled by the IUCN Species Survival Commission's (SSC) Wildlife Health Specialist Group (WHSG), working in concert with the Conservation Breeding Specialist Group (CBSG), Reintroduction Specialist Group (RSG) and Invasive Species Specialist Group (ISSG). EcoHealth Alliance and the Royal Veterinary College (RVC) provided administrative support for the project and staff time.

The IUCN/OIE *Guidelines for Wildlife DRA* was primarily developed under the leadership of Richard Kock (Royal Veterinary College), William B. Karesh (EcoHealth Alliance), Lee Skerratt (James Cook University), Matt Hartley (Zoo and Wildlife Solutions Ltd) and Dominic Travis (Ecosystem Health Initiative, University of Minnesota College of Veterinary Medicine). Rosemary Barraclough and Katharina Stärk provided technical review, and Lisa Starr and Catherine Machalaba provided editorial support for the document. Richard Jakob-Hoff (New Zealand Centre for Conservation Medicine, Auckland Zoo) served as the Lead Editor for the overall project leading to these guidelines and a comprehensive toolkit, the *Manual of Procedures for Wildlife Disease Risk Analysis* (hereafter *Manual*). The IUCN SSC groups provided invaluable information about the needs related to wildlife DRA tools through a survey of the SSC membership.

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Initial plans were developed at the Disease Risk Analysis Tools Workshop at the Auckland Zoo, New Zealand, 4–7 April 2011, sponsored by the Auckland Zoo, Landcare Research, the New Zealand Department of Conservation and the IUCN-SSC Conservation Breeding Specialist Group. It was decided at this meeting that a policy promotion document (this *Guideline*), as a standalone, would best support the future global dissemination and use of the main *Manual*.

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Executive summary

In this document 'wildlife' refers to the World Organisation for Animal Health (OIE) definition of wild animal – *an animal that has a phenotype unaffected by human selection and lives independent of direct human supervision or control*. To further clarify the discussion, the term 'disease' in this text refers broadly to any impairment of the normal structural or physiological state of a living organism resulting from its physiological response to a hazard. In this case a 'hazard' is defined as: 'a biological, chemical or physical agent in, or a condition of, an animal or animal product with the potential to cause an adverse health effect'.

Disease risk analysis (DRA) is an important tool for analysing the risks of disease introduction or emergence in a population (we use emerging disease to describe those that are caused by newly identified species or strains (e.g. SARS (severe acute respiratory syndrome), HIV/AIDS (human immunodeficiency virus/acquired immune deficiency syndrome) that may have evolved from a known infection (e.g. influenza) or spread to a new population (e.g. West Nile virus) or geographic area or be re-emerging infections, such as drug-resistant tuberculosis. A DRA can also help to assess the risk of disease spill-over (when a disease moves from one species to another). Often DRA methods are used to assess a disease risk, which is precipitated by a new or potential action, such as movement (intentional or accidental) of a species into a new habitat. The end-goal of the DRA is to provide efficient and cost-effective disease prevention and mitigation strategies.

DRA has increasingly been used to inform agricultural trade decisions and conservation-based species reintroduction or translocation efforts; however, especially as *human–wildlife* and *domestic animal interactions* increase, its potential use is much wider in the conservation field and beyond. Although international trade regulations for animals and animal products are already in place, a standard approach is still needed for assessing disease risks specific to conservation. The IUCN/OIE *Guidelines for Wildlife DRA* presents such an approach. The purpose of this document is to encourage readers to consider DRA as a planning tool and to direct readers to the technically comprehensive *Manual of Procedures for Wildlife Disease Risk Analysis* for implementation strategies.

These introductory Guidelines highlight the following key messages:

- *Wildlife disease risks have immediate implications for species conservation, as well as wider relevance* to other disciplines including human and livestock health, agriculture, economics, trade and ecosystems services.
- *Wildlife DRA can and should be applied to a variety of situations and disciplines,* including animal translocation or reintroduction scenarios but also in agricultural expansion, conservation planning and tourism, development of transport networks, urban and rural residential design, extractive industries, watershed and land-use planning, sanctuary planning, assessing bushmeat risks and even employee health.
- *The main components of wildlife DRA are hazard identification, risk assessment, risk management and risk communication.* Execution of these components is aided by the efforts of the technical team of wildlife managers and other stakeholders, the DRA tool selection, and data collection and analysis.
- *Wildlife DRA allows for great flexibility around the level of available or devoted resources* (i.e. financial, time or technical capabilities).
- *Wildlife DRA* provides an open, transparent process that can be easily followed for policy and risk management discussions.
- *Importantly, rather than risk elimination, wildlife DRA promotes risk reduction.* This allows for solutions that reduce risk while aiming to accommodate stakeholders' goals. This is predicated upon the fact that there is often no chance of obtaining 'zero' risk.

The IUCN/OIE *Guidelines for Wildlife DRA* intend to provide decision makers (e.g. wildlife managers, public and environmental health officials, government agencies, and industry representatives) with the information needed to integrate the wildlife DRA process into their work. It is hoped that the wildlife DRA process will be utilised on a wide scale to encourage risk mitigation strategies that are mutually beneficial to a variety of stakeholders.

Background and motivation

Disease plays an important role in the natural environment, serving as a regulator of the genetic fitness of wildlife through selective pressure in evolutionary processes. Conversely, it has been shown that the loss of certain microorganisms and parasites can be detrimental to the healthy functioning of ecosystems and species alike. Unfortunately, human-induced changes in our environment caused by habitat destruction or modification, industrial and urban development, population growth and global movement of people and animals have fundamentally changed the way disease affects not only wildlife but also entire ecosystems. These changes require a way of looking at disease that considers the biological, political and economic value of wildlife and the consequences of biodiversity loss. A process known as disease risk analysis (DRA) has been adopted by IUCN and other organisations to analyse and manage the possible outcomes of situations involving disease. These *Guidelines* demonstrate the importance of DRA specifically for wildlife and promote the use of the larger *Manual of Procedures for Wildlife Disease Risk Analysis*.

The most well recognised approaches to DRA are the processes set out in the World Organisation for Animal Health (OIE) *Terrestrial Animal Health Code* (www.oie.int/international-standard-setting/terrestrial-code/) and the Codex Alimentarius Commission (www.codexalimentarius.org). These documents focus primarily on import policy and food safety, respectively. Drawing on expertise across several disciplines, IUCN has built upon this existing OIE framework to address issues of biodiversity loss.

Wildlife DRA should be used in combination with other guidelines that promote evidence-based practices. For example, animal reintroduction planning should employ the use of the IUCN Reintroduction Guidelines as a source of practical information to supplement and guide DRA efforts (*Guidelines for Reintroductions and Other Conservation Translocations* (2013) can be found at http://www.issg.org/pdf/publications/RSG_ISSG-Reintroduction-Guidelines-2013.pdf).

Disease risk analysis – a means of conserving wildlife and biodiversity

Historically, DRA frameworks were applied *ad hoc* to situations involving wildlife often without a standardised approach. DRA for wildlife has been created to provide a consistent framework specifically targeted to situations that involve wildlife. The *Manual*, to which these *Guidelines* refer, describes the wide range of actions or events for which wildlife DRA might be appropriate.

When does DRA have value to decision makers?

A DRA has value to decision makers in all cases in which wildlife may be involved in, or affected by, disease occurrence. This can include the movement of animals or their products, exposure to toxins, investigations of wildlife population decline and analysis of risks associated with wildlife interactions with people or their domestic animals. DRA for wildlife is of value whenever wildlife, their products (e.g. hides, antlers, etc.) or their samples (e.g. blood, urine, etc.) are involved.

Who is affected in these cases?

– The animal or animals in question (exposure to a pathogen or toxin could cause disease outbreaks and/or decline in a population).

– Other animals exposed directly or indirectly during and after an event (the event could be animal movement, urban development, changing land-use).

– Other species of plants or animals that share the same habitat.

– Humans that come into contact with wildlife.

What type of organisation can benefit from using DRA?

– *Public health agencies* – to help formulate policies and develop programmes focused primarily on human health.

– *Conservation organisations* – to assist with designing wildlife protected areas, investigating wildlife population decline or guiding animal translocation or reintroduction efforts.

– *Strategic planners* – for economic development (e.g. ecotourism projects), agricultural extension, development of transport networks, extractive industries, watershed and land-use planning, and urban and rural residential design (e.g. to analyse the risks of Lyme disease emerging in a new park).

– *Government agencies* – to assist with the formulation of guidelines to be used at local, national or international levels.

In addition to its use prior to planned or intentional movement of wild animals or animal products, the wildlife DRA process is increasingly being applied to situations in which public health, domestic animal health or wildlife population health is at risk. In some cases, a thorough DRA will reveal that current risk reduction or risk management practices are either already adequate or could be easily adapted from other existing sources. These practices may include disease testing, quarantine, containment, disinfection or vaccination. In other cases, the DRA will reveal information or procedural gaps that need to be addressed prior to implementing actions involving the animals, people or habitat.

Steps in the disease risk analysis process

The DRA framework we propose is based on the one developed by the World Organisation for Animal Health (OIE), which is used to identify, assess and manage the risks posed by animal diseases with a focus on economic and human health impacts.

The term 'risk analysis' refers to the overall process regardless of the format used or how individual components are defined. The risk analysis begins with problem description (the process of describing and justifying the problem or question) and then consists of five interconnected components (Fig. 1): risk communication; hazard identification; risk assessment; risk management; and implementation and review. Each component of the risk analysis is focused on answering basic question(s).

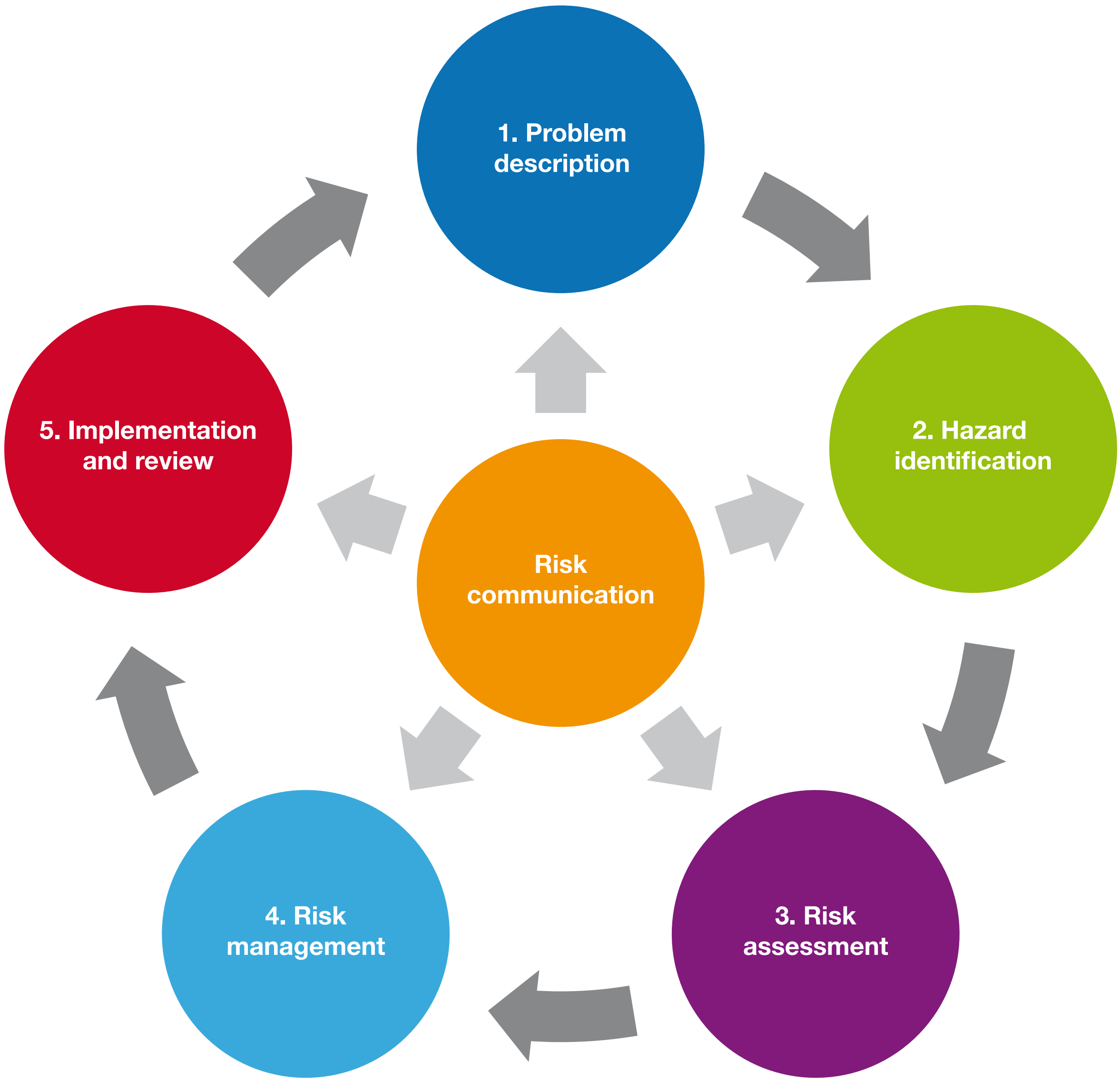


Fig. 1
Steps in the disease risk analysis process

● Risk communication (applies throughout all disease risk analysis steps)

Purpose: Engage with a wide group of technical experts, scientists and stakeholders to maximise the quality of analysis and probability that recommendations arising will be implemented.

Questions: 'Who has an interest, who has knowledge or expertise to contribute and who can influence the implementation of recommendations arising from the DRA?'

❶ Problem description

Purpose: Outline the background and context of the problem, identify the goal, scope and focus of the DRA, formulate the DRA question(s), state assumptions and limitations and specify the acceptable level of risk.

Questions: 'What is the specific question for this DRA, and what kind of *risk analysis* is needed?'

❷ Hazard identification

Purpose: Identify all possible health hazards of concern and categorise into 'infectious' and 'non-infectious' hazards. Establish criteria for ranking the importance of each hazard within the bounds of the defined problem. Consider the potential direct and indirect consequences of each hazard to help decide which hazards should be subjected to a full risk assessment. Exclude hazards with zero or negligible probability of release or exposure, and construct a scenario tree for remaining, higher priority hazards of concern, which must be more fully assessed (Step 3).

Questions: 'What can cause disease in the population of concern?', 'How can this happen?' and 'What is the potential range of consequences?'

❸ Risk assessment

Purpose: To assess for each hazard of concern:

a) the likelihood of release (introduction) into the area of concern;

b) the likelihood that the species of interest will be exposed to the hazard once released;

c) the consequences of exposure.

On this basis the hazards can be prioritised in descending order of importance.

Questions: 'What is the likelihood and what are the consequences of an identified hazard occurring within an identified pathway or event?'

❹ Risk management

Purpose: Review potential risk reduction or management options and evaluate their likely outcomes. On this basis decisions and recommendations can be made to mitigate the risks associated with the identified hazards.

Questions: 'What can be done to decrease the likelihood of a hazardous event?' and 'What can be done to reduce the implications once a hazardous event has happened?'

❺ Implementation and review

Purpose: To formulate an action and contingency plan and establish a process and timeline for the monitoring, evaluation and review of risk management actions. The review may result in a clearer understanding of the problem and enable refinement of the DRA.

Questions: 'How will the selected risk management options be implemented?' and, once implemented, 'Are the risk management actions having the desired effect?' and, if not, 'How can they be improved?'

Wildlife disease case studies – disease risk analysis put into practice

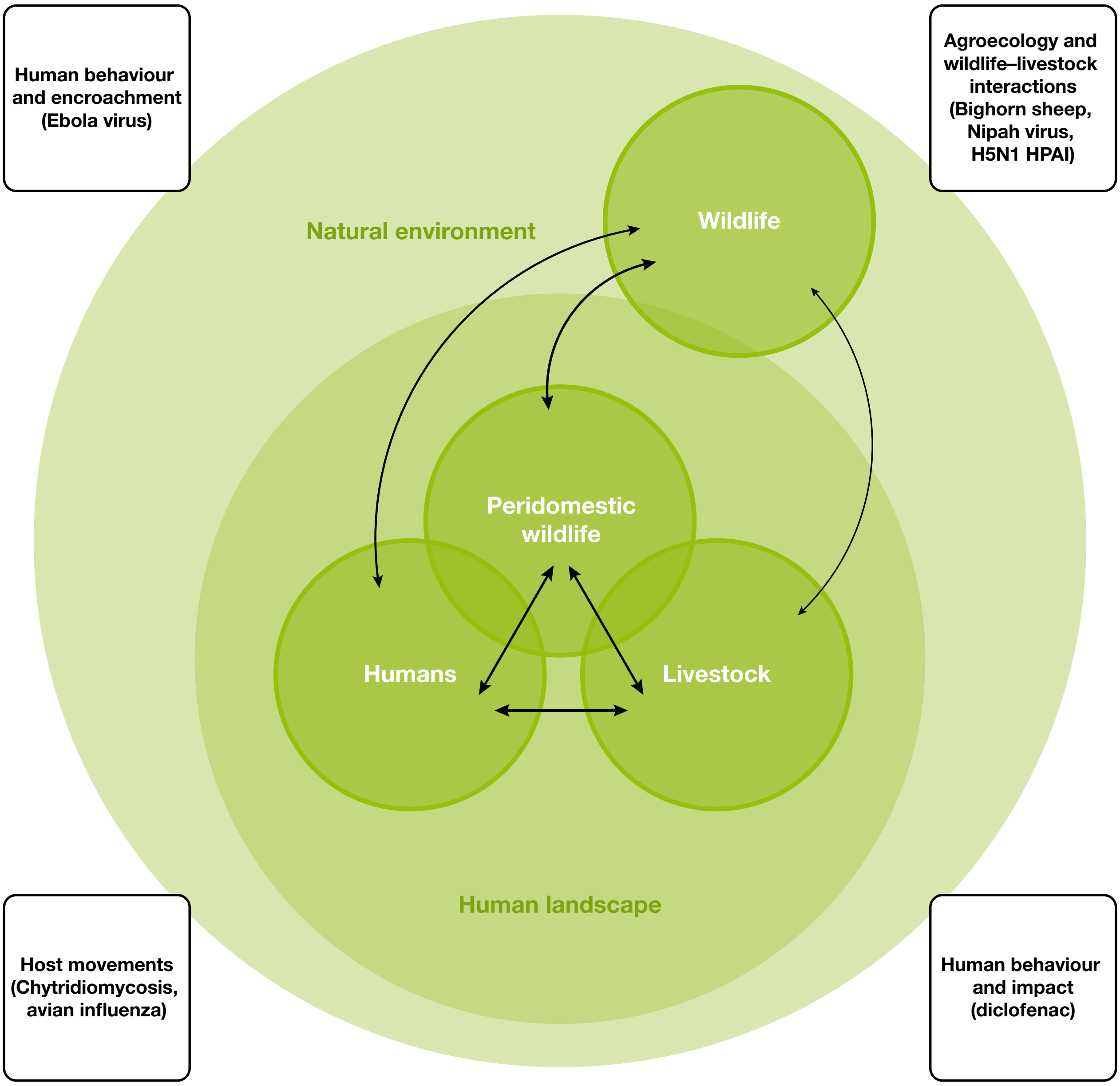


Fig. 2
Pathogen flow and drivers at the human–livestock–wildlife interface
The arrows in Figure 2 indicate direct, indirect or vector-borne pathogen flow
Each box represents a driver for which a case study is provided in the text

The case of the bighorn sheep reintroduction: not as easy as it seems

– Bighorn sheep (*Ovis canadensis*), a free-ranging species that was once very abundant throughout North America, has experienced population decline from over two million individuals at the turn of the century to only several thousand individuals decades later (Goodson 1982).

– Scientific studies have indicated that their populations have declined in large part as a result of diseases transmitted from domestic sheep that increasingly have shared the same grazing territory.

– Free-ranging bighorn sheep are susceptible to many diseases that domestic sheep can carry, including scabies, lungworm and pneumonia (Callan *et al.* 1991).

– Outbreaks of pneumonia, in particular, have been shown to influence the distribution of bighorn populations throughout North America, and there have been several large-scale die-offs due to pneumonia in both the United States and Canada (Shannon *et al*. 1995; Hobbs and Miller, 1992; Jorgenson *et al*. 1997; Valdez and Krusman, 1999).

– Disease has also been shown to compound the effects of other stressors that already threaten bighorn survival such as development on, or near, bighorn sheep habitat, internal and external parasites acquired from domestic animals, and overcrowding on rangeland (Garde *et al*. 2005).

– Reintroduction attempts for bighorn sheep have had mixed results owing to infectious diseases.

– Disease risk analyses are now being used by wildlife agencies to help guide future planning and to improve conservation outcomes for the reintroduction of bighorn sheep (USDA 2006).

Desert bighorn sheep being released in Southern California with a tracking collar
Bighorn sheep are at risk from diseases carried by domestic sheep that share the same grazing areas, so knowing where bighorn are and where they interface with domestic sheep is very valuable in developing management plans
Photo courtesy of Michael D. Kock

Amphibian population decline

– Chytridiomycosis (caused by the fungus *Batrachochytrium dendrobatidis*) has been associated with the extinction of approximately 100 amphibian species and the severe decline of many more from the late 1970s onwards (Skerratt *et al*. 2007).

– Amphibian species in protected, relatively pristine habitats have been particularly affected, showing that traditionally 'protected' areas are not immune to introduced diseases (Skerratt *et al*. 2007).

– Spread of the fungus may be related to increased international movement of amphibian species for use as laboratory animals, food or pets (Weldon *et al*. 2004).

– Large population sizes that are distributed through a range of climates and habitats are more resilient to infection and decline owing to environmental constraints on the pathogen. This is a good example of the positive correlation between high biodiversity and increased resilience to threats and change (Murray and Skerratt 2012).

– The global community is now responding to the threat of chytridiomycosis through improving the biosecurity of free-ranging amphibian populations, *ex situ* conservation (including captive breeding), and researching ways of mitigating disease transmission *in situ* (Australian Government 2006; Gagliardo *et al*. 2008; OIE 2011).

– A DRA could contribute to the success of both *ex situ* and *in situ* programmes for amphibians by identifying the most important risk factors for disease exposure and transmission and approaches to prevention and control.

***Green-eyed tree frog* (Litoria genimaculata)**
The green-eyed tree frog is one of several species threatened by the chytrid fungus, a malady that may be responsible for declines in amphibian populations worldwide
Photo courtesy of Lee Skerratt, James Cook University, Townsville, Australia

Fatal consequences from changing land use: Nipah virus's deadly cycle

- The Nipah virus outbreak among pigs and pig farmers in Malaysia in 1998 and 1999 demonstrated that human-driven intensification of contact among wildlife, livestock and people can have deadly consequences.
- Nipah virus is carried by pteropid fruit bats, which do not show signs of the disease when infected (Field 2009).
- Swine production expanded rapidly in the 1990s in Malaysia, resulting in clearing of forest in pteropid bat habitat (Chua *et al*. 2002; Pulliam *et al*. 2012).
- Some swine producers maintained mature fruit trees over open pigsties, resulting in night-time feeding by pteropid bats and subsequent infection of pigs via bat urine and faecal or salivary contamination of partially eaten fruits that fell to the ground (Luby *et al*. 2009).

Little red flying fox **(Pteropus scapulatus)**
These little red flying foxes are one of many species of fruit bats affected by the deadly Nipah virus
Photo courtesy of Mdk572 Wiki Creative Commons (http://creativecommons.org/licenses/by-sa/3.0/)

- It is suggested that pigs, their semen and infected farm workers moving between pig farms have facilitated the movement of the virus among pig farms (CFSPH 2007; Goh *et al*. 2000).
- The World Health Organization (WHO) has estimated the number of people infected with Nipah virus that die (the case fatality rate for humans) at 40% to 75%. In addition to the effect on human health, agriculture in the region was severely affected as these outbreaks led to the culling of more than one million swine and the implementation of strict quarantine measures to prevent further human to human transmission (Ahmad 2000).
- Analysis of risk factors identified the removal of fruit trees from pig farms as a mechanism for preventing the future introduction of the disease, and this has become standard protocol in Malaysia (Nahar *et al.* 2010; Siembieda *et al*. 2011).
- The addition of wildlife DRA to agricultural and industrial development planning could help to identify potential disease risks, such as Nipah virus, and in turn guide appropriate risk mitigation strategies to prevent an outbreak.

Handling and consumption of wildlife: prevention is better than cure

- Human populations are increasingly encroaching into wildlife habitats and facilitating an increased trade in bushmeat and other wildlife products. This increases human contact with a diversity of wildlife and their pathogens.

- Annual bushmeat consumption in Central Africa alone has been estimated to be a billion kilograms, comprising millions of individual wild animals (Karesh *et al*. 2005).

- Diseases such as HIV infection/AIDS, Ebola haemorrhagic fever virus, monkeypox, and SARS have all been linked to the handling of wild animals for the purpose of human consumption (Greger 2007).

- Disease transmission can also occur from humans or domestic animals to wildlife, as documented for endangered mountain gorillas, which have experienced deadly respiratory infections from human metapneumovirus and human measles. Human-facilitated introduction of domestic species to an area may bring in diseases such as rabies or bovine tuberculosis (Bengis *et al*. 2002).
- DRA in this situation would be similar to the approaches used for determining risks from foodborne infections, including value chain analysis, i.e. determining all the steps from food source to consumption and identifying appropriate monitoring and intervention points.
- A full DRA for bushmeat and other wildlife products intended for trade would include the risk of acquiring animals, handling and transport, consumption and/or use, the implementation of disease prevention strategies, and identification of the relative risks of various products and uses.

From hunter to market table
Animals throughout Asia and Africa are sought for human consumption. This hunter pictured here (in Sudan) represents a common beginning of the wildlife trade cycle and the bushmeat on the market table in Asia a familiar end. As hunters reach deeper into the forest, seeking wildlife for food, both humans and wildlife can be exposed to disease
Photos courtesy of Richard Kock (left) and William B. Karesh, EcoHealth Alliance (right)

'Bird flu': disease risk analysis helping to direct resources

Local newspapers hypothesise that wild bird migration may contribute to the spread of avian influenza. Partially in response to popular media and some scientific reports, the culling of wild birds was proposed in some parts of the world as a solution to control the spread of the disease.

- For over a decade, wild birds have been implicated as a source or a vector of highly pathogenic avian influenza (HPAI) H5N1.

- While HPAI H5N1 has been found in wild birds, to date no long-term reservoir of HPAI H5N1 has been identified in wild bird populations, despite over a million samples tested from a wide range of species and habitats across the globe. It is rarely found in live wild birds, limiting its potential for spread through migration and contact with other animals (Scientific Task Force on Avian Influenza, 2008).

- Follow-up research has shown that domestic poultry and related trade and production and inadequate disease control methods were a primary driver of the HPAI H5N1 outbreaks (Hogerwerf *et al*. 2010).

- A DRA conducted after the initial outbreaks would have prompted research to quantify the risk that wild birds posed in terms of HPAI H5N1 transmission to other wild birds, humans and poultry. A retrospective DRA can still use information gathered from field research conducted to date to guide current control methods.

Collecting samples for avian influenza diagnostic testing from a whooper swan during an HPAI H5N1 outbreak in Mongolia
Photo courtesy of William B. Karesh, EcoHealth Alliance

Vulture mortality in India: an ecotoxicology case study

– Vultures serve a highly valuable ecological role through the removal of dead animal carcases and thereby contribute to the maintenance of public health (preventing the spread of disease agents) and the health of the ecosystem.

– From 1992 to 2007 several species of vultures, including the Oriental white-rumped vulture (*Gyps bengalensis),* Indian Vulture (*G. indicus*) and the slender-billed vulture (*G. tenuirostris*) experienced serious and rapid declines throughout Asia (Gilbert *et al*. 2002; Prakash *et al*. 2003).

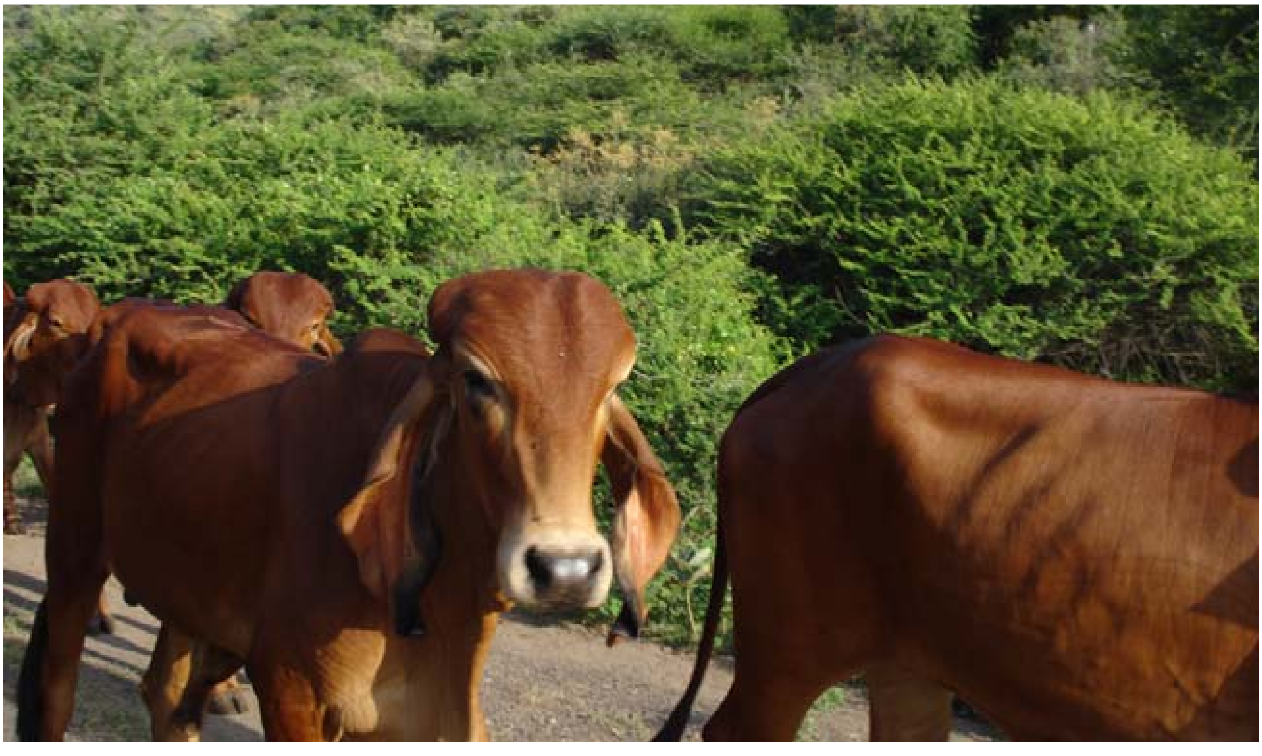
– It was found experimentally that vultures ingesting cattle carcases recently treated with diclofenac, a popular non-steroidal anti-inflammatory drug, needed very little of the drug to succumb to kidney failure and eventually death (Oaks *et al*. 2004). Diclofenac residues in the tissues of dead cattle are highly toxic to vultures, resulting in up to 99% mortality in these birds (Prakash *et al*. 2005).

– This near extinction of *Gyps* species vultures was met with a resounding response from both governments and drug manufacturing companies. The national and local governments banned the veterinary use of diclofenac in 2006 and pharmaceutical companies have increased production of the alternative anti-inflammatory drug meloxicam (Cuthbert *et al*. 2011).

– Unfortunately, continued use of diclofenac in humans and animals has persisted.

– A DRA conducted now could help determine the potential impact of diclofenac in other species (particularly other scavengers) and help guide future production and licensing of similar compounds.

Oriental white-rumped vultures*, Gyps bengalensis*, feeding on a domestic water buffalo,* Bubalus bubalis*, in India
Photo courtesy of Munir Virani – The Peregrine Fund



***Gujarati cows:* cows throughout India are often treated with diclofenac, a veterinary drug that reduces pain and inflammation This drug is lethal to vultures that ingest the bovine carcases after death**
Photo courtesy of Richard Kock, Royal Veterinary College of London

Overview of disease risk analysis methodologies and tools

Selecting the most appropriate tool for your situation

Many tools are available to support the DRA process, ranging from simple to complex, and these are presented in detail in the *Manual*. They may employ a simple paper and pencil, widely available software packages or highly sophisticated quantitative modelling programmes. Tool selection for a given scenario varies according to the team's expertise, the quantity and type of data that exist, and the time and resources available to collect additional information. Figure 3 hereafter highlights some common tools used to address the different phases of the risk analysis process. This figure reflects experience and is not meant to provide an exclusive list of tools, nor is it an endorsement of any specific software programme or company. The following section provides some initial guidelines for tool selection, including circumstances that favour qualitative or quantitative tools for risk assessment and management.

A note on the use of the term 'model'

A 'model', in the context of DRA, is a simplified representation of something that exists in the real world. This is an especially valuable process when trying to understand and/or assess relationships between dynamic systems such as the ecosystem, individual or populations of animals and microbiological disease-causing agents. A simple model may consist of a picture or diagram to help a discussion of how a biological system works. Complex models often consist of quantitative and/or spatial analyses using complex layers of data. The point is that models are an attempt to simplify the real world into something both understandable and representative.

The risk analysis process creates a logical model that helps to work systematically through the different aspects of the overall analysis from a science-based policy perspective (Fig. 2).

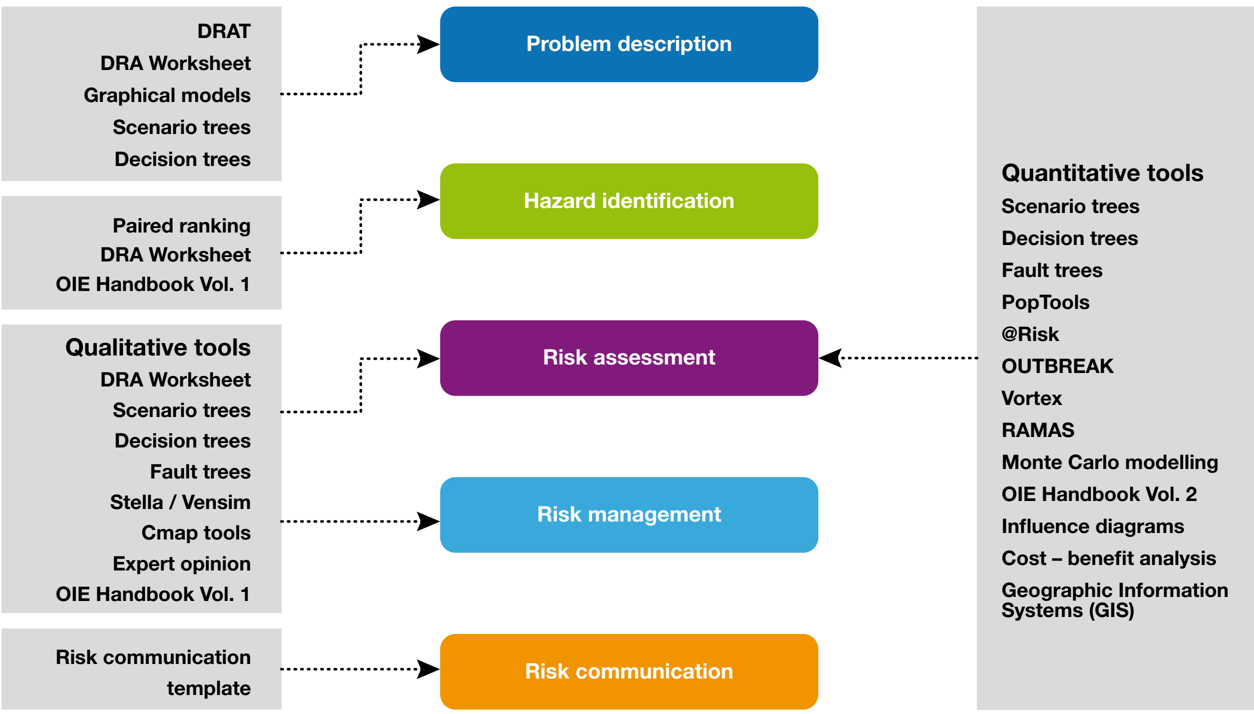


Fig. 3
Various tool types to assist the disease risk analysis process

The hazard identification step of the process involves the creation of scientifically explicit models of the disease hazards using qualitative or quantitative data. The risk assessment step results in an estimation of risk based upon the specific policy question while the analysis as a whole provides a scientific basis for the most appropriate policy response to minimisation of the identified risks. It is an iterative process and can be revisited at any time with new data or tools to improve the accuracy of the modelling and risk definition and quantification. Approaches for *post hoc* attention to risk assessment include the use of a Bayesian updating framework to identify both when and where new data are to be taken and how to incorporate these in updated assessments – this is part of SADA (spatial analysis for decision assistance) www.tiem.utk.edu/~sada/index.shtml.

Amount and quality of available data

Generally an insufficient amount or quality of data is available on wildlife to make meaningful *quantitative* risk assessments or precise estimates during the first iteration of the process. Therefore, the application of a structured qualitative approach is usually preferred as it readily incorporates lack of precision and it is the best way to use available information to analyse risks and generate the insights needed to make informed decisions about where to focus risk management actions.

Limited resources

Much can be accomplished with basic, easy to use tools such as pre-packaged programmes. Often qualitative tools are recommended for the first iteration of the process as they require fewer specialised resources (such as mathematical or programming skills and equipment) and can be conducted with the available information during group workshops.

Qualitative versus quantitative tools

Both qualitative and quantitative processes will highlight information gaps, which can be used to generate research priorities that can provide the quantitative data needed to further refine risk assessments.

In qualitative risk assessments the likelihood of the outcome, or the magnitude of the consequences, is expressed in pre-defined terms such as ‘high’, ‘medium’ or ‘low’. In quantitative risk assessments the likelihood is expressed in terms such as ‘one disease outbreak per 100 animal introductions’ or ‘failure to correctly identify one diseased animal out of 100’. Both qualitative and quantitative approaches to risk assessment are valid and, in practice, all risk assessment are usually first conducted qualitatively. Only if further insight is required is it necessary to attempt to quantify the risk. As North (1995) explains, quantitative ‘… risk analysis is best used to develop insights, and not to develop numerical results which might mistakenly be considered to be highly precise. The discipline of numerical calculation can help to sharpen thinking about risks involving high levels of complexity and uncertainty, and thereby enable conclusions to be drawn which could not have been reached solely on the basis of qualitative reasoning.’

Scale issues

Given the extensive impact that scale (temporal and spatial) has in ecological decision-making this needs to be addressed early on in DRA: not only increasing use of geographical information system (GIS) tools as decision support but also a broader context of conceptualising responses potentially occurring at different spatial scales, depending upon the species/communities/ecosystems of concern, is needed (Fuller *et al.* 2008). An example might be a DRA around the development of fencing options for animal movement control that have broad ecological impacts and which can positively and negatively impact disease occurrence depending on the species and system considered. It is the broadening of the scope in DRA that wildlife DRA requires and which is very different from the conventional veterinary DRA, which is focused on the host and pathogen in the context of trade or animal movement.

Conclusion: wildlife disease risk analysis working in concert with other agencies

Varying DRA formats are currently being used by a diverse array of organisations. These separate guidelines originate from sectors including public health, agriculture, trade, the pharmaceutical industry and wildlife conservation. With a common theme in mind, the specific goals of each DRA may vary depending on the objectives of the individual organisation. IUCN's vision in presenting this approach to DRA is that it will be applied across all sectors concerned with wildlife disease and in doing so reinforce the 'One Health' principle that recognises that the health of people, animals (domestic and wild) and the environment are interconnected. IUCN further hopes that the application of these *Guidelines* will help to promote a standardised and consistent approach to the use of DRA and assist in effective, evidence-based decision making with respect to wildlife interventions and management of wildlife species.

Useful links

IUCN/SSC – Wildlife Health Specialist Group (WHSG). Available at: www.iucn-whsg.org/

IUCN/SSC – Conservation Breeding Specialist Group (CBSG). Available at: www.cbsg.org/cbsg/

IUCN/SSC – Reintroduction Specialist Group (RSG). Available at: www.iucnsscrsg.org/

IUCN/SSC – Invasive Species Specialist Group (ISSG). Available at: www.issg.org/

OIE *Terrestrial Animal Heath Code.* Available at: www.oie.int/international-standard-setting/terrestrial-code/

FAO/WHO Health Standards – Codex Alimentarius. Available at: www.codexalimentarius.net/web/index_en.jsp

Guidelines for the In Situ Reintroduction and Translocation of African and Asian Rhinoceros (IUCN AfRSG/AsRSG publication). Available at: www.rhinoresourcecenter.com/index.php?s=1&act=refs&CODE=ref_detail&id=1236875944

Conservation and Development Interventions at the Wildlife/Livestock Interface – Implications for Wildlife, Livestock and Human Health (IUCN/SSC Occasional Paper from the Animal and Human Health for the Environment and Development [AHEAD] Program). Available at: www.wcs-ahead.org/wpc_launch.html

Health Risk Analysis in Wildlife Translocations (OIE – Wildlife Disease Working Group). Available at: www.ccwhc.ca/wildlife_health_topics/risk_analysis/rskguidintro.php

FAO – EMPRES. Available at: www.fao.org/ag/againfo/programmes/en/empres/home.asp

IUCN/SSC AfESG Guidelines for the in situ Translocation of the African Elephant for Conservation Purposes. Available at: www.african-elephant.org/tools/trnsgden.html

IUCN Policy Paper: *Enhancing the Science and Policy Interface on Biodiversity and Ecosystem Services*. Available at: http://cmsdata.iucn.org/downloads/ipbes_position_paper_for_3rd_ipbes_meeting_may_2010_final_web.pdf

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Guidelines
for Wildlife Disease Risk Analysis

Co-published by: the World Organisation for Animal Health (OIE)
and the International Union for Conservation of Nature (IUCN)

The IUCN–OIE *Guidelines for Wildlife Disease Risk Analysis* will be of value to those policy-makers and decision-makers faced with the social, political and technical complexities involved in wildlife-disease-associated scenarios. It provides an overview of the science-based processes and tools available for wildlife disease risk analysis and their application to a broad range of contemporary issues, including human–wildlife interactions, domestic animal–wildlife interactions and the impacts of massive ecological change on biodiversity conservation. This is a companion volume to the *Manual of Procedures for Wildlife Disease Risk Analysis*.

IUCN

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WORLD ORGANISATION FOR ANIMAL HEALTH
Protecting animals, preserving our future

One Global Wildlife Biobank Network to Support Global Species Targets Post-2020

Convenors: Oliver Ryder and Sonja Luz

Aim:

To progress the design of a workshop on biobanking, to be hosted by Taipei Zoo in 2020.

Background:

The preservation of living cell lines, gametes, and embryos as well as alcohol-fixed or frozen tissue cryobanking, can provide a valuable resource for wildlife conservation, assisted reproduction, evolutionary biology, and wildlife medicine. Examples of current applications include: artificial insemination using cryopreserved sperm from irreplaceable and long-dead individuals; development of a bank of reference barcode samples for the identification of illegal specimens associated with illegal wildlife trade; whole genome sequencing projects; and studies into the potential for emerging stem cell technologies to rescue species from the brink of extinction. Led by San Diego Global and Wildlife Reserves Singapore, a group of organisations are coming together to realise the following vision for the future:

An international network of cryobanks under the umbrella of a Global Wildlife Biobank that is dedicated to sharing resources and expertise and growing a worldwide legacy of irreplaceable reproductive and genetic material that can be used in support of species conservation.

In April 2020, Taipei Zoo will host a CPSG-facilitated workshop to kick-start a potential South-East Asian arm of this Global Wildlife Biobank network.

The aim of this working group is to bring together those who have been involved in discussions to date with other members of the CPSG community with an interest in this topic, to review draft workshop goals and intended outputs, to review and further develop a draft workshop program and to identify other opportunities for moving this project forward (e.g. WCC).

Process:

The workshop will be 3 hours long and will proceed as follows:

- Presentation of concept and progress so far (Ollie Ryder and Sonja Luz)
- Q & A to support those not previously part of discussions
- Summary of previously identified challenges to establishing a South-East Asian arm of this Global Wildlife Biobank network and an opportunity to add to these.
- Summary of priority themes/solutions identified to date and discussion of these
- With these challenges and priority themes/solutions displayed:
  - DRAFT a list of priority presentations and presenters for the workshop (to ensure that participants are brought up-to-speed with key issues)
  - DRAFT a list of potential working group topics and check likely allocation of potential participants
  - Review workshop participants list in light of the above and adjust as needed

- Discuss factors likely to increase the success of this initiative
- If time, discuss other supporting initiatives (e.g. WCC Motion)

Outcomes:

- A revised agenda for the 2020 workshop
- A revised participants list
- Suggestions for biobanking-related revisions to the WCC Ex situ Motion text

Materials:

None

Shared Ownership: Inspiring leaders around the world to unite behind their collective responsibility to save species

Convenors: Caroline Lees

Aims:

To discuss this pillar of CPSG's new strategic plan with a wider audience, review it and recommend improvements and potential activities.

Background:

The Convention on Biological Diversity is reaching the end of its 2011 – 2020 programme and is working to define the programme and targets for the next ten years.

Aichi Target 12 of the current programme reads: By 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained. We know that efforts to achieve this have largely failed and that we need new and different approaches in the coming decade.

Inspired by what has been achieved by the Protected Areas Community, at CPSG's 2019 strategic planning meeting we discussed the need for a different global infrastructure and a single, coherent programme of work for the new species target (i.e. for whatever replaces Target 12. Ideas about how to build and power this became one of three main pillars of work for CPSG's new strategic plan.

Process:

The workshop will take place over two sessions and will proceed as follows:

- Presentation of concept and progress so far (Caroline Lees)
- Q & A to support those not previously part of discussions
- World Café Session:
    - Table 1) What do you know about how your government: a) assesses conservation status of species; b) plans conservation of species and c) moves that planning to action?
    - Table 2) How is the work of your organisation connected to your government's processes for assessing, planning for or implementing plans for, threatened species? What involvement would you like to have?
    - Table 3) How does the work that your organisation does contribute to the current Target 12? How does it contribute to your country's NBSAP? Through what mechanism is your work reported to the CBD?
    - Table 4) Depending on numbers! What experience do you have of your IUCN National/Regional bodies: a) what do they do? b) how do you contribute? c) how do you benefit?
- Presentation and discussion of World Café outputs
- Presentation of relevant outputs from Session 1 - Roopali Raghavan and Karen Bauman
- Discussion of CPSG's concept for the Shared Responsibility Pillar

- Brainstorm of potential activities for increasing the connectivity of global efforts on the new CBD Species Target

Outcomes:

- Summary of what is known about current national species conservation frameworks;
- Examples (good and bad) of how conservation organisations currently connect with this work;
- Ideas of how to improve on this.

Materials:

Please come to this workshop having read:

- The draft working group output from the San Diego strategic planning meeting (below)
- Your country's NBSAP (or that of the country you do most work in): https://www.cbd.int/nbsap/

And, if possible, come with a working knowledge of how your country delivers its obligations to the CBD.

Working Group: Shared Ownership of Global Species Conservation Targets

GOAL: A united voice for species with shared responsibility for global species conservation targets. Inspired conservation leaders embrace and are united behind their collective responsibility for the success or failure of efforts to save species.

WHO WE ARE: champions for the SSC, extending our reach beyond enabling species conservation projects and into influencing global policy.

WHAT WE DID, WITH OUR PARTNERS:

- We embedded species conservation planning within governments by 1) lobbying successfully to create a network of National Species Champions (NSCs) and associated teams, within each government, dedicated to achieving global species targets; and 2) by supporting mainstreaming species conservation planning across all government planning agencies (e.g. agriculture, urban and infrastructure planning).
- We mobilized the power of the CBD by lobbying successfully for strong CBD species targets post-2020, and for a CBD focal point for species (modeled after the protected areas focal point), to support and connect the NSC network.
- We mobilized the power of the IUCN to help influence governments and other conservation leaders to get behind these initiatives.
- We supported a Global Species Conservation Summit, at which we brought together NSCs and other species conservation leaders and inspired them to unite behind a shared responsibility for saving species.
- We created ONE GLOBAL PLAN, with these conservation leaders, to lead species conservation efforts to success.
- We helped to drive national efforts by supporting NSCs to build and unite their own national, multi-sectoral networks of conservation actors dedicated to achieving global species targets.

- We supported a Global Species Championship in which countries competed to demonstrate national success in achieving species targets.

THE DETAILS:

Embedding species conservation planning within governments

Planning for species should be embedded at the government level. The Protected Areas community has been good at doing this and we can follow their lead. Ideally there would be a specific department or unit within government, dedicated to the achievement of global species targets (CBD, CITES, RAMSAR etc). As part of its work, and with support from external partners where needed, this entity would ensure the integrated presence of planning for species across all government policy and operations, especially those affecting agriculture, urban and infrastructure planning. This would ensure that planning for species is proactive rather than reactive and is integral to the operation of government rather than by invitation. As one mechanism for this, species conservation planning should be embedded within all national Environmental and Social Impact Assessments (EIAs and SIAs).

Areas of Activity

- Lobby to create a network of National Species Champions (NSCs) and associated teams, within each government, dedicated to achieving global species targets.
- Support mainstreaming species conservation planning across all government planning agencies (e.g. agriculture, urban and infrastructure planning).

Mobilizing the power of the CBD

The CBD is a powerful vehicle for change. Its post-2020 targets will chart a course for governments over the following decades and it is increasingly being see as a "docking station" for other biodiversity-directed conventions such as CITES and RAMSAR, to help these initiatives work more synergistically. The integration of CBD targets with UN Sustainable Development Goals (SDGs) presents a huge opportunity to access development funds to pursue projects that generate benefits to both wildlife and people.

Areas of Activity

- Contribute CPSG's ideas to post-2020 species target discussions through the IUCN SSC Task Force, to ensure strong CBD species targets are recommended
- With partners, lobby for the adoption of strong post-2020 targets
- With partners, lobby for a CBD focal point for species (modeled after the protected areas focal point), to support and connect the proposed NSC network.
- Submit CPSG's ideas on national species champions as an information document to CBD meetings
- Organize side events in CBD meetings to promote species conservation planning
- Seek out opportunities to connect with governments beyond CBD – use connections, sit with key people and talk!

Mobilizing the power of the IUCN

The IUCN has huge reach and a vast array of programs and areas of expertise. CPSG could both benefit and contribute to this, not only across the SSC but across the different IUCN

Commissions and programs. Also, though non-binding, the Motions put forward at the four-yearly World Conservation Congress can influence the thinking and actions of governments, NGOs and the IUCN itself. Further, they can influence changes made to international treaties such as CITES and CBD, which have even greater power. We need to tap into this potential more deliberately and effectively.

Areas of Activity

- Embed the use of CPSG tools within the SSC and in the wider IUCN wherever relevant, providing training where useful.
- Work more closely with the other IUCN Commissions to develop a better understanding of what they are doing and to identify and exploit potential synergies.
- Partner with other IUCN teams to explore new ways to scale-up.
- Bring the expertise of multiple Commissions together through planning, to provide cross fertilization.
- Ensure that the IUCN program for the next quadrennium reflects CPSG priorities by contributing to IUCN Regional Forums and IUCN National Committees.
- Work with the wider SSC, other IUCN commissions and with the proposed CBD species focal point, on high-level strategic biodiversity conservation planning at country level. Ensure that species needs are met within those frameworks.
- Within the IUCN, increase awareness of how CPSG, SGs and Commissions can help governments with conservation planning.
- Use side events at the IUCN World Conservation Congress to promote 1) the value of a NSC network; 2) the importance of a CBD species focal point and c) the value of a Species Conservation Summit.
- Submit key Motions at the World Conservation Congress on 1) Global adoption of the One Plan Approach 2) Establishing a Global Network of Species Champions, connected through the CBD Secretariat and 3) Convening a Species Conservation Summit.

Supporting a Global Species Conservation Summit

A Global Species Conservation Summit would provide a forum in which the proposed network of National Species Champions (NSCs) and their teams could come together with the proposed CBD Species Focal Point, with IUCN Commissions and Specialist Groups, with NGOs, with Indigenous Peoples organisations, and with potential donors, to learn about current species conservation tools, to identify gaps in their current capability and resourcing, and to identify a broad way forward to address this. This would form the beginning of a high-level global program of work for species. The forum would be designed not only to inform and empower national teams, but also to inspire and unite them behind global species targets.

Areas of Activity

- With partners, convene a Global Species Conservation Summit.
- Embed the theme of Assess-Plan-Act into the fabric of the Summit, e.g. three differently themed pavilions – one for each of the Assess, Plan, Act pillars.
- Ensure integration of the human dimension: human well-being, human population growth, human consumption, economics, indigenous rights, human-wildlife conflict, One Health, etc.

Creating ONE GLOBAL PLAN,

As described above, there is potential to use a Global Species Conservation Summit as a springboard to a global program of work for species, which can be supported by a high-level, written plan to lead species conservation efforts to success.

Areas of Activity
TBD

Helping to drive national efforts

Both directly and through its partners, particularly the global zoo community, CPSG can support National Species Champions and their teams to build and unite their own national, multi-sectoral networks of conservation actors dedicated to achieving global species targets. In this way there is the potential to ensure that all efforts are pulling in the same direction and are reporting up to the CBD focal point to ensure better capture of global efforts. Public opinion and economics are drivers of political will and associated government action. Working on these two areas, galvanizing public support, ensuring that species conservation work is done sensitively with respect to affected communities and wherever possible ensuring clear benefits to them, will be key to elevating the importance and scale of species work undertaken or supported by governments.

Areas of Activity

- Incorporate human well-being dimensions into CPSG processes.
- Influence public opinion through social media.
- Connect with organizations that influence public opinion to promote national pride for wildlife.
- Capitalize on the popularity of zoos to engage the public and shape opinion.
- Explore/adopt/customise a tool kit for behaviour change.
- Encourage politicians to support species conservation, giving them the information through personal talks and short summary reports
- Partner with local NGOs to influence public opinion and government decisions
- Devise ways to challenge the view that saving species is something pursued by “hippies” or “bunny-huggers” as a hobby, rather than something necessary to the Planet’s survival.
- With partners, create outreach programs aimed at industry, government, academia, NGOs.
- Develop ideas from the marketing world to engage people and leaders: “conservation marketing”

Supporting a Global Species Championship
In which countries competed to demonstrate national success in achieving species targets.

Areas of Activity
TBD

Access to Knowledge: Transforming the way conservation decisions are made with open and accessible critical knowledge and resources

Convenors: Phil Miller and Bob Lacy

Aim:

The aim of this Working Group session is (a) to identify ways in which our species conservation efforts are hampered by limited access to information across biological and non-biological (e.g., social, anthropological, economic, etc.) disciplines, and (b) for CPSG to develop the concepts and technical methods for integrating these data sources in a way that improves species conservation planning.

Background:

Biodiversity conservation practitioners are now well aware of the importance of bringing many different types of information to the process of saving endangered species and their imperiled habitats. The emergence of new disciplines such as conservation psychology, ecological economics, and the application of social marketing to biodiversity management has revolutionized the ways in which we think about collecting and using disparate data to solve conservation problems. The Conservation Breeding(Planning) Specialist Group has been working to address this need for almost 20 years, recognizing the critical need to explicitly incorporate the "human dimension" into conservation planning – defined in terms of both participation by a diverse body of stakeholders and the integration of their disciplinary data into the analysis phase of that planning (Westley and Miller 2003).

While we have long recognized the need to assemble and integrate diverse types of data and information, practically achieving that goal has proved to be challenging. Many questions have emerged during our thinking around this general topic:

- What types of species conservation issues require us to look for diverse types of information to improve our analyses?
- What kinds of data do we need to address these issues?
- Do the required data exist? If so, where can we find them? Are they accessible to us?
- How do we assemble these different datasets into meaningful collections of information to assist us in our conservation planning?
- Do we have access to the technology required to implement the assembly of these diverse datasets? If not, how do we gain that access?
- Are there issues of data ownership that we must address in order to use disparate sources of information for participatory conservation planning efforts?
- What partnerships with the information technology industry or other communities may be necessary for CPSG to facilitate meaningful progress on the challenges around integration of diverse datasets for effective species conservation?

An organizational strategic planning meeting held in San Diego, CA (USA) in May 2019 led to the identification of a major pillar defining future CPSG activities around the topic of knowledge/data integration: "Access to Knowledge". But identifying this as an important theme for future CPSG work, we now have the opportunity to directly address the above questions in order to improve our ability to assemble disparate information in more meaningful ways to influence successful species conservation planning.

Process:

The working group will begin by reviewing past discussions on the topic, and revisit the important questions (summarized above) guiding our thoughts on the topic. Participants will be encouraged to brainstorm potential mechanisms for effective data integration, and alternative technologies that may be best suited to implement these mechanisms. Where appropriate, we will have targeted discussions intended to identify key partners, not yet identified in past CPSG-led discussions on this topic, that should be invited to collaborate with us to move this workplan forward.

Outcomes:

The group will produce a set of suggestions for advancing the conceptual design of an effective knowledge integration system useful to CPSG in species conservation planning. Furthermore, recommendations can be made for who to engage in this effort, including both technical experts from the information science and computer technology fields, as well as those with expertise in securing the necessary resources – financial and otherwise – to complete the proposed work and generate the desired products.

Materials:

Westley, F.W., and P.S. Miller (eds.). 2003. *Experiments in Consilience: Integrating Social and Scientific Responses to Save Endangered Species*. Island Press, Washington DC.

Using Data to Foresee and Respond to Species Conservation Crises

CPSG Strategic Planning Workshop (May 2019) - Technology Working Group Notes

Data Integration Meeting (July 2018) - Notes

The Conservation Planning Specialist Group:
Using data to foresee and respond to species conservation crises

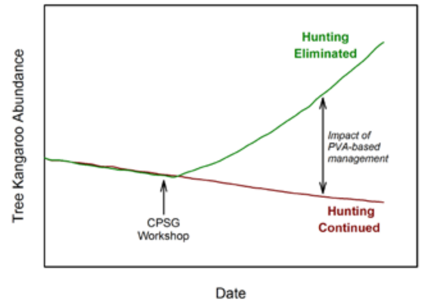
Assessing the human condition and its consequences for wildlife persistence

In its most applied form, population viability analysis (PVA) has emerged as one of the most effective processes for providing scientific rigor to species conservation planning efforts. The prospective simulation modeling tools used in PVA can help clarify, evaluate and prioritize human-mediated threats to wildlife populations and habitats, define and evaluate alternative management options in relation to their effectiveness in promoting demographic stability within declining populations, and develop operational strategies for long-term species conservation that are explicitly based on assessments of relative risk. As such, PVA is playing an increasingly central role in the formulation of long-term recovery plans for threatened and endangered species worldwide.

However, our ability to incorporate more complex interactions involving social science data and processes into these quantitative risk assessments is more limited. Nearly all existing PVA models make simplified assumptions about the impacts of human activities on the dynamics of wildlife populations and the ultimate driving forces that affect the proximate threats. If PVA is to evolve into an ever more useful tool, the analytical models we use must be able to more effectively integrate a variety of data types from diverse scientific disciplines. In this way, a more focused picture of the complex nature of human-wildlife interaction will emerge.

Tree kangaroos are native to West Papua, Papua New Guinea and northern Australia. The ten species comprising this group occupy some of the world's last remaining undisturbed rain forest habitat. Perhaps the most endangered species is Scott's tree kangaroo, known locally in northwestern Papua New Guinea as the tenkile. There are likely less than 250 tenkile remaining in the rain forests on the slopes of the Toricelli Mountains. While loss and degradation of their habitat is always a concern, perhaps the most acute threat to the species' future persistence is unsustainable hunting by local human communities. In particular, local hunters have a strong preference for removing adult females because of their relative ease of capture and the larger biomass obtained per unit hunting effort, given the frequent presence of a young offspring (joey) still nursing from its mother. Therefore, it was critical to assess the magnitude of the hunting threat for this species and its impact on the likelihood of persistence.

We were able to construct simplified predictive models for the tenkile and other related tree kangaroo species, and attempted to incorporate the female-biased hunting threat into our risk assessments. Our general models proved to be successful in illustrating conceptually the consequences of removing adult females from the population, and prompted local community leaders to consider modifying their hunting practices to help conserve this unique biological resource. Unfortunately, however, we were missing key pieces of information that would have



greatly improved the accuracy and utility of our model projections – improvements that could have further protected the tenkile from future extinction.

Firstly, while we were able to interview local hunters to derive basic estimates of the total number of tenkile females removed annually from the wild, we were unable to determine what proportion of the total population that offtake represented. Because we lacked credible estimates of the total population size for the species in the wild, we could not deduce the proportional impact of the hunting threat. This proportional expression of the hunting threat is a critical parameter used in our prospective risk assessments. We recognize that data such as these may not always be available; on the other hand, if they are available we may not always know the proper channels to access the data for our conservation planning. Developing a more effective mechanism for scouring the global biodiversity data universe would be an indispensable component of our quantitative risk assessment efforts.

Secondly, and perhaps more importantly, we lacked important information on the projected future characteristics of the human communities near the tenkile's wild habitat. These characteristics would no doubt shape our understanding of how hunting might change in nature and intensity as the local human population changes in response to a host of biological and social variables. What is the predicted number of humans expected to occupy this region over the next 50 years? What is the expected community age and gender structure, which would help us predict the number of active hunters among these communities? What is their predicted level of economic development, which might impact their future propensity for hunting tenkile? And what are the current and future behavioral drivers that motivate individual hunters to act the way they do? All of these questions elicit critical pieces of information that are used in a PVA context to project the intensity of hunting as a future threat to tenkile populations. Yet we had very little available expertise in the fields of human population demography, anthropology and sociology to draw upon for answers to these questions. As a result, we could not provide meaningful perspectives on the future for tenkile conservation in the face of an evolving human-dominated landscape. Gaining access to these types of data – likely available across a range of sources in the business, human health and sociological sectors – would revolutionize our ability to effectively plan for effective species conservation in a rapidly-changing world.

Our goal as the Conservation Planning Specialist Group is to help the global species conservation community create effective plans to save the world's endangered species. By uniting different disciplines and the information upon which they are built, we can advance the science and practice of species conservation to a new level of sophistication and effectiveness.

Forecasting the impacts of climate change on ice-dependent arctic fauna

The reduced access to prey by polar bears that feed from ice floes in the Canadian arctic has been well publicized and is causing appropriate alarm as one indicator of the impacts that are expected from global warming. Unfortunately, however, that is just the tip of the iceberg [sorry, I couldn't resist the analogy] regarding the changes that will be coming to the arctic fauna. Working with the Norwegian Polar Institute, we have been using "meta-models" that link population projections of polar bears, ringed seals, and bearded seals in the Barents Sea via the impacts that each species has on the other and the ways that those interactions will be affected by reduced springtime ice cover.

Ringed seals and bearded seals are currently abundant, and are essential prey species for polar bears and other top predators. Polar bears emerging with cubs from winter dens in the spring require abundant prey near shore in order to nurse their growing cubs and replenish the fat reserves of the mothers. Ringed seal pups in lairs (snow-covered dens) on the land-fast ice provide that essential resource, while bearded seals provide an additional primary prey throughout the year. In recent years, ice cover on the fjords around the archipelagoes of the Barents Sea has not been adequate to provide a platform for ringed seals to raise pups. Pups are therefore abandoned by their mothers and immediately eaten by bears, foxes, and other predators and scavengers.

Through the novel use of linked models of the population dynamics of the three species, we were able to project that the consequences of the reduced ice will be played out over a period of decades: initially, bears can easily prey on the abandoned seal pups; subsequently, the seal population will crash due to a lack of surviving pups to replace adults that age; eventually, the polar bears will lack the springtime prey needed to raise cubs; finally, both the ringed seal and bear populations will collapse. Several lessons emerged from our analyses, none of which would have been predicted from the single-species models typically employed by wildlife agencies and conservation scientists. The arctic species facing the greatest impact of climate change might well be the ringed seal – a species that is currently abundant and therefore not the focus of close monitoring and concern, but a species that is a key link in many arctic food chains. Furthermore, the consequences of the changing arctic climate might not be readily apparent until several decades after the processes have already been set in motion. Finally, to detect the disruptions to the ecological communities more quickly will require monitoring of seal pup and bear cub survival, rather than the standard censuses of the adult populations.

We were able to forecast impending changes in the arctic community through the use of our new modeling tools that enable analysis of effects that cascade through species interactions. However, a major constraint on our ability to predict the time course and the spatial patterns of the changes is the very limited data on the local and seasonal changes to ice cover around the archipelagoes. Consequently, currently we can provide only coarse guidance to management authorities regarding, for example, what areas of the arctic to protect (from impacts of increased shipping, mineral exploration, and tourism) as refugia for ice dependent fauna.

The essential climate data that are needed to make predictions (e.g., ice and snow cover of fjords in April) will not come from the global or even regional climate models that have been developed, but rather from assembled local knowledge – from accounts of fishermen and hunters, ecotourists, and others in the local communities. Intensive scientific monitoring of local weather conditions could fill the need, but the data must already exist within local reports, social media, and other local sources, if only it could be accessed efficiently. Traditional scientific data collection across the Arctic to detect where important changes are occurring would require a massive monitoring program, whereas people engaged in various activities are increasingly dispersed throughout the Arctic and therefore could provide a more extensive monitoring system than anything that the agencies could implement. Presently, the wildlife conservation and management communities do not have the expertise or resources to access the data that are available. That needs to change.

Seeing emergent diseases before it is too late

Over the past few decades a previously unknown fungal disease (chytridiomycosis) rapidly spread through ecosystems in every continent (except Antarctica), decimating frog populations and causing the extinction of almost certainly 100s of species. Although we don't often think about the role that amphibians serve in ecosystems, in many regions they are major components of the food chains – connecting the invertebrate microfauna to the larger vertebrates.

The decimation of frog populations due to the human-mediated spread of chytrid was detected only when individual field biologists traded stories and a few of them realized that the collapses of populations that they studied were not just local phenomena but instead part of a global disaster. The recognition of what was happening occurred just in time for the conservation community to mount a response of research, monitoring, and rescue that has prevented the ultimate loss of 100s of species. [Zurich Zoo has been among the leaders with the "Amphibian Ark" initiative – taking action to protect frog species through breeding programs, support of field efforts, and communicating the issues to the public.] Unfortunately, however, recognition of the crisis was too late for many other species.

If the chytrid epidemic had been recognized just a few years later (as would have been likely if a few scientists had not been comparing notes), the devastation would have been worse. Time was needed to develop tests for the fungus, determine treatments, develop husbandry and breeding methods for rescued populations, and establish field monitoring. Conversely, if the patterns had been recognized even a few years sooner, protocols to stop the spread of the fungus into additional regions could have been put in place, as is now being done to prevent the spread of a related and potentially equally devastating salamander chytrid disease.

Chytrid fungal disease in frogs is not a unique outcome of global commerce, and it certainly will not be the last time that a disease is spread to ecological communities that are not adapted to withstand it – with devastating impacts ecologically and often also on human health and economies. Other cases that we are currently facing include the white-nose syndrome that has decimated many bat species in North America, West Nile disease and avian influenza affecting bird populations, tuberculosis and other diseases transmitted between wild and domestic ungulates, ebola in great apes, distemper in many carnivores, … and who knows what other epidemics that are already underway but not yet recognized.

We know that these pandemics have happened, are happening, and will happen. We shouldn't be relying on surveillance by luck to try to see trends in time to take necessary actions. A data aggregation system that constantly monitored scientific publications, agency reports, news reports, and other sources of information for trends in wildlife population numbers, areas of occurrence, and unusual amounts or causes of mortality would reveal prospective disasters far more quickly and reliably than the fortuitous recognition (or not!) by a few scientists who were paying attention to broad patterns. The same surveillance would help reveal also the arrival of invasive species, something that presently is usually noted too late for effective action.

The Conservation Planning Specialist Group and its partners have developed and employed powerful analytical models for projecting consequences of environmental change and human activities on wildlife, and also processes for using such analyses within stakeholder deliberations to develop effective conservation action plans. However, successful application of these proven methodologies must be underpinned by data. Given the magnitude of the problems, and our abilities to respond, it is not sufficient to keep relying on just the knowledge of the "people in the room". We need to effectively and efficiently access the world's data.

CPSG Strategic Planning Workshop
May 2019

Technology Working Group Notes

Members: Taylor Callicrate, Jim Guenter, Bob Lacy, Phil Miller, Paul Pearce-Kelly, Kathy Traylor-Holzer, et al.

TIME Cover Activity – Technology Group

TIME

Harnessing the Power of Knowledge:
Saving Species
for a Healthy Planet

Who we are: cutting edge, innovative technology creators [adaptors]

- Integrating data sets
    - Global climate: status, trends
    - Human population: status, distribution, trends, activities
    - Socio-economic drivers of human activity, underlying behavior
- Working to make technology a positive concept
- Scaling up how we do things
- Utilizing all new technologies to gather information
- Technology as a tool – to do what?
- Using current relevant information
- Combining assessment with evaluation
- Knowledge = information & assessment
- Developing & adapting tools to integrate multi-disciplinary data to inform species conservation action
- Merging the power of the tech world with the passion of the conservation world

What we did

- Convened a group of leaders in "big data" technology and creative conservation thinkers in a weeklong workshop where we used CPSG processes to create an implementation and assessment plan
- Created a real-time global conservation data portal owned by, and accessible to, the people who want to save the world
    - Using the knowledge from the portal to save the ocean's coral by bringing together climatology, oceanographic, and biological communities to reverse the decline of corals in the Great Barrier Reef
- Developed tools, technology, and methods to transform information into species conservation action
- Inspired a global "pop-up alert system", as part of a larger online species conservation dashboard, that highlights current species status and conservation successes and challenges
    - Reversed the amphibian decline
    - Identified a new crisis – stopped disease transmission
    - Saved the cacao trees
    - Saved the world's fisheries

Technology Group: Equity in Access to Knowledge – Day 2 Discussions

Goal is to develop critical knowledge resources for effective species conservation planning that are open and accessible. Transform disparate, relevant data into accessible conservation knowledge by efficiently identifying, assembling, integrating, and analyzing diverse information. Transform the way conservation decisions are made, with open and accessible critical knowledge resources.

Open = freely available for any use
Accessible = data are in a format that can be used, with tools to use or process those data to answer your questions, for those communities that need to use it
Knowledge = data analyzed so that it can be applied to help answer the problem

3-5 Year Goal:

- Identify
- Assemble
- Integrate
- Make accessible
- Analyze

Data → Info → Knowledge

CPSG's strengths

- Convening
- Facilitating collaborations
- Existing networks
- Resourcefulness (working with what's on hand)

- Years of experience in conservation planning
- Already have globally used methods & tools

How do we do this?

- Develop iteratively collaborative relationships with the tech community around developing innovative tools for conservation planning, with the conservation community
    - Identify existing data integration efforts
- Collaborate with conservation relevant organizations to promote open and accessible data sharing in both directions
- Develop better understanding of problems that new tools can help us solve
    - Integrative
    - Analytical
    - Process

<u>Brainstorm and thematic clustering of key issues and ideas pertinent to use of technology for improved conservation data access</u>

- Tech connections:
    - Pitching to big tech companies
    - Develop a collaboration among conservation practitioners and tech leaders
    - Identify who we know in tech community, high up person
    - Connect and collaborate with others with expertise on other relevant technologies
    - Make connections with data analytics organizations
    - Build relationships and a network of data/information organizations
- Conservation relevant connections:
    - Make basic species information available on-line (consider existing databases)
    - Develop networks with academic groups to find the next generation of Innovative Planners
    - Think about new partnerships; think outside the box a bit
    - Ensure scope of relevant info and contacts is wide enough and make the collaborations/connections
    - Establish common goals and objectives with key holders of knowledge to share, integrate, analyze, etc.
    - Open dialogue with relevant IUCN people re. integration of knowledge products , improvements, enhancing effectiveness
    - Work with Red List processes and other species Specialist Groups to make assessments, support conservation planning
- Data integration connections
    - Envision & develop multiple levels of data/information scaled to different conservation decision challenges
    - Species and ecosystem info must integrate
    - Can we use the Green List to help move this forward?
    - All analysis needs to connect
    - Layered information systems to visualize species/threats/habitats/protected areas, etc. – all exist but can't be seen in one place – INTEGRATE
    - Identify and continuously refine the list of key resources

- Process tool development
    - Reproduce CPSG workshop in social media
    - Transmit conservation knowledge to the communities through social media, radio, TV, and organizing meetings
    - Better tools to evaluate success
    - Include feedback in connected assessments
    - Learn how to translate human population/demographic/economic model predictions into expected wildlife impacts
    - Conservation gaming – use gaming to help develop plans and solution
    - Iterative info harvesting and assessment is essential
    - Promote development of missing resources
    - Customize species knowledge dashboards for leaders/practitioners
    - Facilitate (via tools) exploration of solutions (e.g. Miradi – VAM link)
    - Develop a clear description of how we think data analytics could help scale up conservation
    - Match complexity of tools with complexity of issues – simple tools for simple issues
    - Learn from Open Standards – how did they do it and how can we do it?
    - Need to deal with uncertainty
    - Hold a workshop to brainstorm automation of basic/pilot PVAs
    - Automate 1st cut species assessments
    - Multi-species PVA modeling tools
    - Learn what conservation relevant parameters can be predicted from social/consumer data
    - Versions of our tools put into open sandbox for world to improve
    - Identify and develop key CPSG resources for planning based on all other available resources – "CPSG Last-Mile Technology"
    - Crate "CPSG Valley" for innovation of scalable planning ideas and tools
    - Our outputs must include the language/format of all formal assessments (Red List, etc.) for more policy impact
- Training and capacity
    - Integrate our tools into (leading) university curricula worldwide
    - Create "virtual office" where we all work and interact

Data integration meeting/conversation -- 18 July 2019

Phil Miller notes

Meeting Participants:
Phil Miller, CPSG
Dalia Conde, Species360
Jim Guenter, Species360
Doug Verduzco, Species360
Taylor Callicrate, SCTI (remote)
Bob Lacy, SCTI (remote)

PROBLEMS TO SOLVE
1. Dalia -- Need to plan for more species -- want to see how to serve species conservation. And we don't know for a given species, what levels of data -- biological, legislative, genetic, threats, managerial -- are available.
2. Doug -- want to serve the community, don't now what the problmes are, just want to help.
3. Phil -- two levels of organization: do more work on more species, and do better work on single species (e.g., chimps in Liberia)
3A. Taylor -- Bob and I have talked to Apex-RMS (Canada) about how they integrate all sorts of data for their predictive work. We should talk to people like that...
3B. Dalia -- yes, we don't want to re-invent things
4. Dalia -- we talk to TAGs...our members ask us, how do we prioritize species conservation work? how do we prioritize our collections? We're beginning to bring in-situ people -- Arnaud and Pati -- into ZIMS to implement a One Plan Approach for specific projects
5. Taylor -- really focused on the implementation perspective...how do we bring in tech like machine learning to improve our tool development, and how do we access knowledge around existing tools to do our job better? How do we access tools that assess global trends, emerging information, etc. We don't have these partnerships in place that will be key to our evolution.
6. Jim -- So is the problem: We don't have the data? You can't find the data? The data are not standardized?

Lots of overlap in our issues/problems/challenges!!! We gotta start working together...

Dalia will send papers on case studies of data integration that have come out of her lab...NOAA shipwrecks, etc.

Jim -- update on Conservation Science Alliance... Dalia's team in Copenhagen...also have three sponsors: WRS Singapore, Copehagen Zoo, WAZA

Bob -- who is our audience for this product? And based on this, what kind of interface do we develop to satisfy these audiences?
Jim -- Our audience is very broad: governments, specialists, academicians, zoo people, etc. We should probably start small and work our way outwards to bite off something we can chew reasonably effective...
Phil -- hmmm...do we start simple for everyone, or do we start complex for a professional and then make it simpler?

Bob -- We really need to scale up our activities...more data on more species...need to scale up our ability to collect, assemble, integrate and analyze more data to make a bigger impact.
Phil -- what about just assembling PVA model inputs into a single facility so people can look at this?! Low-hanging fruit for lots of information on lots of speces. Perhaps this is a simple, short-term, effective way to gather information. And when doing RedListing, we need to have a facility for accessing very basic information on what's known about, for example, amphibians to facilitate that knowledge.
Dalia -- Maybe the Species Knowledge Index has some of that information, but probably not for amphibians. My idea is to expand that Index to include many more types of information

UPDATE ON SPECIES360 HUB -- Doug
Possible to get his presentation?

SOLUTIONS
Jim -- our goal is to develop something like a Wikipedia page for each species, linking all the "data" that is pulled in to get a better understanding of the species, its threats, its in-situ and ex-situ status, and its conservation opportunity. Species 360 is working with Red List people to get ex-situ data into RL assessments.

First big database conference: Biodiversity Next -- Netherlands, October 2019. Doug and Johanna will be there...

Bob -- Low-hanging fruit: Develop the Species Knowledge Index into a facility that facilitates Red List assessments, providing information specifically for the questions needed to make a RL assessment. Would need demographic data like generation length, but would also need info on AOO, EOO, threats, etc.
Jim -- that seems too easy...why hasn't this happened already? Do the data not exist, or they're too hard to find? Need to find this out, across multiple taxa...
Phil -- a tool like an expanded Species Knowlede Index could be really useful in our A2P process to facilitate improved Red Listing and assessing for the purposes of planning.

PROPOSED PHASE 1
Think about developing Dalia's Species Knowledge Index into a tool to access/provide data that are appropriate for implementing a Red List assessment across multiple species. This includes data on basic species biology/demography, distribution, and threats (ideally spatially explicit and perhaps prioritized (although that could be a post-processing task), per an A2P process).
Jim -- Phil, would this kind of tool be valuable to you?
Phil -- absolutely...we're pushing the A2P process, and this would be a really valuable way to facilitate expanded Red Listing across a larger number of taxa.
Bob -- Need to think about bringing Rest Akcakaya into this process, as he's been involved in building RAMAS Red List.
Dalia -- we don't want to step on the Red List people's toes...gotta be careful about this...this can be a more generic assessment (A2P-type) tool that we can use to facilitate later planning, and others can use to ultimately facilitate more specific Red Listing.
Jim/Phil -- this is sounding alot like the existing Red List database...are we doing someting new?
Dalia -- yes, as there's lots of data that are available that are NOT already in the Red List database...
Phil -- temperature check...where are we?
Bob -- I think we're going down a good road...we need to develop a system that allows users to access ALL the data that are helpful for status assessment, so this is a good thing. The issue I see is around resources...how do we get started? Where do we start? What's the prototype that can demonstrate proof of concept, that we can show as a successful first step?

So...we need to figure out (for, perhaps, putting together a funding proposal):
- What exactly is this thing?
- Who will be the audience?
- What kinds of data will be in it?
- How will data ownership work?
- Who has access to the data?
- Who owns the tool itself?
- Who will be our collaborators to make it happen?

How much does this thing cost?
- Depends on: how big it is, and how fast you want it...$200,000 would go pretty quick...

Notes from Taylor Callicrate follow on the next page...

- Data needs & what problems are we trying to solve
  - Different projects have different types of data needs, but there may be some patterns
  - First need to establish what are the problems that we're running into with data access & availability
    - Dalia: conservation planning needs to be done for thousands of species; how do we work together to provide this information and also develop the tools to use it for massive-scale planning
    - Species360 has data that will be useful for species conservation, but also welfare of captive animals (health trends
      - Will make data available for research
  - From the end user standpoint, specialist groups will be coming to CPSG to do planning for all the species they've red-listed
    - Need access to a wider breadth of species information for higher-level groups ('grasshoppers' or 'freshwater fish')
    - Also need some species-specific information (I.e., chimpanzees in Liberia)
      - In addition to typical PVA info, need info about the government, human population, human age structure, distribution of oil palm plantations… and projections for all of these things
      - Species knowledge index may not be as useful when we need all this contextual information
  - We'll make a Google doc to share a list of other groups that have similar problems that we might want to reach out to
    - Like Apex RMS- they may need/use this contextual data for landscape modeling
  - Really need to be able to rapidly gather large amounts of data for assessments
    - These data are in various states: spread amongst existing databases, found in the literature, multiple formats…
    - Phil would like some kind of data portal where you can search on a taxa, and then be able to see all the information
      - It would link to other databases that have info on this species
      - Biology of related taxa
      - Projections for sea level rise or other relevant contextual/ancillary information like feral cats
  - With ancillary information, it's a two-level question
    - Is that data stream relevant (how many feral cats, and are they even a threat?)
    - If it is relevant, then how does it impact our model input?
    - Dalia's center is working to fill these knowledge gaps
    - Scale of this data is also important - both temporal and spatial

Human dimension
X Biological traits
Threats in the interxn

Dalia's Conservation index based on threats

- Talking about the hub and what it would look like
  - Links between databases (nodes) that meet at key nodes where the data are aggregated and displayed
  - Working only with open data due to the MOU with Red List(?), working with Open Air and Prayce(?) and science data alliance, things that the EU is developing to support research and policy makers (Dalia will send more info on this)
  - Need to develop a working model first before having a hub that dynamically pulls info from each node and displays current data in real-time according to user request
- Doug: presentation about the data hub design

- Who do we want to serve?
    - Especially targeting how we engage governments more effectively
- Types of data
    - Aggregated, shared data (ZIMS)
        - Belongs to Species360
    - Local shared data (shared across ZIMS database)
    - Local shareable data (possible to share but maybe no mechanism in place)
    - Local-only data
        - All of these belong to the ZIMS members
- What should 'open' data look like for Species360, considering organizational sustainability
    - If all data is opened up, may lose members
    - Some data will only be open to membership (medical data, for example)
    - Free access to the public (general trends, aggregate summary stats, etc)
    - A medium tier with more info than free that would be monetized
    - Kind of a mall of America concept with different hubs with access to different bits of data targeted to different audiences
    - Links with CITES, Red List, but also human population and urbanization databases, possibly via Dalia's center a U Denmark
- Species360 making links with IUCN
    - Data standardization has been an issue
        - Vocabulary (I.e., what do you call the age of first reproduction?)
        - Taxonomy
    - Have worked with an R programmer to standardize data as you pull it
        - R open science group
    - Linkages with Oceanarium (Joal? In Portugal) and with Jon Paul to work on linkages with IUCN
        - How can we put data from oceans together to advise policy processes?
        - This is maybe a case study of a single institution that wants to work on bringing data together, and could be considered another data hub
- BiodiversityNEXT conference about biodiversity databases in the Netherlands in October
    - Lots of discussion on operational parts of it (like standardization)
    - Implementation of machine learning to facilitate this communication
- Linkages with GBIF which is working on linking different types of databases

- Conservation Science Alliance
    - WRS, WAZA, and Copenhagen are sponsors supporting Dalia's research team
    - The goal is to do some strategic research to illustrate the value of the data for conservation, and inspire others to do research with the data and then facilitate that work

Afternoon Session

- Question categories - 6 questions that break down into three streams

- What data do we want to improve our conservation planning?
    - And how much of those data are actually available/accessible
  - Who's already working in this space of data accessibility/integration?
    - How do we most effectively work with them and others?
  - What are the gaps in existing work on data accessibility/integration?
    - How do we act to begin filling the gaps
- Based on these questions, how can we work together as a group of groups, given that there is quite a bit of overlap between our needs and expertise
  - We already have some conversation summaries from previous CPSG meetings regarding what we want
  - Dalia (and others?) will distribute those summaries
- Who is this for?
  - Have to carefully consider who it's for in deciding the design and how user-friendly it is
    - To consider the balance between technical and powerful, and being user-friendly
- Need to be careful that we're not trying to create a mega database, but rather a meta database
- What can we do relatively quickly/simply that will have a big impact?
  - With red listing (amphibian example), right now a bunch of experts sit around a table and think about who might know something
    - Hard to know if the data exist, or if they just exist in hard to find formats, or something else
    - And the challenges of assembling the data will be different for different taxa
  - It would be easier to have a database or index that would just tell you if that info is available and where it is
  - Demographic knowledge of species index hosts some data, but for some users have to click to visit external database
  - Would be difficult to query databases using a tool that just pulls from various databases because they each have their own rules for who can run queries; there are legal complications
- Using the species knowledge index to facilitate red list assessments
  - Would need distribution and threats information
  - What's been done so far
    - Using simple text mining to get the threats
- Might be possible to make a prototype using data sources that are open, to develop an aggregator tool that will pull data needed for red list assessments
  - First phase: red list assessments via providing or directing to data using the species index
    - Possibly letting users select which variables/data streams are important to them, for example region so they could retrieve data related to threats in that region only
  - Second phase: with more partners, data
  -

Inclusive Voices: Working beyond the professional conservation community to empower new voices to effectively drive change

Convenors: Jamie Copsey and Richard Jakob-Hoff

Aim:

To input into the development of one of CPSG's new strategic areas of work focused on developing tools and processes to support indigenous groups in planning for threatened species that they care about.

Background:

The recent IPBES 2019 report is the latest in a stream of global assessments that present a stark picture for biodiversity and the need for 'transformative change' if we are to reverse trends. Human communities worldwide have immense power to influence future change. Indigenous People alone have ownership and use or management rights over more than 38 million km2 (a quarter of the world's land surface), spread over 87 countries. Two thirds of this land is considered 'essentially nature'[1], supporting thousands- if not millions- of species, a proportion of which need conservation. Importantly indigenous people are custodians of knowledge and practices built on generations of living in harmony with their environment. Accessing and adding this to western scientific approaches holds the potential to radically enhance conservation planning outcomes.

Indigenous People now have a formally-recognised membership category within IUCN, highlighting a move to endorse their right to play a central role in conservation decision-making. Many organisations exist to promote social inclusion, development and environmental change within these community-based groups. Some organisations (e.g. the Conservation Measures Partnership) have been developing more culturally and socially-relevant planning tools and processes to support such groups (e.g. Healthy Country Planning). We believe there is an opportunity to add a significant new 'string to the CPSG bow' by enhancing and promoting species conservation planning processes designed to support indigenous groups to take more of a leading role in threatened species recovery. This 'new string' could be developed in partnership with other organisations- including other IUCN Commissions- that have indigenous organisations at their heart. This 'ground up' approach will complement our existing support for NGOs, zoos, and governments, enabling us to include new indigenous voices in successful efforts to increase the number of threatened species with effective conservation plans in place.

Process:

The Working Group will be co-facilitated by Jamie Copsey (CPSG Director of Training) and Richard Jakob-Hoff (CPSG Australasia Co-Convenor). We will begin with a short presentation to introduce the topic, providing some fundamental questions to guide working group discussions. This will be followed by a facilitated World Café event in which working sub-

[1] Garnett, S.T., Burgess, N.D., Fa, J.E., Fernández-Llamazares, Á., Molnár, Z., Robinson, C.J., Watson, J.E., Zander, K.K., Austin, B., Brondizio, E.S. and Collier, N.F., 2018. A spatial overview of the global importance of Indigenous lands for conservation. Nature Sustainability, 1(7), p.369.

groups will brainstorm a set of questions to inform the development of this new strategic arm for CPSG. We will also present some possible scenarios as prompts to get us thinking about what this new area of work for CPSG might 'look like'.

The session will end with summary presentations back from the working sub-groups and the identification of next steps in the development of this area of work.

Outcomes:

1. Identification of some of the core risks and opportunities of this new strategic direction for CPSG.

Question prompts:

a. To what extent would this new direction fit within our existing mission?
b. To what extent do we think the space is already 'full'/ is there a need and how would we know?
c. How might this new area of work inform our current practice?
d. Would we risk losing our identity or reconfirming it?
e. How might our supporters view this new direction?
f. Might this limit or expand our funding opportunities and how?

2. Collation of other sources of information on individuals and organisations that are working within this area who could inform or assist its development for CPSG.

Question prompts:

a. What can we learn from the Healthy Country Planning approach and others already established in the field?
b. How different do we think their (and others) processes/ approach are from ours?
c. **Why would an indigenous group want to connect with us rather than another organization? What is special that we bring to the table?**
d. How might we connect with other IUCN Commissions/ SSC Specialist Groups to develop work in this area?
e. Who else should we 'connect' with?

3. Examples of potential 'case studies' that could be developed to inform CPSG's growth in this space.

Question prompts:

a. Opportunities/risks of partnering with an existing provider of planning to indigenous groups?
b. What examples of indigenous groups seeking to conserve threatened species (for cultural, spiritual, harvesting or other needs) are we aware of which we might explore as potential case studies?

Materials:

Watch the recent webinar within the CPSG webinar series on Healthy Country Planning as an example of a planning process designed with and for aboriginal groups in Australia, and now beginning to be used more widely.