IUCN

SSC
Species Survival Commission

CONSERVATION
PLANNING
SPECIALIST GROUP
Changing the Future for Wildlife

Briefing Materials

2018 CPSG Annual Meeting
Bangkok, Thailand

2018 CPSG Annual Meeting

Berlin, Germany

18-21 October 2018

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CPSG Annual Meeting Working Group Schedule

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Working Group Descriptions 2018 CPSG Annual Meeting

Assessing to Plan (A2P): Using the Red List to its best advantage

CONVENOR: Claudine Gibson

AIM: The aim of this working group session is to explore how we can maximize the systematic and effective completion of the conservation actions section of Red List assessments, so they provide vital information for linking the assessment process directly through to a process of conservation action planning and delivery.

BACKGROUND: The IUCN Red List of Threatened Species^{TM} provides a universally recognized, global approach for assessing the conservation status of the world's animal and plant species. Each species assessment is generated based on an analysis of a wide range of information including population status, trends and threats, which is then intended to be used to help inform and catalyze conservation action.

Within each species assessment, there is a comprehensive section for inputting information on conservation actions currently in place, and for those that are needed. Potentially, this could provide a huge leap for many species, into conservation action planning. However, there are currently some challenges:

- these fields are not mandatory (and so are often only partially completed)
- preliminary analyses of a sample of records from the database show a disconnect between the threats listed as impacting on species, and the kinds of conservation action recommended, suggesting that the data may require additional review before adoption for conservation action planning.
- the Red List data potentially tell us what conservation action is needed, but not where it is needed, or who might take it forward, which again suggests that an extra layer of work is needed to maximize the value of this information for conservation action planning.
- the Red Listing process (mostly) happens separately from conservation planning activities meaning these two intrinsically-linked processes end up being disconnected.

CPSG is renowned for its facilitation of conservation planning and 'transforming passion for wildlife into effective conservation'. This has typically focused on single species or population planning; however CPSG is now up-scaling this work across multiple taxa. Currently, two objectives of CPSG's work are: **i) to improve the complementarity between Red Listing work and conservation planning work and ii) to develop a tool for moving more species, more quickly, from assessing and into planning (in line with the SSC's ASSESS – PLAN – ACT model).**

PROCESS: The working group will begin with an overview of the Red List process, the IUCN Species Information System (SIS) Toolkit and discussion of the current scope and capacity of assembling information on conservation actions 'in place' and' needed', within individual species assessments. The following issues and questions will then be discussed:

- Threat assessment – to conservation action review: what data do we have and what data do we need?
- Up-sizing: how do we scale up from single species to multi-species review of prioritizing conservation actions needed?
- Building momentum: how can we ensure that the assessment of taxon threat and conservation continues onto the next stages of conservation planning and implementation?

OUTCOMES: i) The group will produce a set of recommendations that describe the various stages of the Red List assessment process that CPSG can synergistically integrate into the development of a comprehensive summary report of the conservation actions needed, for a multi-species, taxonomic group; ii) the group will also make recommendations on how this information can best be delivered to support governments, and the wider conservation community to plan for and apply the most appropriate conservation actions that will most effective for improving the status of threatened species.

PREPARATION: Participants for this working group (especially those not involved with the IUCN Red List assessment process) are encouraged to have a look at various species assessments already published on the IUCN Red List website (www.iucnredlist.org), to become familiar with the information provided within the assessment fields. Other documents that will be useful to be aware of are the classification schemes for 'threats' and 'conservation actions needed', both available on the IUCN Red List website here:

http://www.iucnredlist.org/technical-documents/classification-schemes

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Planning to Act (P2A) on ASAP! species: how do we best support those charged with getting things done?

CONVENORS: Jamie Copsey, Caroline Lees, Nerissa Chao, and Vicki Guthrie

AIM: To identify current barriers to the implementation of species conservation plans. We will explore how we might develop new and improved avenues of support to key individuals charged with responsibility for driving action ('species champions') or for coordinating formal plan implementation. Emphasis will be placed on ASAP! species.

BACKGROUND: CPSGs remit is clearly focused around the processes and tools that enable the development of collaborative species conservation plans. ASAP!'s focus is on catalyzing conservation action for ASAP! species. Both organizations recognize that the development of effective plans can contribute to species recovery and we want to better understand the links between planning and implementation so that we can hone our planning processes. Individuals assigned responsibility either for driving or coordinating formal plans, play a pivotal role. These individuals may be referred to as 'Species Champions' or as 'Plan Implementation Coordinators' though at present these roles are not well defined or differentiated. These individuals may be more effective in their roles where they have access to particular kinds of support, including further training and provision of other tools. This working group explores what kinds of support might be of value and what roles CPSG and ASAP! might have in providing that support.

PROCESS: We will begin with scene-setting presentations followed by an open discussion on barriers to plan implementation. As a group will agree on draft definitions for a Species Champion (as distinct from a Plan Implementation Coordinator). We will then separate into two working groups:

Working Group 1: Plan Implementation Coordinators role and support needs. This group will develop a profile for an implementation coordinator, identifying the skills and any innate qualities required to carry out the role effectively and what their specific role would be. The group will dig further into some of the obstacles that specifically these coordinators may face in performing their role, and identify avenues through which support can be provided to these people through the CPSG planning process. The group will also review the DRAFT CPSG implementation tracking tool.

Working Group 2: Species Champions role and support needs: This group will define the ideal 'species champion' identifying what skills they will require and any innate qualities that might be required, as well as what their role might be. The group will then look at the broader set of conservation action obstacles faced by species champions, again identifying avenues for providing support to this group. This group will also review the DRAFT ASAP! conservation ladder.

Groups will come back together to present their findings and agree on next steps.

OUTCOMES: As a consequence of the workshop we will have:

- Identified barriers 1) to conservation action in general, and 2) to driving formal conservation plan implementation, with special focus on ASAP! species;
- Differentiated and defined the roles of 'Species Champion' and 'Plan Implementation Coordinator' (recognizing that in some cases the same individual may fill both roles);
- Developed "ideal" profiles for each;
- Produced a list of recommended areas for support to those operating in these roles, given the obstacles identified;
- Reviewed the draft CPSG tracking tool for plan implementation, and solicited feedback;
- Reviewed the ASAP! species plotting tool, and solicited feedback.

Illegal Wildlife Trade as a theme for planning

CONVENORS: Chris Shepherd and Caroline Lees

AIM: The aim of the working group is to explore the question: When planning action for species impacted by illegal wildlife trade, how can we get more benefits to more species?

BACKGROUND: CPSG traditionally supports groups – government agencies, NGOs, other SSC Specialist Groups – to plan the conservation of single species. It is now scaling up its operations and developing new tools to support more planning, for more species. A strand of this new work involves grouping species that can be expected to respond in a similar way, to similar sets of planned conservation actions. One of the ways in which we can group species is by threat, and one of the most challenging threats to wildlife in Southeast Asia (as well as in other regions) is illegal wildlife trade. The workshop will consider two broad themes:

1) Increasing the efficiency of existing work

There are examples of where action taken for high profile species could have made a difference to many other, similarly affected taxa, but where this opportunity was missed. Taxon-focused groups often work in isolation, leading to duplication of effort, wasted resources and missed opportunities. There must be ways to do this better.

Single-species workshops have been held recently for several species affected by illegal trade in Southeast Asia (e.g. Helmeted Hornbills, Sunda and Formosan Pangolins, Sun Bears). Within these workshops, small working groups on illegal trade issues were formed which gave rise to actions which are broadly similar across plans and which provide opportunities for inter-species consolidation and collaboration on actions. Further, there may be other, less well-known species that could “piggy-back” on action taken for those higher-profile taxa and there may be simple, achievable ways of maximizing those opportunities.

2) A threat-focused workshop process

Asian song-birds provide an example of a multi-species planning initiative for illegal trade affected species, which is now moving forward successfully to implementation. There is scope to develop a CPSG workshop process that targets multiple species simultaneously but which looks solely at the threat of illegal trade (rather than attempting to tackle all relevant threats concurrently). This new workshop process could differ from CPSG’s standard format in: the types and sources of information gathered and collated in advance of the workshop; the types of stakeholders invited to participate; the boundaries of the system that we aim to influence through planning; the working group topics; the planning outputs; the framework set up to drive plan implementation.

PROCESS: The workshop will begin with 2-3 short, scene-setting presentations (20-30 minutes including questions):

1) Introduction to the issues and what we are trying to achieve
2) Learning from mistakes: case-studies of opportunities missed

Following this the group will:

- Develop a trade-focused “threats map” for a flagship species for which illegal wildlife trade is the major threat. The map will work from poacher through trafficking routes to consumer, including both direct and indirect threats
- Add to this, at pertinent points on the map, broad threat mitigation strategies
- Use this to look at the range of areas in which multiple species could be gathered under the umbrella of a plan for a single-species
- Discuss how this could be made operational in the context of a CPSG planning process.

OUTCOMES: A first step towards a CPSG multi-species planning process centered around a primary threat of illegal wildlife trade.

Wildlife Health as a theme for planning/Disease Risk Assessment

CONVENOR: Boripat Siriaroonrat

AIM: The aims of this working group are to:

1. Provide an opportunity for participants to apply the IUCN-SSC/OIE Wildlife Disease Risk Analysis (DRA) framework to a scenario based on a disease impacting multiple species in an Asian location.
2. Identify approaches and tools to facilitate conservation planning for multiple species facing the same disease threat.

BACKGROUND: The SSC mandate to CPSG is to significantly increase capacity and capability in conservation planning, in order to meet the large and growing need for evidence-based plans that feature meaningful actions aimed at mitigating threats to species survival. Increasingly, for many species, both infectious and non-infectious diseases are recognized as either primary or secondary drivers of population decline. Examples include the catastrophic decline of several species of Asian vulture due to toxicity associated with eating bovine carcasses treated with the anti-inflammatory drug diclofenac, and the continuing spread of the fungal disease chytridiomycosis that is driving amphibian declines around the world. Additionally, wildlife species are primary reservoirs of some pathogens such as rabies, Nipah virus and West Nile Virus that cause serious disease in people and domestic animals, which may lead to extreme responses including indiscriminate culling of wildlife populations. This may, in turn, result in some unintended consequences such as the further spread of the disease, further threats to rare wildlife species and interruption of important biological cycles such as pollination by bats.

The One Health concept represents a shift in the current dominant approach to wildlife health management from human-centric to eco-centric – a new approach that now recognizes and addresses the interrelationships between the health of people, animals and the ecosystem of which they are a part.

The IUCN Species Survival Commission's Conservation Planning, Wildlife Health, Invasive Species and Reintroduction Specialist Groups joined with the World Animal Health Organization (OIE) to develop an approach incorporating Disease Risk Analysis (DRA) processes founded on the principles of One Health. The result was the publication in 2014 of the *Manual of Procedures for Wildlife Disease Risk Analysis*, and the companion *Guidelines for Wildlife Disease Risk Analysis*. Both of these documents are available for free download from the CPSG website: http://www.cpsg.org/document-repository.

This interactive workshop will demonstrate the application of the IUCN-SSC/OIE Disease Risk Analysis process to an example disease impacting multiple species followed by an exploration of approaches to conservation planning for multiple species facing the same disease threat.

PROCESS:

1. A DRA training "mini-workshop" to familiarize the group with the IUCN-SSC / OIE process.
2. Facilitated discussions around the following topics:
    - How disease threats impact multiple species;
    - The elements of an approach to developing conservation plans focusing on disease threat mitigation, including the processes and tools available to assist in workshop design and implementation.

OUTCOMES:

1. Participants are aware of the IUCN-SSC/OIE DRA process and core requirements for its application to wildlife disease risk assessment and management.
2. Identification of the elements of an approach to conservation planning for disease threats impacting multiple species and processes and tools to assist this.
3. An action plan and implementation group committed to progressing the further exploration and development of the identified processes and tools.

PREPARATION: Download the IUCN-SSC/OIE Manual of Procedures for Wildlife Disease Risk Analysis, available here.

Bring examples of wildlife conservation scenarios you are involved with in which disease has been identified as a significant threat to multiple species. If you have examples of conservation planning approaches to these, whether successful, unsuccessful or in development please bring them along to share.

SCTI Advisory Group Meeting

Highlights of activities – Species Conservation Toolkit Initiative

May 2018 - September 2018

SCTI
Species Conservation Toolkit Initiative

{ Software
for
saving
species; }

The **Species Conservation Toolkit Initiative** (SCTI) is a partnership to ensure that the new innovations and tools needed for species risk assessment, conservation planning, and managing populations are developed, are globally available, and are used effectively. The initiative leverages expertise in population biology, computer programming, and species conservation planning to: build and support modeling tools that are essential to guiding conservation actions for thousands of threatened species in the wild; facilitate the intensive management of hundreds of species that are being protected within *ex situ* programs; and integrate conservation efforts across the spectrum of management approaches.

New partners!

The Association of Zoos and Aquariums (AZA) and the European Association of Zoos and Aquaria (EAZA) have joined SCTI as major sponsors. They value both the SCTI software tools that guide scientific management of the *ex situ* populations and the contribution that a SCTI tools make to conservation and management of species in their natural habitats. We are equally excited that several more partners from Europe, Asia, and USA plan to join SCTI in 2019 (but we can't yet tell you who they are).

Planning for the future

The SCTI team (Jon, Onnie, Bob, Taylor, and Sara) met at the CPSG offices in Minnesota to reaffirm our mission, describe the primary areas of expertise that are needed to meet our goals, identify what roles can be filled by existing SCTI staff and by colleagues at partner organizations (e.g., IUCN CPSG, Species360, and the zoo associations), and determine what additional staffing or partners are needed to fulfill our mission. The primary areas in which SCTI needs to have access to expertise either on staff or via partnerships are the development of the science of species conservation methods, software coding, training and user support, and assisting in the use of the software to improve species conservation planning. It might be tempting to see SCTI as primarily a “coding shop”. However, SCTI was formed to sustain innovation in species conservation tools, and that means that we need also to be developing the science so that we can identify the next tools. To meet this mission, SCTI also needs to make sure that practitioners can use the software and use it appropriately, and that means that we need to provide adequate documentation, training, and support. In order to understand and serve the needs of the conservationists and managers who use our tools, SCTI needs to work collaboratively with them – especially on analyses that push the limits of our current knowledge and technologies. To enable our small team to be effective, we also need support for office management and communications and for organizational leadership and oversight.

Although we can and will rely heavily on collaborative partners to help fill some of the roles above, we recognize that currently the SCTI team is too small (with one conservation scientist programmer, one leader of our training efforts, and some donated time of two senior conservation scientists) to keep advancing and supporting the innovations that are needed by the species conservation communities. Minimally, we need to start developing technical expertise and experience in species conservation planning in a second conservation scientist-programmer, we need a person both to lead communications with our diverse audiences and to assist with creating training materials, and we need to develop more formal relationships and commitments for collaborative work from partner organizations that share our mission.

Building the capacity of SCTI to serve the conservation community

Due to the support of all the SCTI partners, we are now able to address at least one of the needs identified above: We have begun a search for a second full-time postdoctoral level conservation scientist-programmer! We know that we are looking for someone with special talents, but we are optimistic that we can find the right person to fill the position before the end of 2018.

Strategic thinking

The creation of SCTI was a bold initiative that was hatched out of discussions at CPSG (then, CBSG) meetings. We had optimism that the communities in which we work would being willing to form a partnership to support a small and flexible think-tank to sustain and grow innovation that serves the broader species conservation needs. We are now approaching the end of the first three years of the Initiative, and we need to determine how we can best serve the needs for the next three years and beyond. We need to make use of the expertise in our partners and our Advisory Group to help us think creatively about how to meet our broad mission.

Accordingly, we are planning to have a strategic thinking meeting with primary partners and advisors. We will be conveying more information about these plans soon, but we are thinking about a 2 to 3 day meeting, with an external facilitator, probably sometime in early 2019.

Advisory Group

SCTI benefits from an Advisory Group comprised of both representatives of major organizational partners of SCTI (a number of zoos, zoo associations, and conservation NGOs) and experts in the application of our tools for species conservation. The SCTI Advisory Group provides strategic advice on our mission and scope, broad priorities for tool development and support, scientific advances, technological opportunities, and new innovations that are needed to address increasingly complex conservation challenges. To provide diverse perspective and expertise on the Advisory Group, we have recently worked to recruit additional experts – from more scientific disciplines, more countries, and more kinds of institutions.

The Advisory Group had its first meeting in Berlin in October 2017, and will meet next at the CPSG annual conference in Bangkok in October 2018. The group will have a 3-hour working meeting during the CPSG conference. We are also organizing a mini-symposium for a CPSG plenary session in which several SCTI partners and colleagues will describe exciting and innovative methods that they are applying to species conservation planning.

Ensuring success for the next generation

A primary reason for the creation of SCTI was that we cannot rely on the same people forever to deliver the tools we need to succeed in species conservation and population management. We need to recruit the next generation of conservation scientists to serve our communities. SCTI is well on the way to doing just that, and perhaps just in time! We are fortunate that Jon Ballou – even a few years after his retirement from the Smithsonian Conservation Biology Institute – continues to devote substantial hours each week to work with the SCTI team on envisioning and building valuable tools. Bob Lacy has recently announced that he will be retiring from his position at the Chicago Zoological Society (CZS) in early 2019. However, Bob too will continue working with SCTI (following in Jon's footsteps, as always!). Moreover, CZS is committed to continuing its leadership in population biology and species conservation methods, and has begun a search for a Conservation Scientist with expertise in population biology and an eagerness to work with SCTI.

A manual for Outbreak

For several years, the OUTBREAK software has provided the means to model the spread (and control) of infectious disease in wildlife populations. The model can be linked with Population Viability Analysis models (such as VORTEX) to enable consideration of disease in species risk assessments and population management. However, although the program was intuitive enough that a number of scientists and students picked it up and have used it effectively (especially in Australia and Brazil), wider use of the software has been hindered by the lack of a complete manual.

Thanks to the efforts of Carlo Pacioni of Australia, Sara Sullivan of SCTI, Caroline Lees and Phil Miller of CPSG, Bob Lacy of CZS, and others (and some funding from the US National Science Foundation), we have now released the first complete manual for OUTBREAK! The manual is available on-line, is included in the latest installation of the program, and has been integrated into the software as context-sensitive Help.

Software enhancements

We continually make refinements in all of our software tools. These include improvements to the user interfaces, adjustments to algorithms for handling unusual species and data, and changes to keep current with evolving operating systems and network implementations.

Among the recent enhancements to PMx is a completely revised Selection tab in PMx, allowing much easier identification of which animals are to be included in genetic and demographic calculations. The Demography section has been steadily enhanced, with new metrics for reporting the status of the populations and completeness the data.

To Outbreak, we added the ability to describe any input rates (such as disease transmission rates and recovery times) as functions of individual and population properties, rather than only as constant values. In Vortex, improvements were made in the ways that management of captive populations can be modeled, and to the graphical analyses of sensitivity tests of uncertain parameters.

Building capacity to use the tools

At the request of the Canadian government (and with funding from them), we taught a workshop, hosted by the Seattle Zoo, on advanced uses of VORTEX. The Canadian government and several NGOs are eager to have their scientists become experts in VORTEX, so that the agencies can assess the cumulative impacts of anthropogenic threats to species and test proposed management actions.

Earlier this year, SCTI began to develop online training materials for Outbreak and PMx. Among the first products of this effort are a series of introductory videos on the OUTBREAK software, first trialed at a Disease Risk Assessment workshop in Brazil and now available at http://www.vortex10.org/Outbreak.aspx. To determine priority training needs for PMx, we distributed a Training Needs Assessment on our website and various international listservs in March 2018. Over 130 PMx users from 23 countries responded, giving us a better understanding of where additional training is most needed and in what format our users are interested in receiving that training. Currently, three online formats are being tested, and PMx users are welcome to view these materials and leave feedback using the following links:

- Short, interactive module: Creating a PMx Project with ZIMS export files
- Comprehensive overview course: The Genetics Module
- Narrated video: Who is in the Managed N?

To distribute our training materials, we are developing a dedicated training section of our website. Here, toolkit users will be able to access materials through personal accounts, track their activity through user profiles, and interact with other users in dynamic forums. Additionally, the SCTI team will be able to gain insight into learning behaviors and pinpoint areas for improvement by tracking metrics related to completion rates, learner performance, and learner satisfaction. As these e-learning materials take time to design, build, and evaluate, we will also provide quick pdf-based technical guides and make updates to the user manuals as needed. Most recently, we partnered with Species360 to produce an online guide for testing ZIMS PMx exports. This pdf is available for download using the “Walk Me” tool on the Species360 website. We will continue to collaborate with partners providing their own online or in person training related to our tools and provide daily technical assistance to queries sent to help@vortex10.org.

Working with partners

The SCTI team met with the science team of Species360 to share new developments and discuss possible areas of collaboration. We are working closely with Species360 to ensure full compatibility and exchange of data between ZIMS and PMx. In the process, this has led to a number of enhancements to both PMx and ZIMS for Studbooks, and we are now working with Species360 to export additional data fields from ZIMS to PMx.

We continue to help regional zoo associations with the new exports of data from ZIMS to PMx. Documentation of data standards and guides were created to help user groups confirm the accuracy of data exports.

We are continuing to work with a group of botanical gardens to test the use of PMx and population management methods developed by zoos for guiding collaborative breeding programs for plants. We hosted a workshop for colleagues from 6 botanic gardens on the use of PMx for plant population management. This project has led us to improve how PMx handles hermaphroditic (monoecious) species – an enhancement that will likely be useful for management of some fish and many invertebrate animal species as well.

SCTI provides expert advice (and sometimes debugging, as needed) to CPSG as it applies the latest features in Vortex to some of the most complex species risk assessments. When time permits, technical assistance is provided also to graduate students, researchers, wildlife agencies, zoos and aquariums, and others.

Go to scti.tools!

A new SCTI website is about to be unveiled. (It is still in development as of 1 October.) The site provides much more information about SCTI, downloads of software and documentation, and more. It will soon provide access to on-line training modules and videos, and forums for supporting communities of users.

Some of our plans for the next few months

SCTI is flexible and responsive. We are constantly refining software and increasing support, and adding new features and even new programs, as suggestions, new ideas, and new science are identified by our team, our partners, or the broader conservation community. Among the developments underway, and which we expect to release within the next few months, are:

SCTI is participating in the annual conferences of EAZA, AZA, and CPSG to meet with partners and users of the SCTI tools.

A training workshop on the OUTBREAK software will be conducted in conjunction with the EAZVW/AAZV/IZW joint conference, held in Prague.

We will be completely revising the PMx manual, especially to describe the many newer features.

The SCTI Team

Jonathan Ballou

Onnie Byers

Taylor Callicrate

Robert Lacy

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SCTI Partners (as of August 2018)

Association of Zoos and Aquariums

Auckland Zoo

Chicago Zoological Society

Copenhagen Zoo

European Association of Zoos and Aquaria

Living Desert Zoo & Gardens

National Zoo/Smithsonian Conservation Biology Institute

Oceans Initiative

Raincoast Conservation Foundation

Saint Louis Zoo

San Diego Zoo Global

San Francisco Zoo & Gardens

Seattle Aquarium

SOS Rhino

Species360

IUCN SSC Conservation Planning Specialist Group

Zoological Society of London

Contract support for specific projects:

Canada Department of Fisheries and Oceans

The Nature Conservancy

US Institute of Museum & Library Services

US National Science Foundation

Investigating patterns of international wildlife trade in ASAP species

CONVENORS: Johanna Stärk, Chris Shepherd, Rita da Silva, Ioanna Alexiadou, and Dalia A. Conde

AIM: Investigate and discuss patterns of international trade in ASAP species to unveil fraudulent claims of captive-breeding.

BACKGROUND: Unsustainable and illegal wildlife trade is one of the major challenges of South East Asia (SEA) and its rapid growth is threatening many CITES-listed species. An analysis of the CITES Trade database showed that over 35 million CITES listed animals have been exported from SEA between 1998 to 2007, with 4.5 million derived from captive-breeding facilities [1]. While trade in captive bred individuals can relieve pressure on wild populations, the high number of transactions of specimens claimed to be captive-bred raise concerns about the potential illegal laundering of wild caught animals declared as produced in captivity [2]. Successful breeding of threatened species on a commercial scale requires extensive knowledge in captive husbandry, good record keeping, and high standards of veterinary care. Moreover, establishing captive breeding populations capable of producing second-generation offspring takes considerable time and effort.

This is especially the case for species with slow life histories, i.e. species that mature late and produce few offspring, as for example the case in many turtles and tortoises; hence making captive-breeding unprofitable [3]. For example, the Critically Endangered Palawan Forest Turtle (Siebenrockiella leytensis) listed on CITES Appendix II, has been commercialized as captive bred, however this is unlikely, since up until 2015 it had never successfully reproduced in captivity [4]. The Palawan Forest Turtle is only one of currently 176 species in South East Asia that have been prioritized by the IUCN SSC's Asian Species Action Partnership (ASAP) focusing on critically endangered land or freshwater vertebrates occurring regularly in the region. Of these, 39 species are species listed on CITES Appendix I and 29 species are listed on Appendix II [5]. A major challenge for many countries to meet the requirements for trade in CITES-listed species to control the illegal laundering include corruption, weak law enforcement, insufficient capacity of the authorities and lack of knowledge on species captive breeding potential. In this workshop, we will work with data from the CITES Trade database to discuss and identify ASAP species at highest risk of unsustainable trade and identify species that may be illegally laundered as captive-bred to support authorities in their fight against illegal trade.

PROCESS:

1. General presentation of trade analytics of ASAP species and the CITES Trade database
2. Division into smaller working groups divided by taxa to discuss trade patterns, identify possible fraudulent claims of captive breeding and to prioritize ASAP species at highest risk of unsustainable or fraudulent trade
3. Presentation of main findings and discussion of follow up actions

RECOMMENDED READING:

Relevant definitions of CITES source codes: Captive breeding and ranching of CITES-listed animals: EU approaches to handling imports of C, F, and R specimens
http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=33543&no=40

An example of how to identify illegal laundering based on the species reproductive potential:
Nijman, V. and Shepherd, C.R. (2015). Adding up the numbers: an investigation into commercial breeding of Tokay Geckos in Indonesia. TRAFFIC.
https://www.traffic.org/site/assets/files/6060/adding-up-the-numbers.pdf

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[1] Nijman, V. (2010). An overview of international wildlife trade from Southeast Asia. Biodiversity and conservation, 19(4), 1101-1114.

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[3] Iverson, J. (1992). Correlates of Reproductive Output in Turtles (Order Testudines). Herpetological Monographs, 6, 25-42. doi:10.2307/1466960

[4] https://www.traffic.org/news/captive-breeding-claims-turned-turtle/

[5] CITES Appendices I, II, III https://cites.org/eng/app/appendices.php

Ex situ management of ASAP species

CONVENORS: Sonja Luz, Danny de Man, Kathy Traylor-Holzer, and Roopali Raghavan

AIM: The aim of this working group is to discuss the Ex-Situ needs for ASAP species and the potential requirement for a more pro-active strategy for Ex-Situ management approaches.

BACKGROUND: Integrated and professionally managed Ex-Situ programs of threatened species can substantially support conservation efforts, and many notable examples exist in which Ex-Situ facilities like Zoos have helped to save species from extinction. With that there is no longer the need to discuss what roles Zoos and Aquaria can play in conservation, but rather when should such programs be considered (especially for species on the brink of extinction) and who is in the best position to do so. While comprehensive guidelines have been developed (e.g. IUCN guidelines on the use of Ex-Situ management for species conservation) to help evaluate Ex-Situ involvement, it seems we are still struggling greatly to reach agreement among relevant stakeholders and with that are often far too late in implementing such programs.

For the 175 Critically Endangered ASAP species an Ex-Situ Working Group was established, which is currently trying to better understand needs, opportunities and constraints for Ex-Situ management of ASAP species specifically.

PROCESS: The CPSG working group will be introduced to the ASAP Ex-Situ working group and receive a preliminary overview of the status of current Ex-Situ management of ASAP species. For that purpose, and to our best knowledge, ASAP species have been sorted into 3 categories:

1. None currently kept in captivity
2. Currently kept in captivity, but not clear to how well they are integrated in conservation programs/action plans
3. Currently kept in captivity, with Ex-Situ programs seemingly well integrated into conservation programs/action plans.

Furthermore, the participants will receive a brief introduction to the existing evaluation tools (e.g. IUCN Ex-Situ Guidelines and ICAP process).

Following that, we hope that specific issues and questions will be discussed:

- Are the existing tools to evaluate Ex-Situ needs of species properly used and understood, and is there a need for more specific guidelines or even protocols?
- Who should/can make the recommendation/decision on when to start Ex-Situ programs and what info is (i) necessary or (ii) highly desirable before this decision is made?

- How do we ensure that captive management programs are ethical, legal and sustainable, as well as properly integrated in In-Situ conservation of the species?
- When and where should such programs be initiated, what is the role of western zoos and how do we build appropriate capacity managing Ex-situ programs for ASAP species in range countries?

OUTCOMES: We hope that the discussions of this working group will help us improve existing programs as well as aid in prioritizing needs for Ex-Situ management programs of ASAP species. We furthermore hope to get more insights from both In-Situ and Ex-Situ stakeholders on how to optimize processes leading to a successful One Plan Approach conservation outcome.

PREPARATION: Please review the following documents:

IUCN SSC Ex Situ Guidelines

Supporting the implementation of CPSG's Strategic Plan

CONVENORS: Jo Gipps and Brad Andrews

AIM: To consider ways in which the CPSG community can 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, following a meeting and workshop in Minneapolis in April 2017, and was discussed at the CPSG Annual Meeting 2017 in Berlin. Other sections of the Plan (Mission, Approach and Challenge; Introduction and Context; Governance; Finance; Fundraising) have been added subsequently. Two Fundraising Case for Support documents have also been drafted.

PROCESS: We shall quickly review the Strategic Plan, without attempting further editing. We will then review the Fundraising Case for Support documents (both the 1 page and the 12 page booklet versions, (see links below) to assess their viability, discuss appropriate audiences, and determine what, if any, additional tools may be required to assist the fundraising effort. We shall consider any major ideas, suggestions, concerns, or additions that emerge from our discussions. Some questions we will review are:

- How can CPSG best target its existing funder base while at the same time develop a new funder base to support delivery of the strategic plan?
- What potential partnerships exist for CPSG to strengthen its 'case for support'?
- Are there institutions out there that would commit significant and consistent staff time to help CPSG scale up its planning and capacity building for planning work?

OUTCOMES: Improvements in structure, reach and utility of all the work needed to deliver the Strategic Plan successfully.

PREPARATION: Please review the following documents:

Conservation Pivot Points: Building Global Capacity for Species Conservation Planning

Building Global Capacity for Species Conservation Planning

Working Group Descriptions

2018 CPSG Annual Meeting
Bangkok, Thailand

Working Group Materials

2018 CPSG Annual Meeting
Bangkok, Thailand

Assessing to Plan (A2P): Using the Red List to its best advantage

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Assessing to Plan (A2P): Using the Red List to its best advantage

CONVENOR: Claudine Gibson

AIM: The aim of this working group session is to explore how we can maximize the systematic and effective completion of the conservation actions section of Red List assessments, so they provide vital information for linking the assessment process directly through to a process of conservation action planning and delivery.

BACKGROUND: The IUCN Red List of Threatened Species™ provides a universally recognized, global approach for assessing the conservation status of the world's animal and plant species. Each species assessment is generated based on an analysis of a wide range of information including population status, trends and threats, which is then intended to be used to help inform and catalyze conservation action.

Within each species assessment, there is a comprehensive section for inputting information on conservation actions currently in place, and for those that are needed. Potentially, this could provide a huge leap for many species, into conservation action planning. However, there are currently some challenges:

- these fields are not mandatory (and so are often only partially completed)
- preliminary analyses of a sample of records from the database show a disconnect between the threats listed as impacting on species, and the kinds of conservation action recommended, suggesting that the data may require additional review before adoption for conservation action planning.
- the Red List data potentially tell us what conservation action is needed, but not where it is needed, or who might take it forward, which again suggests that an extra layer of work is needed to maximize the value of this information for conservation action planning.
- the Red Listing process (mostly) happens separately from conservation planning activities meaning these two intrinsically-linked processes end up being disconnected.

CPSG is renowned for its facilitation of conservation planning and 'transforming passion for wildlife into effective conservation'. This has typically focused on single species or population planning; however CPSG is now up-scaling this work across multiple taxa. Currently, two objectives of CPSG's work are: **i) to improve the complementarity between Red Listing work and conservation planning work and ii) to develop a tool for moving more species, more quickly, from assessing and into planning (in line with the SSC's ASSESS – PLAN – ACT model).**

PROCESS: The working group will begin with an overview of the Red List process, the IUCN Species Information System (SIS) Toolkit and discussion of the current scope and capacity of assembling information on conservation actions ‘in place’ and’ needed’, within individual species assessments. The following issues and questions will then be discussed:

- Threat assessment – to conservation action review: what data do we have and what data do we need?
- Up-sizing: how do we scale up from single species to multi-species review of prioritizing conservation actions needed?
- Building momentum: how can we ensure that the assessment of taxon threat and conservation continues onto the next stages of conservation planning and implementation?

OUTCOMES: i) The group will produce a set of recommendations that describe the various stages of the Red List assessment process that CPSG can synergistically integrate into the development of a comprehensive summary report of the conservation actions needed, for a multi-species, taxonomic group; ii) the group will also make recommendations on how this information can best be delivered to support governments, and the wider conservation community to plan for and apply the most appropriate conservation actions that will most effective for improving the status of threatened species.

PREPARATION: Participants for this working group (especially those not involved with the IUCN Red List assessment process) are encouraged to have a look at various species assessments already published on the IUCN Red List website (www.iucnredlist.org), to become familiar with the information provided within the assessment fields. Other documents that will be useful to be aware of are the classification schemes for ‘threats’ and ‘conservation actions needed’, both available on the IUCN Red List website here:

http://www.iucnredlist.org/technical-documents/classification-schemes

Planning to Act (P2A) on ASAP! species: How do we best support those charged with getting things done?

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Planning to Act (P2A) on ASAP! species: how do we best support those charged with getting things done?

CONVENORS: Jamie Copsey, Caroline Lees, Nerissa Chao, and Vicki Guthrie

AIM: To identify current barriers to the implementation of species conservation plans. We will explore how we might develop new and improved avenues of support to key individuals charged with responsibility for driving action ('species champions') or for coordinating formal plan implementation. Emphasis will be placed on ASAP! species.

BACKGROUND: CPSGs remit is clearly focused around the processes and tools that enable the development of collaborative species conservation plans. ASAP!'s focus is on catalyzing conservation action for ASAP! species. Both organizations recognize that the development of effective plans can contribute to species recovery and we want to better understand the links between planning and implementation so that we can hone our planning processes. Individuals assigned responsibility either for driving or coordinating formal plans, play a pivotal role. These individuals may be referred to as 'Species Champions' or as 'Plan Implementation Coordinators' though at present these roles are not well defined or differentiated. These individuals may be more effective in their roles where they have access to particular kinds of support, including further training and provision of other tools. This working group explores what kinds of support might be of value and what roles CPSG and ASAP! might have in providing that support.

PROCESS: We will begin with scene-setting presentations followed by an open discussion on barriers to plan implementation. As a group will agree on draft definitions for a Species Champion (as distinct from a Plan Implementation Coordinator). We will then separate into two working groups:

Working Group 1: Plan Implementation Coordinators role and support needs. This group will develop a profile for an implementation coordinator, identifying the skills and any innate qualities required to carry out the role effectively and what their specific role would be. The group will dig further into some of the obstacles that specifically these coordinators may face in performing their role, and identify avenues through which support can be provided to these people through the CPSG planning process. The group will also review the DRAFT CPSG implementation tracking tool.

Working Group 2: Species Champions role and support needs: This group will define the ideal 'species champion' identifying what skills they will require and any innate qualities that might be required, as well as what their role might be. The group will then look at the broader set of conservation action obstacles faced by species champions, again identifying avenues for providing support to this group. This group will also review the DRAFT ASAP! conservation ladder.

Groups will come back together to present their findings and agree on next steps.

OUTCOMES: As a consequence of the workshop we will have:

- Identified barriers 1) to conservation action in general, and 2) to driving formal conservation plan implementation, with special focus on ASAP! species;
- Differentiated and defined the roles of ‘Species Champion’ and ‘Plan Implementation Coordinator’ (recognizing that in some cases the same individual may fill both roles);
- Developed “ideal” profiles for each;
- Produced a list of recommended areas for support to those operating in these roles, given the obstacles identified;
- Reviewed the draft CPSG tracking tool for plan implementation, and solicited feedback;
- Reviewed the ASAP! species plotting tool, and solicited feedback.

Illegal Wildlife Trade as a theme for planning

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Illegal Wildlife Trade as a theme for planning

CONVENORS: Chris Shepherd and Caroline Lees

AIM: The aim of the working group is to explore the question: When planning action for species impacted by illegal wildlife trade, how can we get more benefits to more species?

BACKGROUND: CPSG traditionally supports groups – government agencies, NGOs, other SSC Specialist Groups – to plan the conservation of single species. It is now scaling up its operations and developing new tools to support more planning, for more species. A strand of this new work involves grouping species that can be expected to respond in a similar way, to similar sets of planned conservation actions. One of the ways in which we can group species is by threat, and one of the most challenging threats to wildlife in Southeast Asia (as well as in other regions) is illegal wildlife trade. The workshop will consider two broad themes:

1) Increasing the efficiency of existing work

There are examples of where action taken for high profile species could have made a difference to many other, similarly affected taxa, but where this opportunity was missed. Taxon-focused groups often work in isolation, leading to duplication of effort, wasted resources and missed opportunities. There must be ways to do this better.

Single-species workshops have been held recently for several species affected by illegal trade in Southeast Asia (e.g. Helmeted Hornbills, Sunda and Formosan Pangolins, Sun Bears). Within these workshops, small working groups on illegal trade issues were formed which gave rise to actions which are broadly similar across plans and which provide opportunities for inter-species consolidation and collaboration on actions. Further, there may be other, less well-known species that could “piggy-back” on action taken for those higher-profile taxa and there may be simple, achievable ways of maximizing those opportunities.

2) A threat-focused workshop process

Asian song-birds provide an example of a multi-species planning initiative for illegal trade affected species, which is now moving forward successfully to implementation. There is scope to develop a CPSG workshop process that targets multiple species simultaneously but which looks solely at the threat of illegal trade (rather than attempting to tackle all relevant threats concurrently). This new workshop process could differ from CPSG’s standard format in: the types and sources of information gathered and collated in advance of the workshop; the types of stakeholders invited to participate; the boundaries of the system that we aim to influence through planning; the working group topics; the planning outputs; the framework set up to drive plan implementation.

PROCESS: The workshop will begin with 2-3 short, scene-setting presentations (20-30 minutes including questions):

1) Introduction to the issues and what we are trying to achieve

2) Learning from mistakes: case-studies of opportunities missed

Following this the group will:

- Develop a trade-focused “threats map” for a flagship species for which illegal wildlife trade is the major threat. The map will work from poacher through trafficking routes to consumer, including both direct and indirect threats
- Add to this, at pertinent points on the map, broad threat mitigation strategies
- Use this to look at the range of areas in which multiple species could be gathered under the umbrella of a plan for a single-species
- Discuss how this could be made operational in the context of a CPSG planning process.

OUTCOMES: A first step towards a CPSG multi-species planning process centered around a primary threat of illegal wildlife trade.

Wildlife Health as a theme for planning/Disease Risk Assessment

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Wildlife Health as a theme for planning/Disease Risk Assessment

CONVENOR: Boripat Siriaroonrat

AIM: The aims of this working group are to:

1. Raise awareness of how the DRA process is typically applied to single-species planning situations.
2. Identify approaches and tools to facilitate conservation planning for multiple species facing the same disease threat.

BACKGROUND: The SSC mandate to CPSG is to significantly increase capacity and capability in conservation planning, in order to meet the large and growing need for evidence-based plans that feature meaningful actions aimed at mitigating threats to species survival. Increasingly, for many species, both infectious and non-infectious diseases are recognized as either primary or secondary drivers of population decline. Examples include a) the catastrophic decline of several species of Asian vulture due to toxicity associated with eating bovine carcasses treated with the anti-inflammatory drug diclofenac, and b) the continuing spread of the fungal disease chytridiomycosis that is driving amphibian declines around the world.

Additionally, wildlife species are primary reservoirs of some pathogens (e.g. rabies, Nipah virus, West Nile Virus) that cause serious disease in people and domestic animals. Such events can lead to extreme responses including indiscriminate culling of wildlife populations. This may, in turn, result in some unintended consequences such as the further spread of the disease, further threats to rare wildlife species and interruption of important biological cycles such as pollination by bats.

The One Health concept represents a shift in the current dominant approach to wildlife health management from human-centric to eco-centric – a new approach that now recognizes and addresses the interrelationships between the health of people, animals and the ecosystem of which they are a part.

The IUCN Species Survival Commission's Conservation Planning, Wildlife Health, Invasive Species and Reintroduction Specialist Groups joined with the World Animal Health Organization (OIE) to develop an approach incorporating Disease Risk Analysis (DRA) processes founded on the principles of One Health. The result was the publication in 2014 of the Manual of Procedures for Wildlife Disease Risk Analysis, and the companion Guidelines for Wildlife Disease Risk Analysis. Both of these documents are available for free download from the CPSG website: http://www.cpsg.org/document-repository.

PROCESS:

1. A presentation on the use of the IUCN-SSC/OIE Disease Risk Analysis to focus on planning for a single species.

2. Facilitated discussions around the following topics:
    - How would this DRA process be used in a multispecies planning context for, say, vultures in Asia or bats in North America? Would the process be really different? If so, how?
    - What would we need to consider in the design and implementation of such a process?
    - Who would need to be invited to participate?

OUTCOMES:

1. Participants are aware of the IUCN-SSC/OIE DRA process and core requirements for its application to wildlife disease risk assessment and management.
2. Identification of the elements of an approach to conservation planning for disease threats impacting multiple species and processes and tools to assist this.
3. An action plan and implementation group committed to progressing the further exploration and development of the identified processes and tools.

PREPARATION: Download the IUCN-SSC/OIE Manual of Procedures for Wildlife Disease Risk Analysis, available here.

Bring examples of wildlife conservation scenarios you are involved with in which disease has been identified as a significant threat to multiple species. If you have examples of conservation planning approaches to these, whether successful, unsuccessful or in development please bring them along to share.

IUCN

SSC
Species Survival Commission

Manual
of Procedures for Wildlife Disease Risk Analysis

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Protecting animals, preserving our future

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© Cover images from left to right:
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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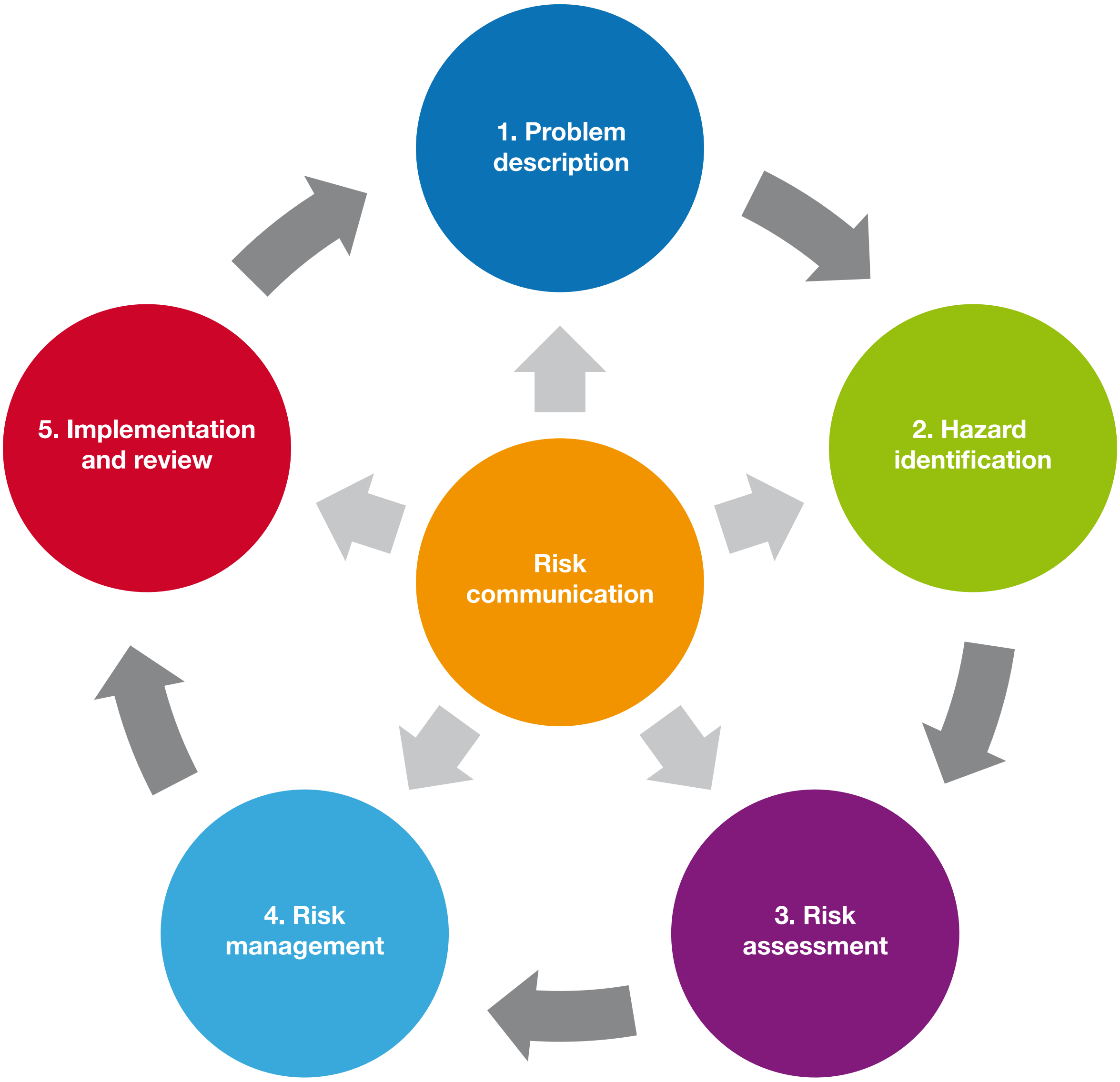
Disease risk analysis (DRA) process steps



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:

Bob Lacy and, subsequently, Onnie Byers, Conservation Breeding Specialist Group;

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.

We also greatly appreciate the thoughtful and diligent assistance of the OIE publications team under the direction of Dr Daniel Chaisemartin – in particular Annie Souyri, Chief of the Publications Unit, and Gillian Whytock, copy-editor at Prepress Projects.

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OIE Preface

World Organisation for Animal Health
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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

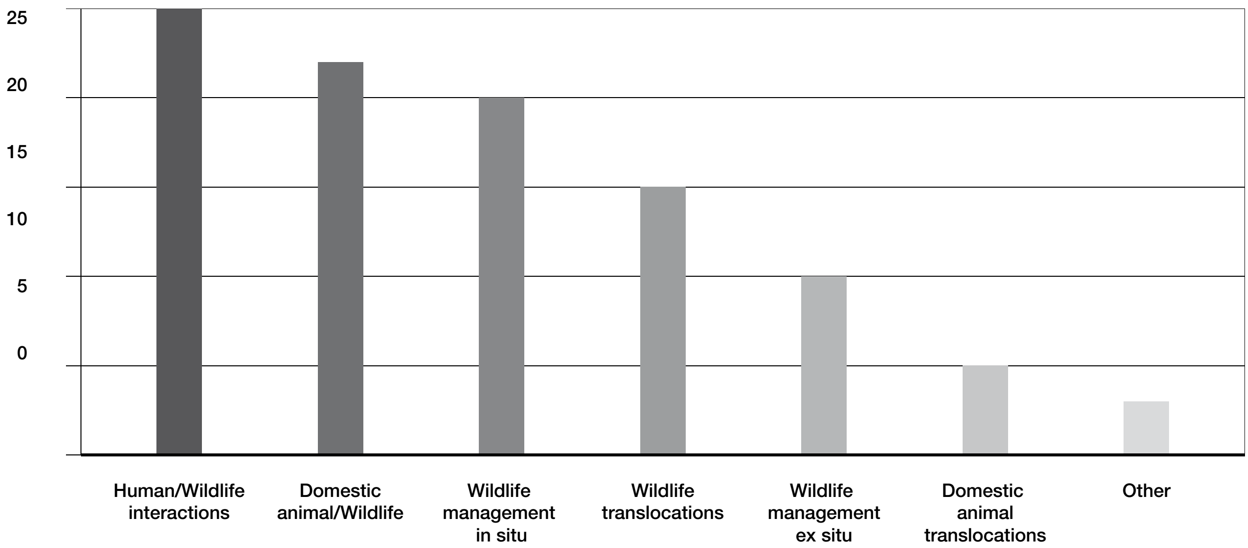

Fig. 1
Needs analysis survey respondents' main areas of wildlife disease concern (*n* = 290)

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).

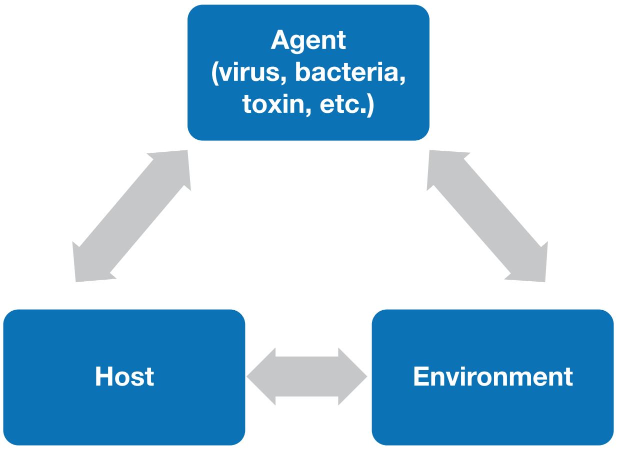

Fig. 2
Interaction among pathogenic agent, host and environment

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.

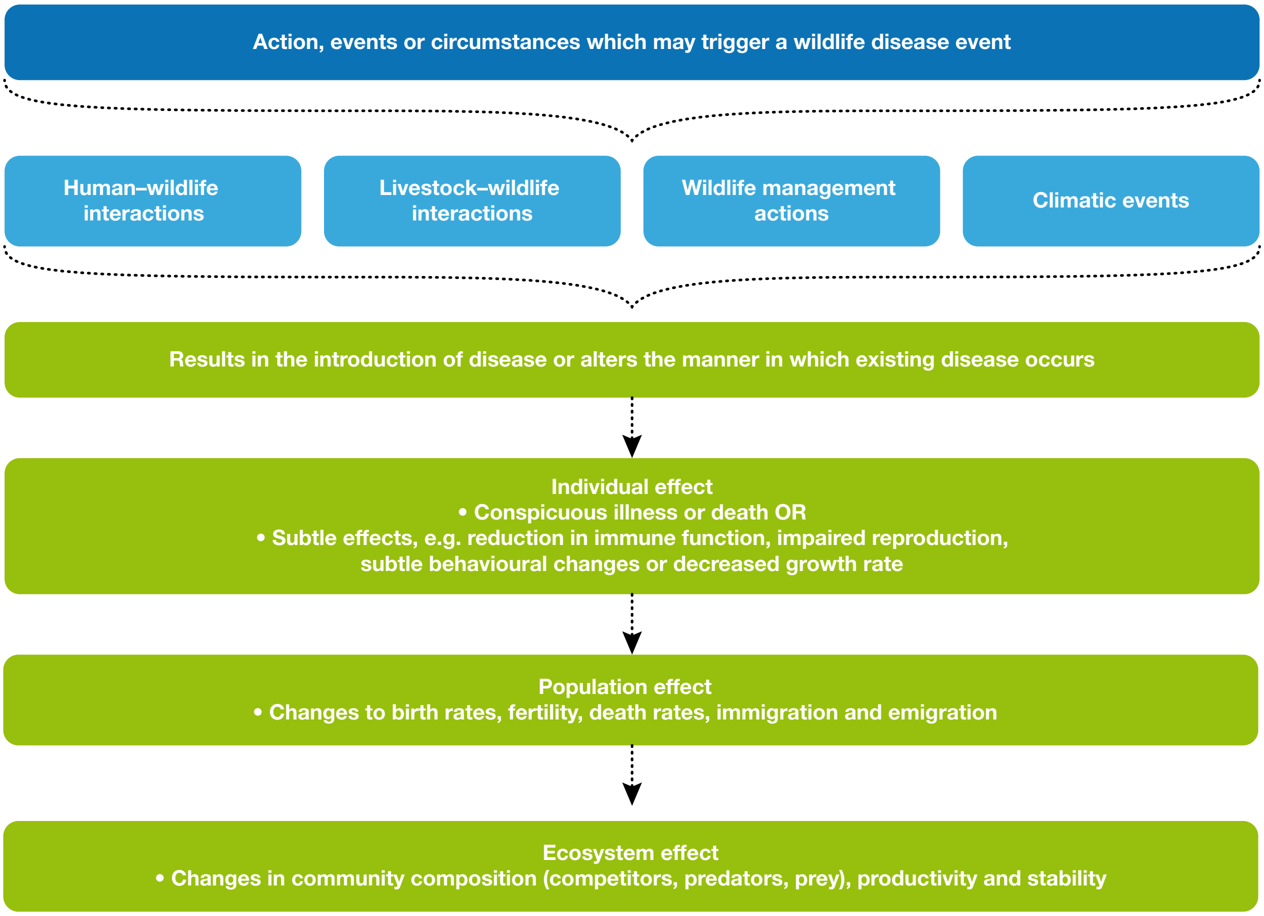

Fig. 3
Possible drivers of disease introduction and associated consequences

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.

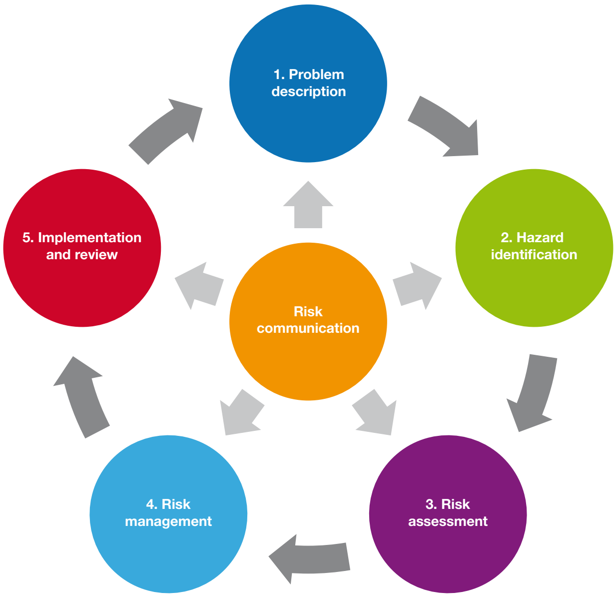

Fig. 4
Steps in the disease risk analysis process

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 tuberculosis* 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

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[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.

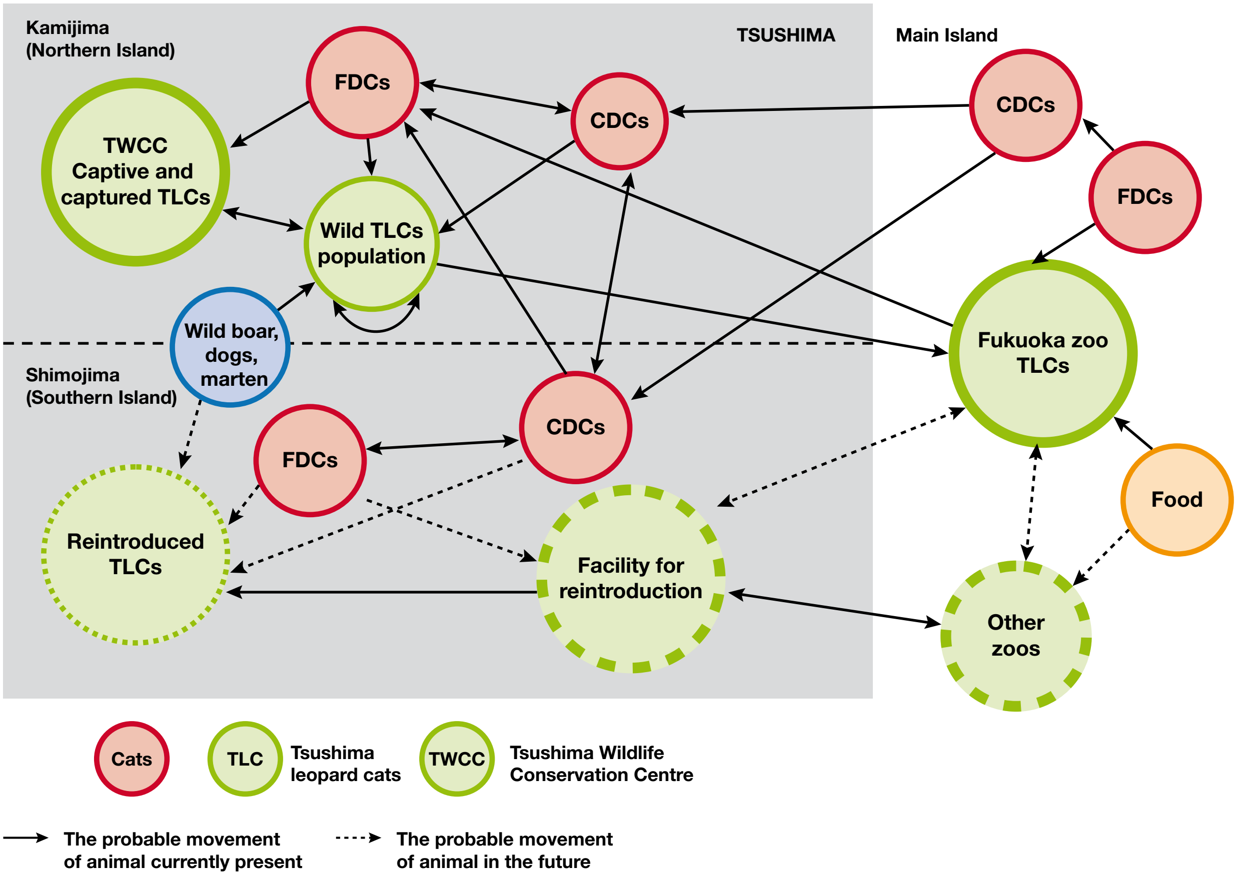

Fig. 6

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

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[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.

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[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.

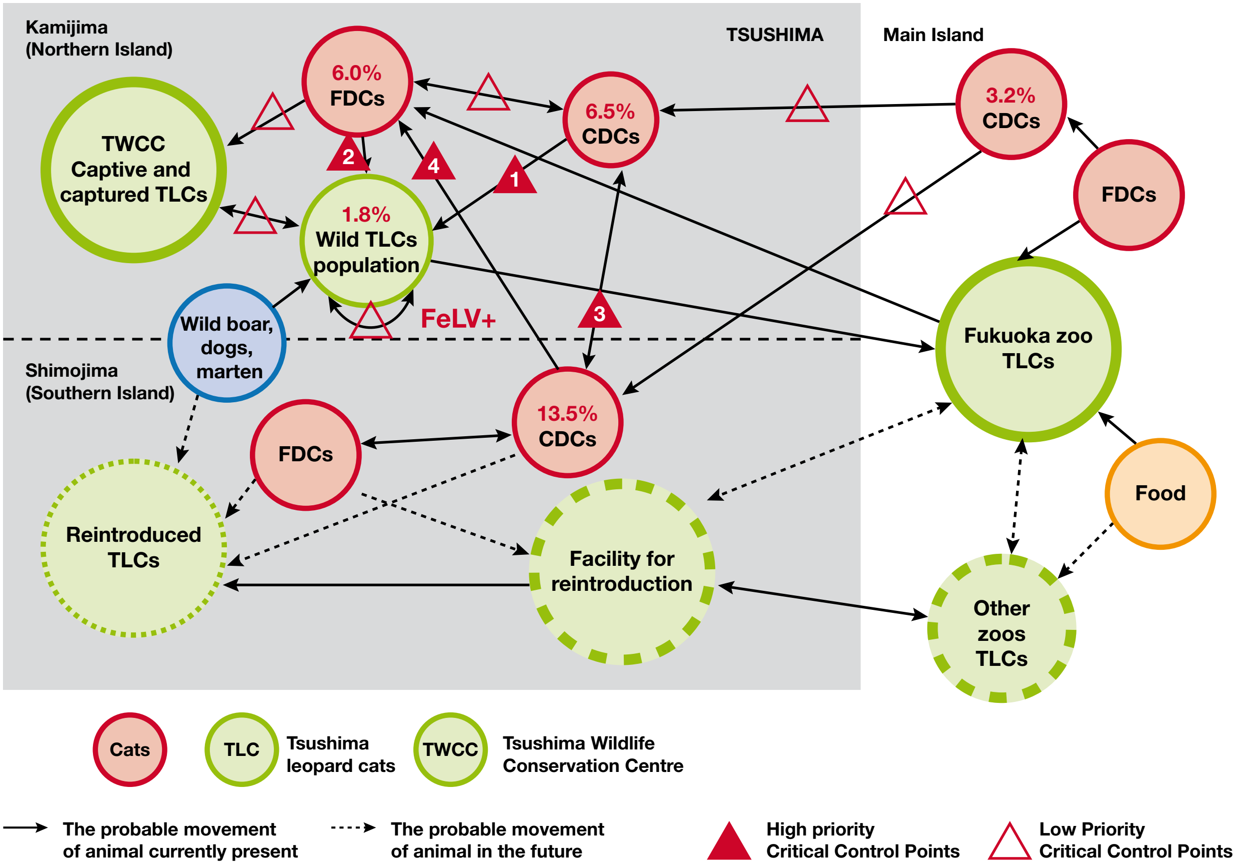

Fig. 7
Example of the application of critical control points (CCPs)

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

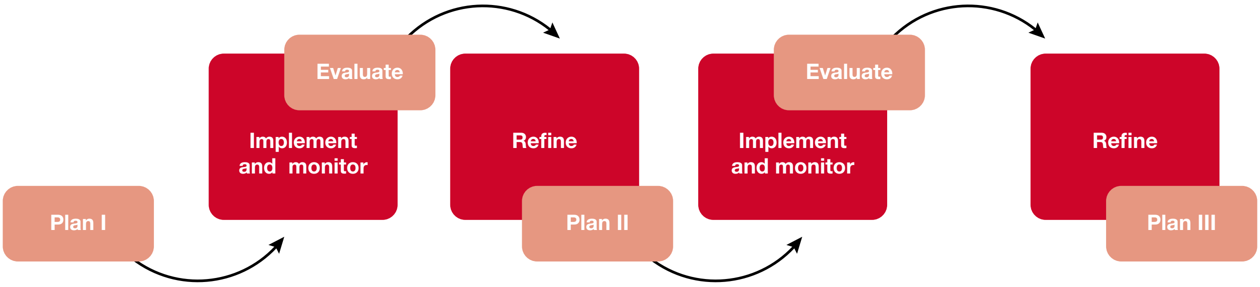

Fig. 8
A depiction of an adaptive management cycle

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).

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[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.

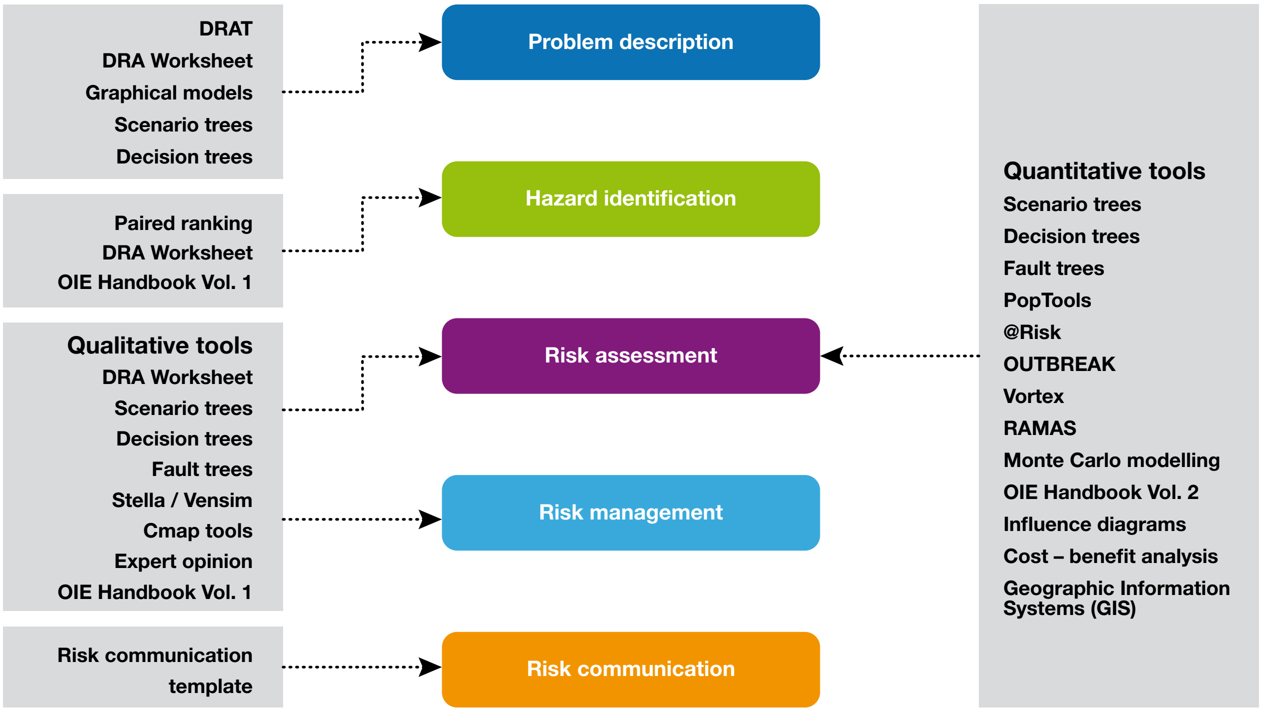


Fig. 9
Flow chart to illustrate where selected tool types can assist the disease risk analysis

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 *pathogens* 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.

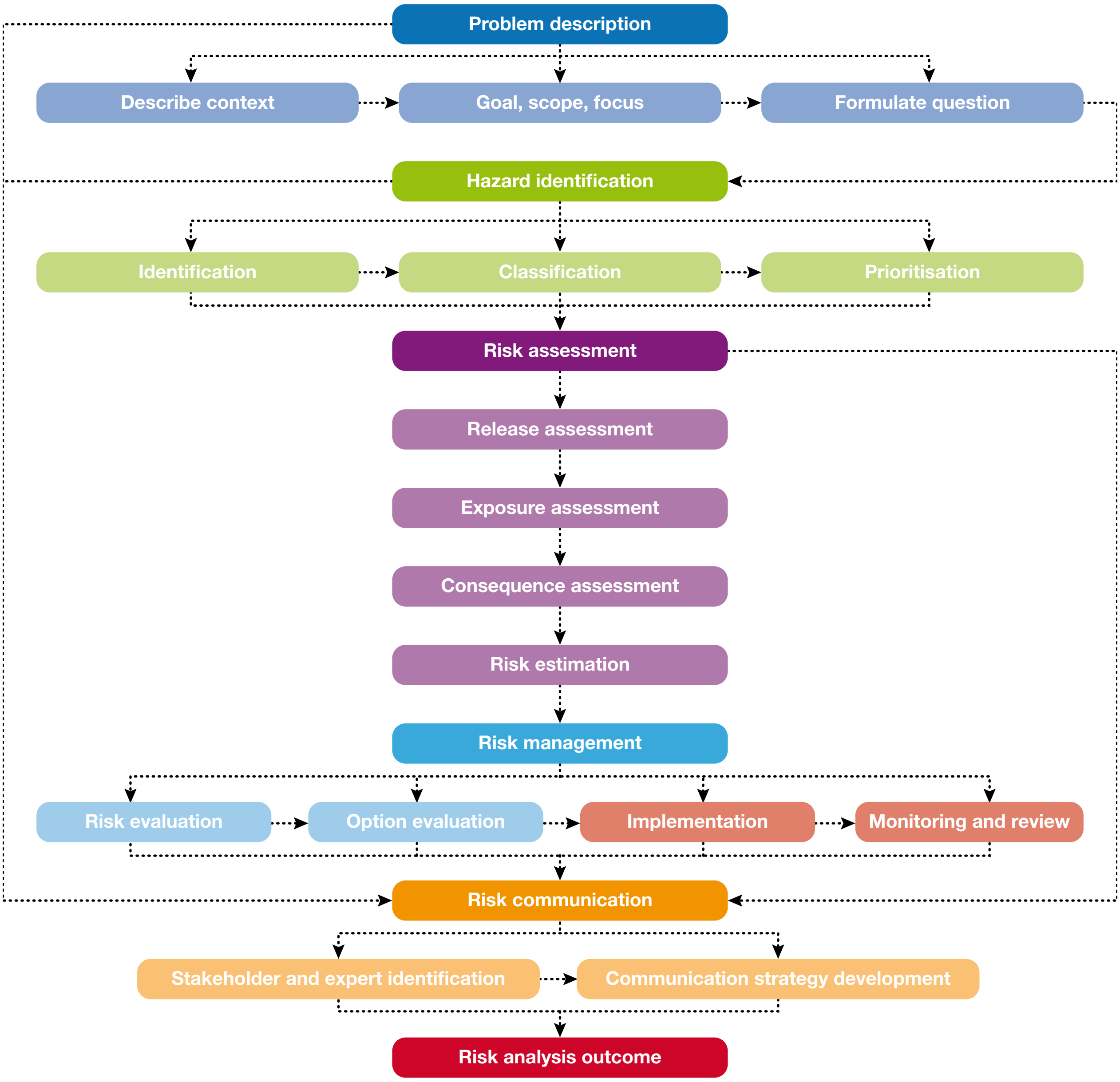


Fig. 11
Conceptual model of the generic disease risk analysis process

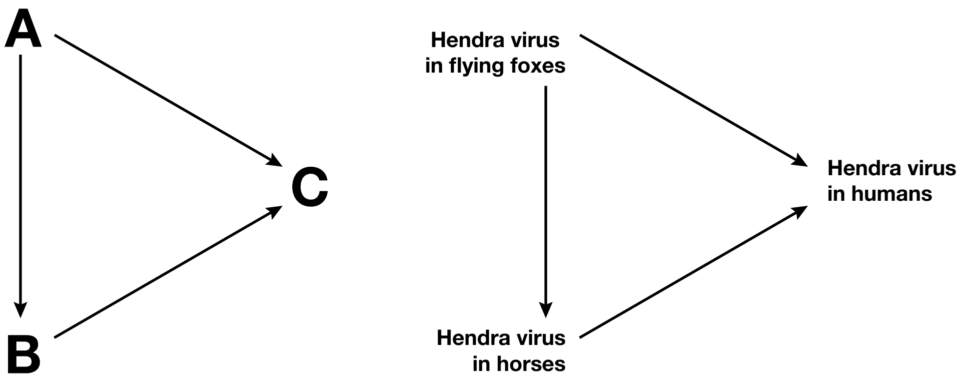


Fig. 12
Path diagram with direct and indirect causal association (A with C)
Adapted from Thrusfield (2005)

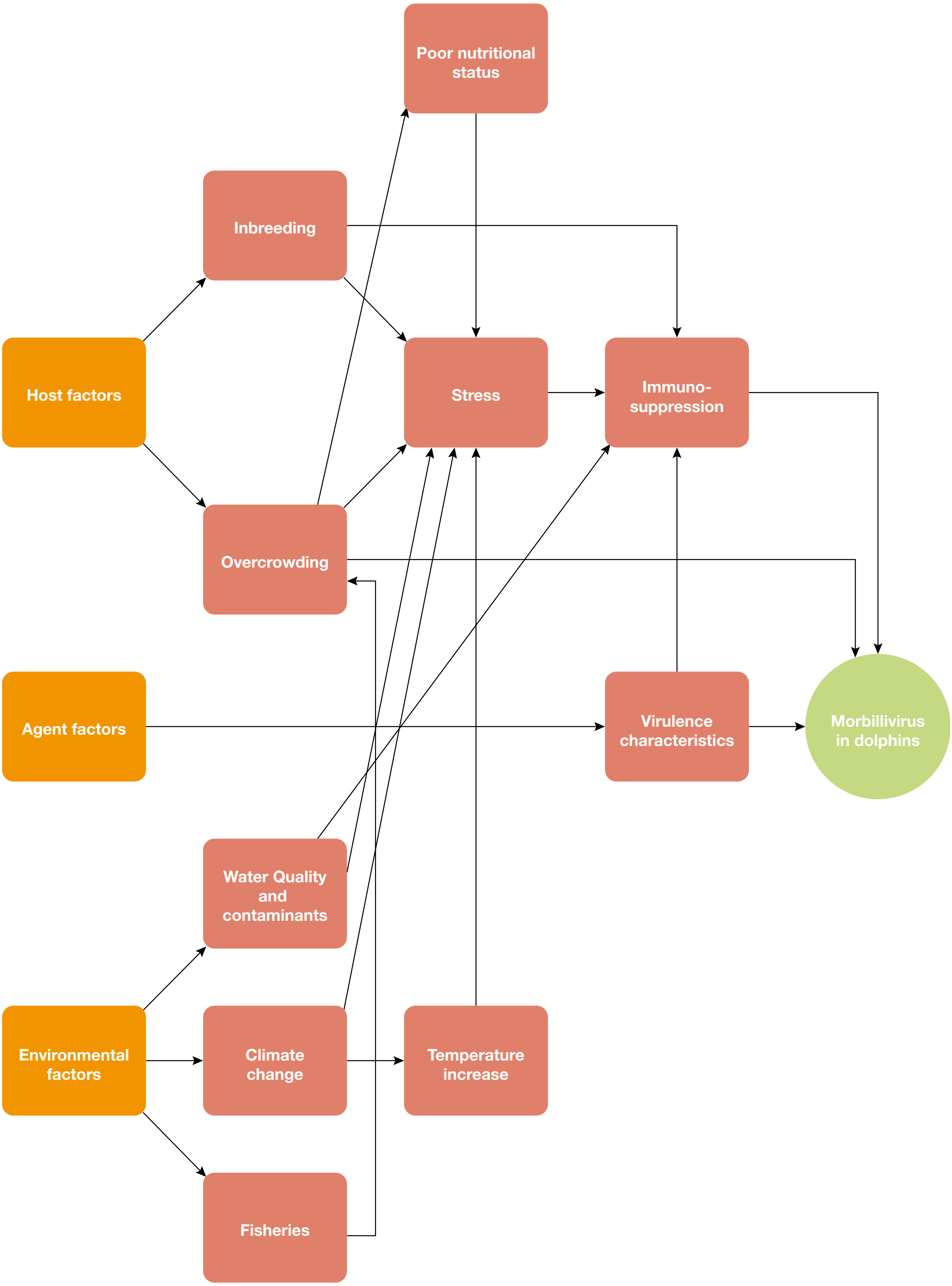


Fig. 13
Causal web model of morbillivirus infection in cetaceans
Figure 13 is a causal web of morbillivirus in dolphins. This was constructed easily using the program Miradi

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.

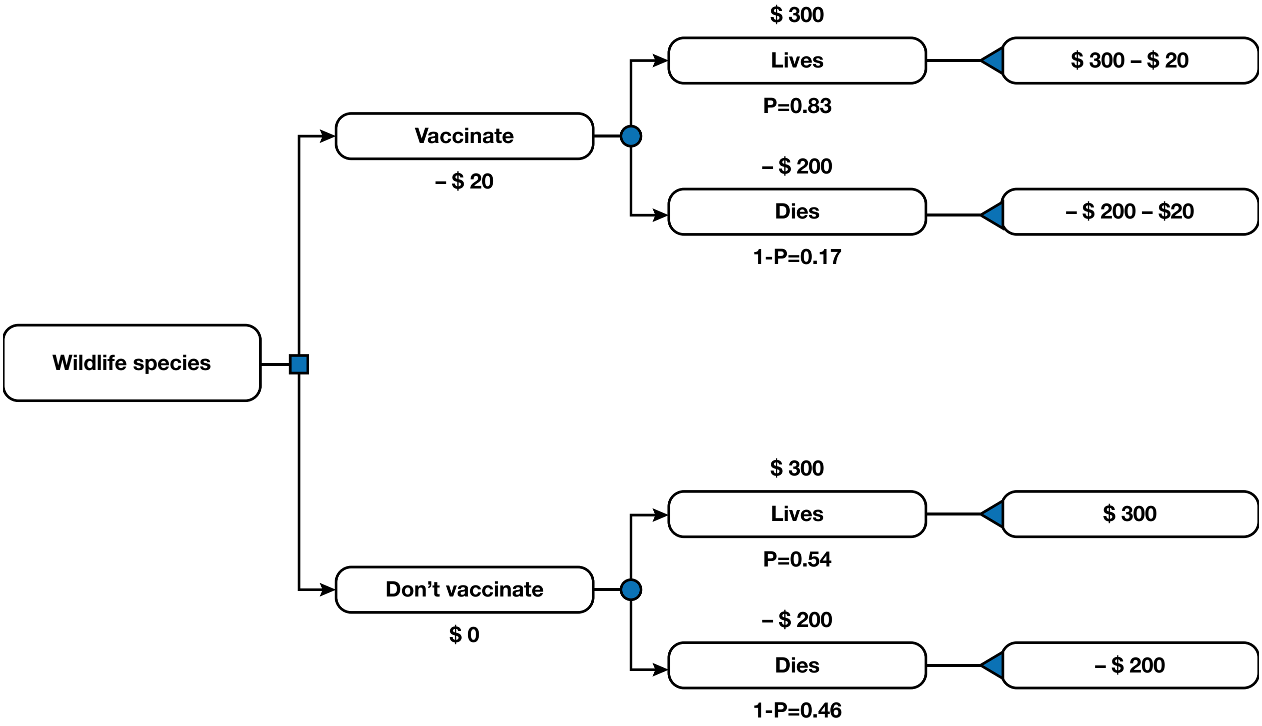


Fig. 14
Decision tree, assessing vaccination as a control strategy

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*.

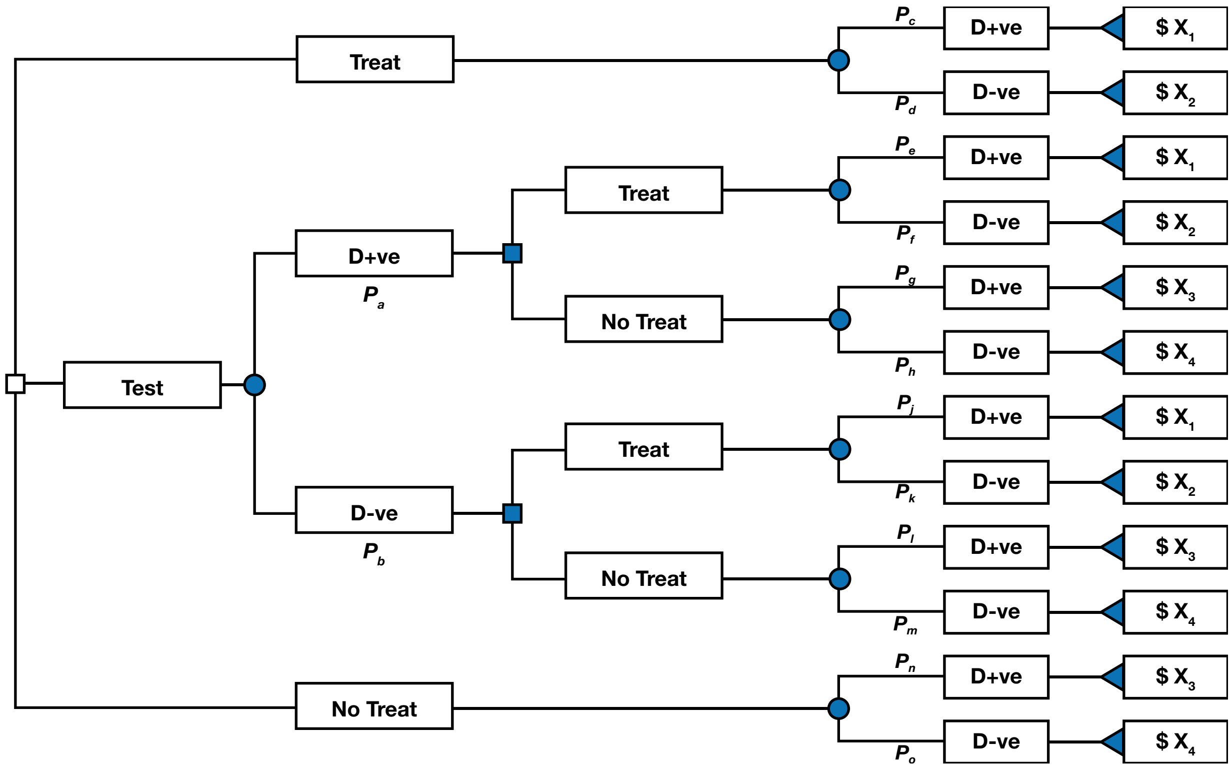


Fig. 15
Example of a more complex decision tree analysis
Where *p*(a–o) = probability; and X = dollar value.

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.

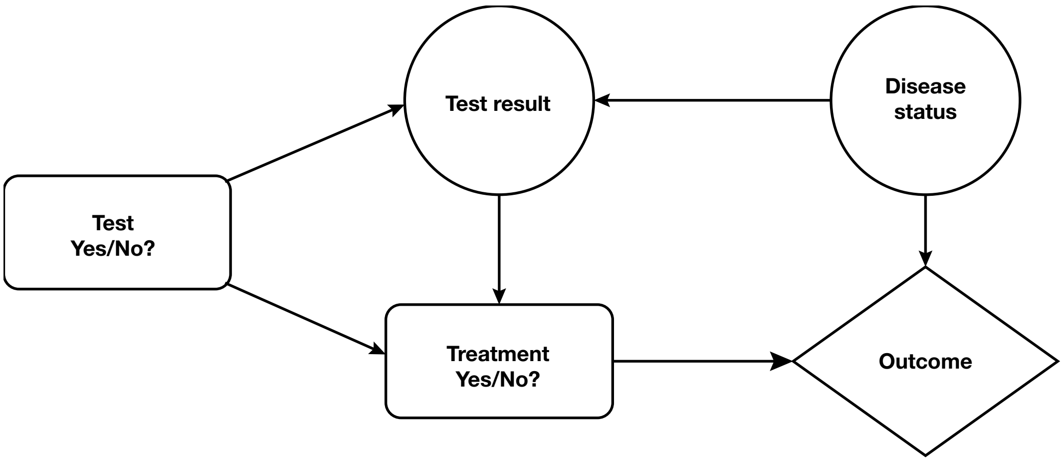


Fig. 16
Influence diagram that complements the decision tree in Fig. 15

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.

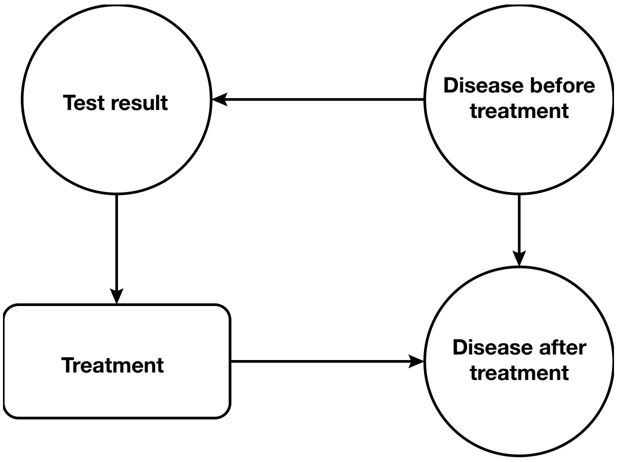


Fig. 17
Simplistic example of an influence diagram
Treatment: decision node
Test result, Disease status: chance nodes
Arrow ending on treatment: informational arc
Arrows ending on chance nodes: conditional arcs

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*.

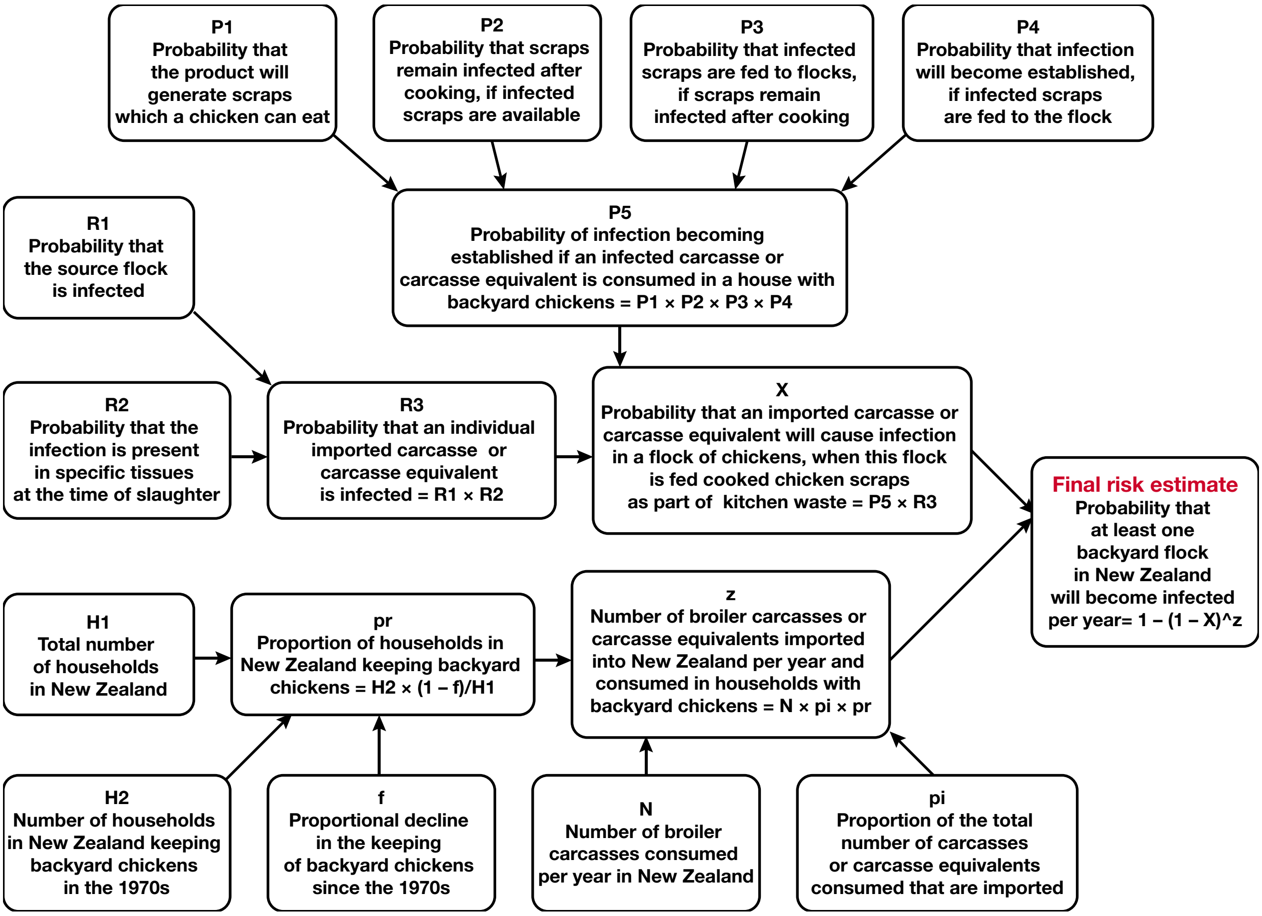


Fig. 18
An example of a complex influence diagram (Ministry of Agriculture and Forestry Regulatory Authority 1999)
From Murray *et al.* (2010). – Handbook on Import Risk Analysis for Animals and Animal Products, Volume 2. Quantitative Risk Analysis, 2nd Ed. World Organisation for Animal Health (OIE), 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.

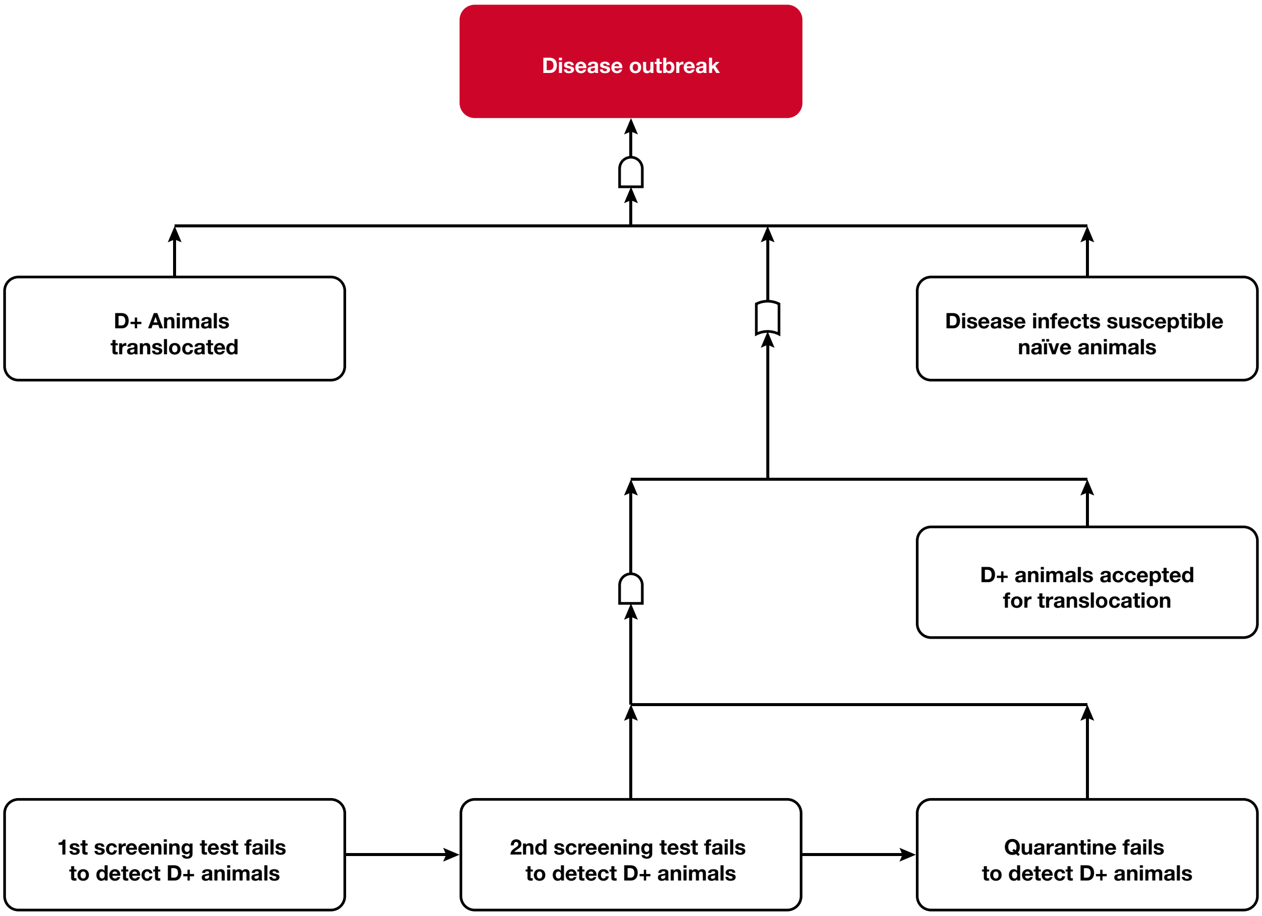


Fig. 19
Fault tree demonstrating the failures needed to result in disease outbreak

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.

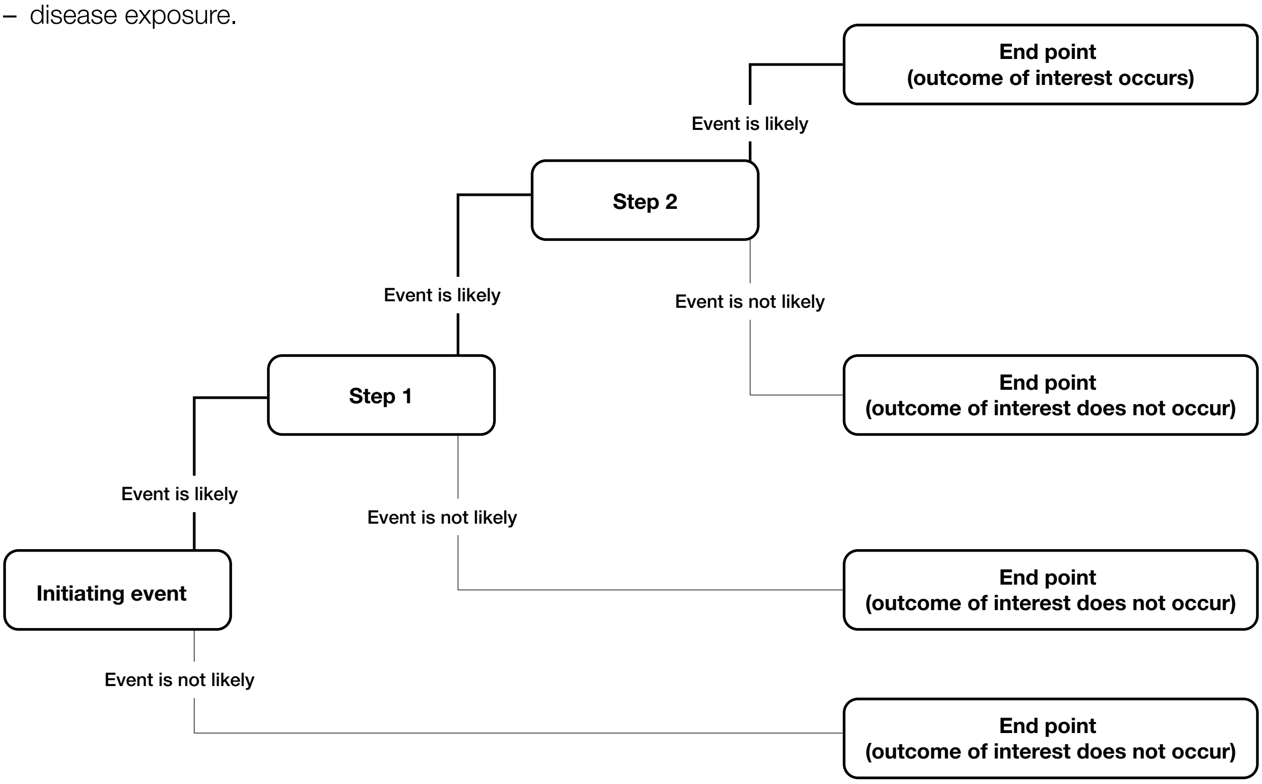


Fig. 20
Example framework for constructing a scenario tree (MacDiarmid and Pharo 2003)

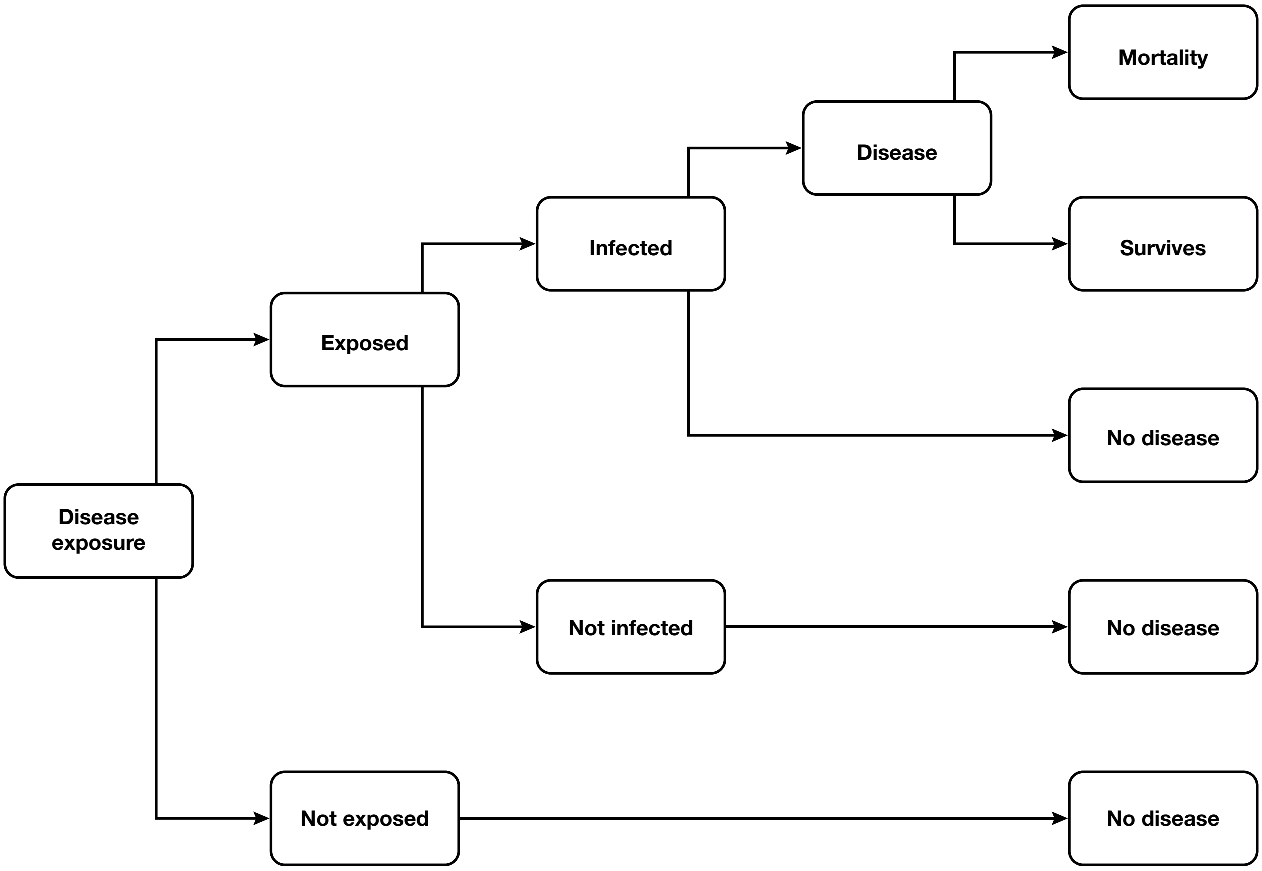


Fig. 21
Scenario tree outlining various events that may result in disease

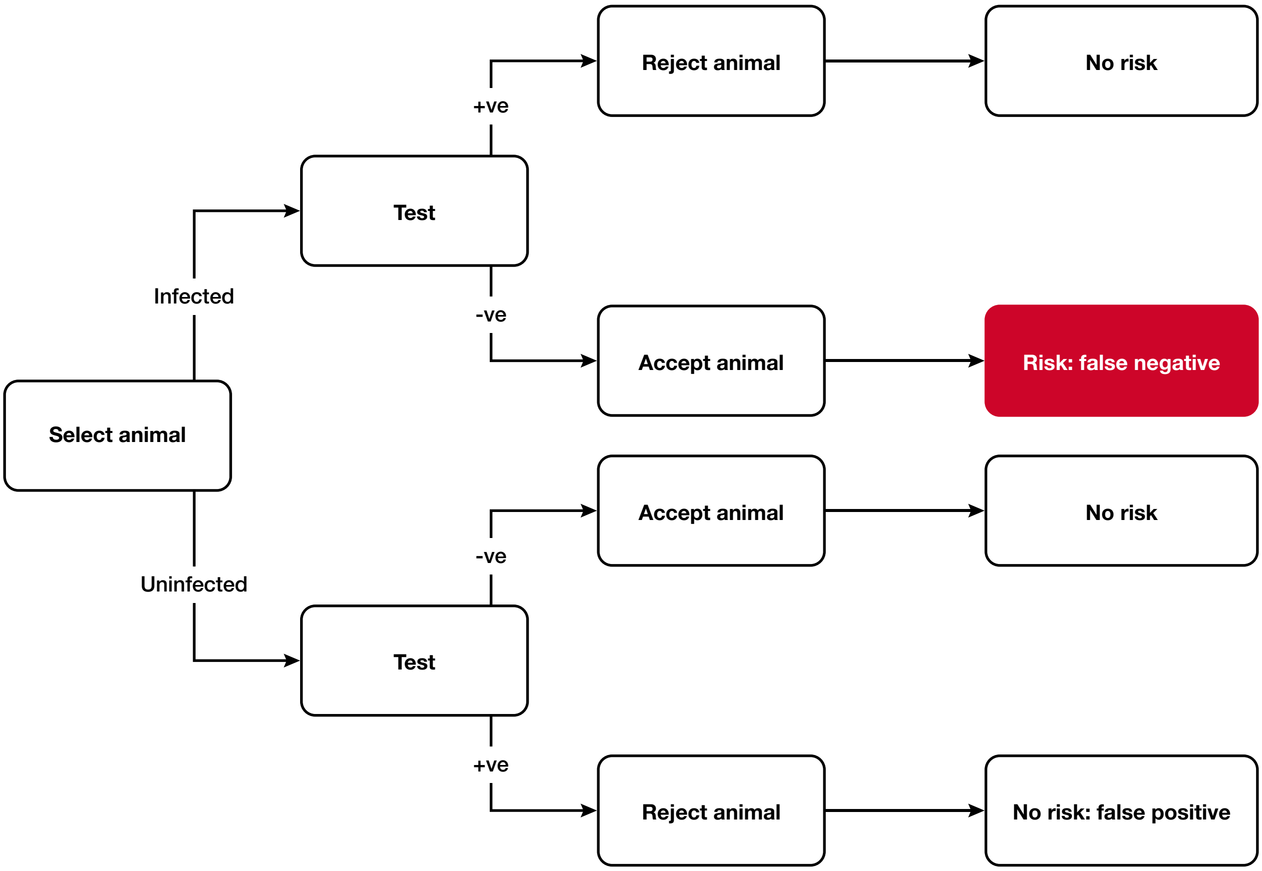


Fig. 22
Scenario tree outlining events that may result in a disease outbreak

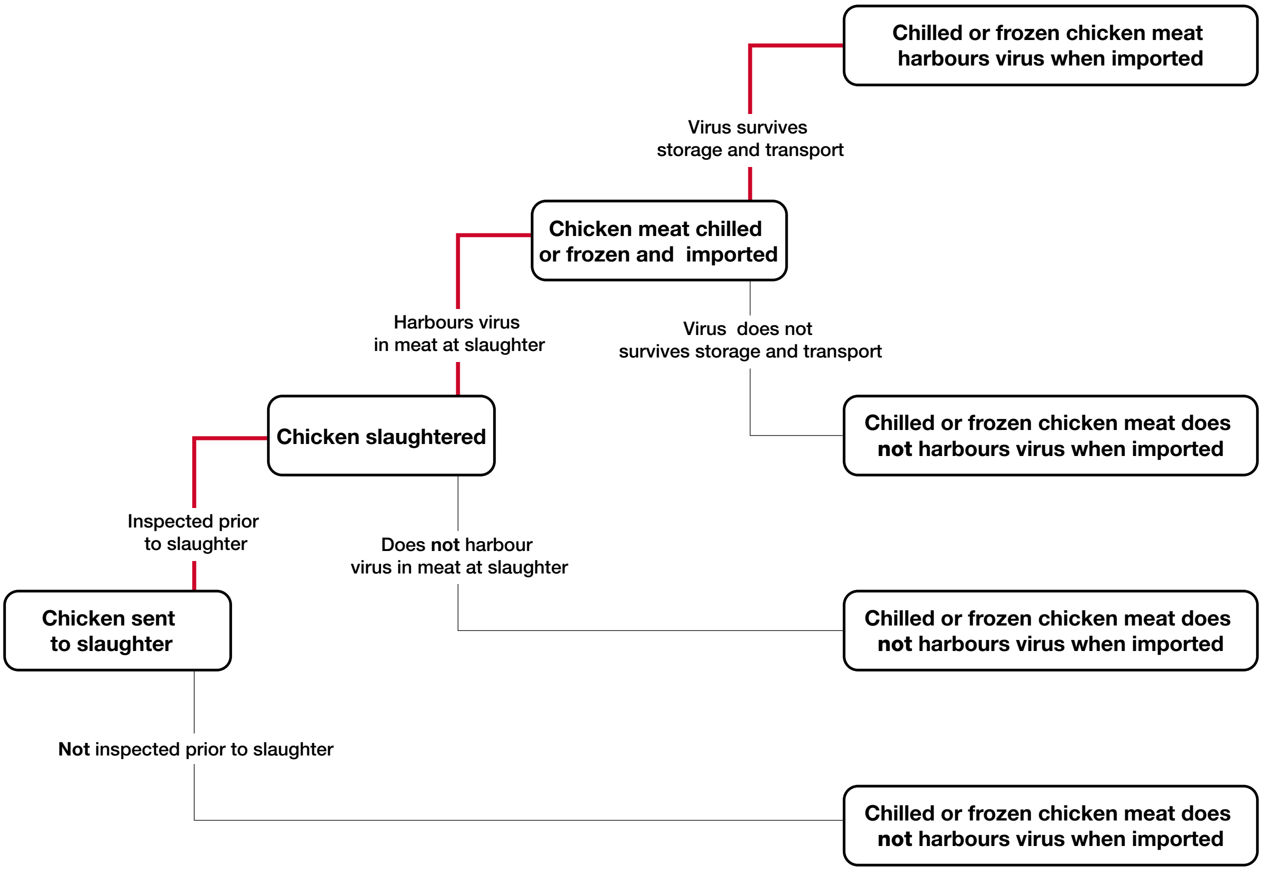


Fig. 23
Scenario tree for release assessment (MacDiarmid and Pharo 2003)

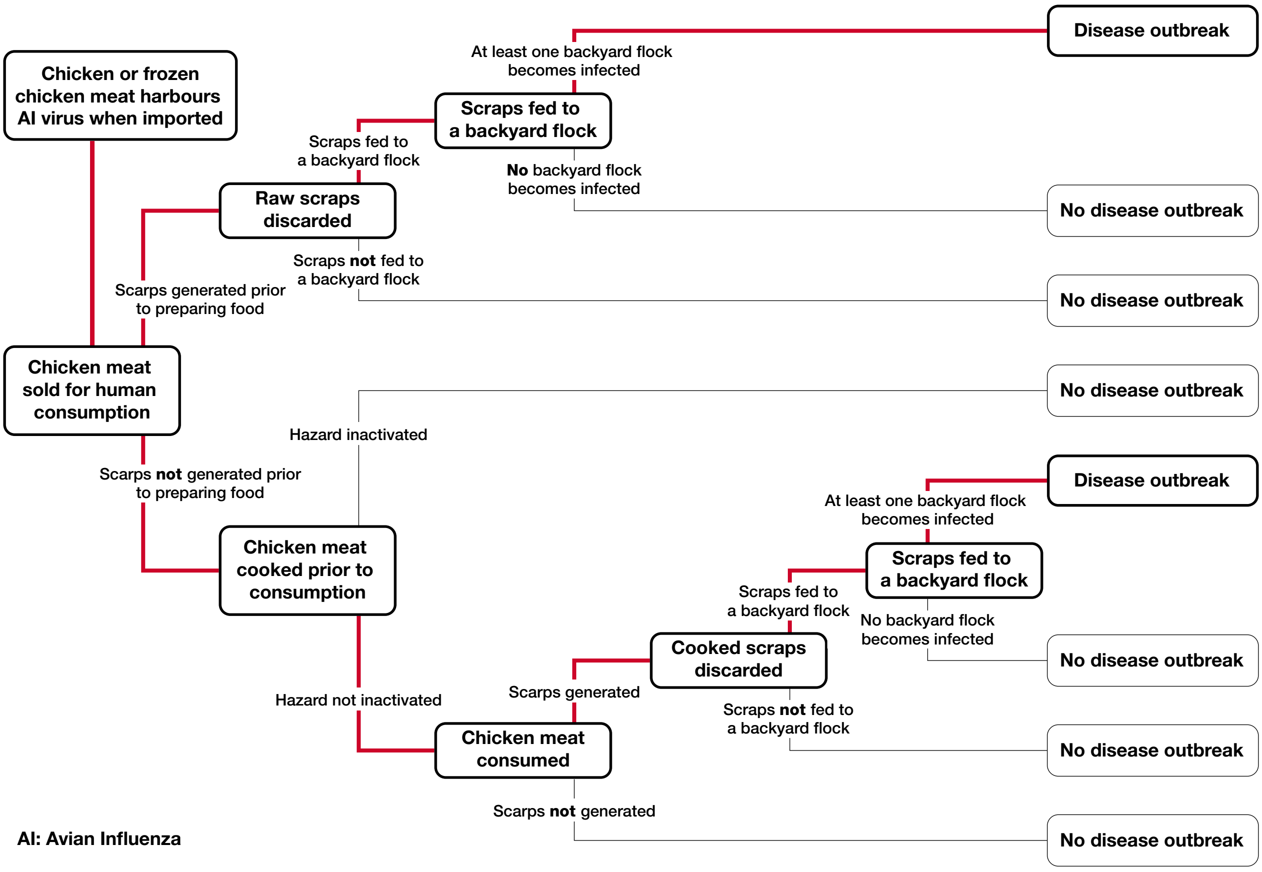


Fig. 24
Scenario tree for an exposure assessment
From MacDiarmid and Pharo (2003), *Rev. sci. tech. Off. int. Epiz.*, 22 (2)

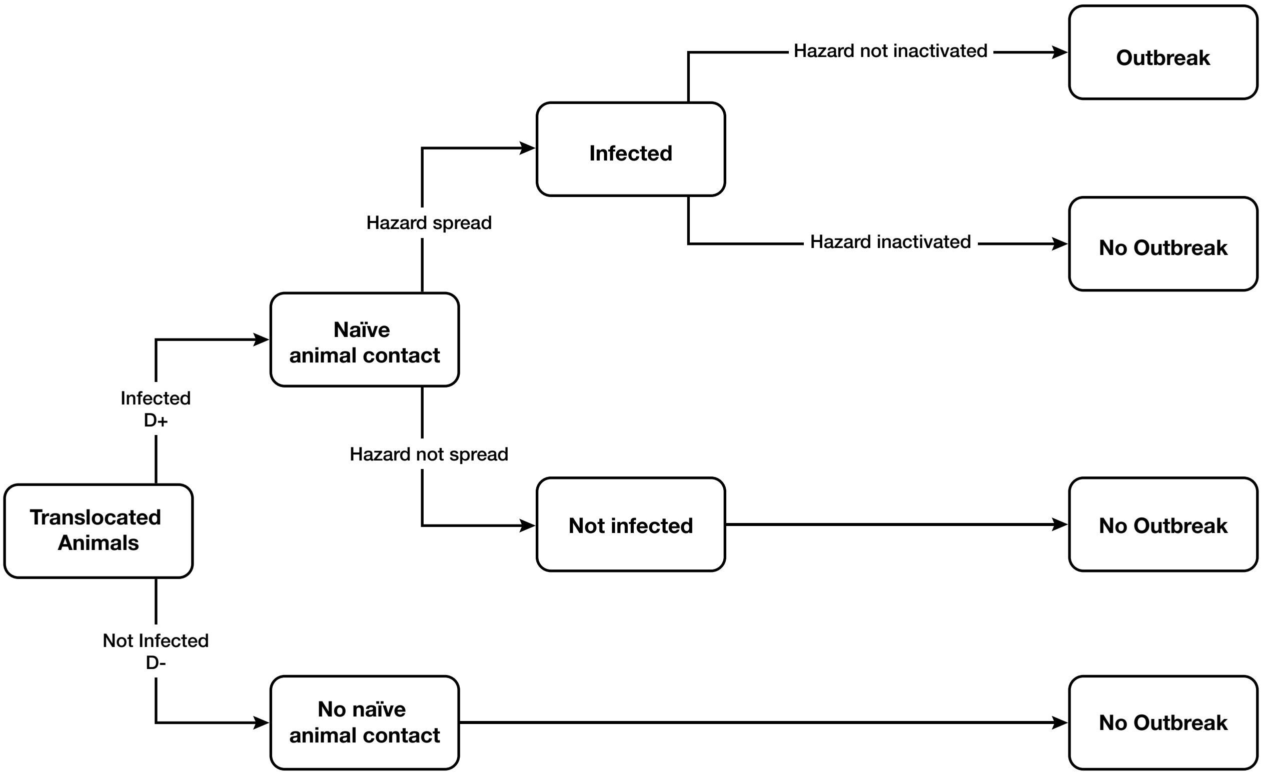
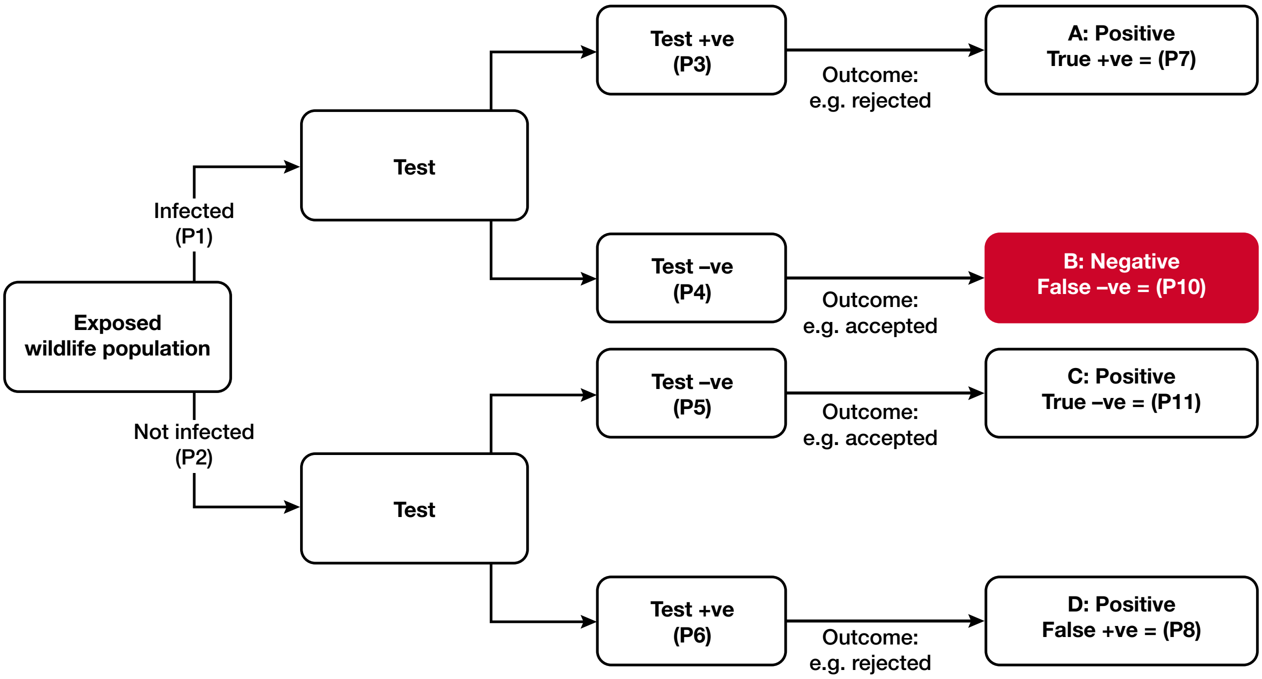


Fig. 25
Scenario tree for a consequence assessment



P1 p = probability of infection
P3 Se = sensitivity
P5 Sp = specificity

P2 1–p
P4 1–Se
P6 1–Sp

P7 p x Se
P8 (1–p) x Se
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 *vector*s, 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 *vector*s, 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

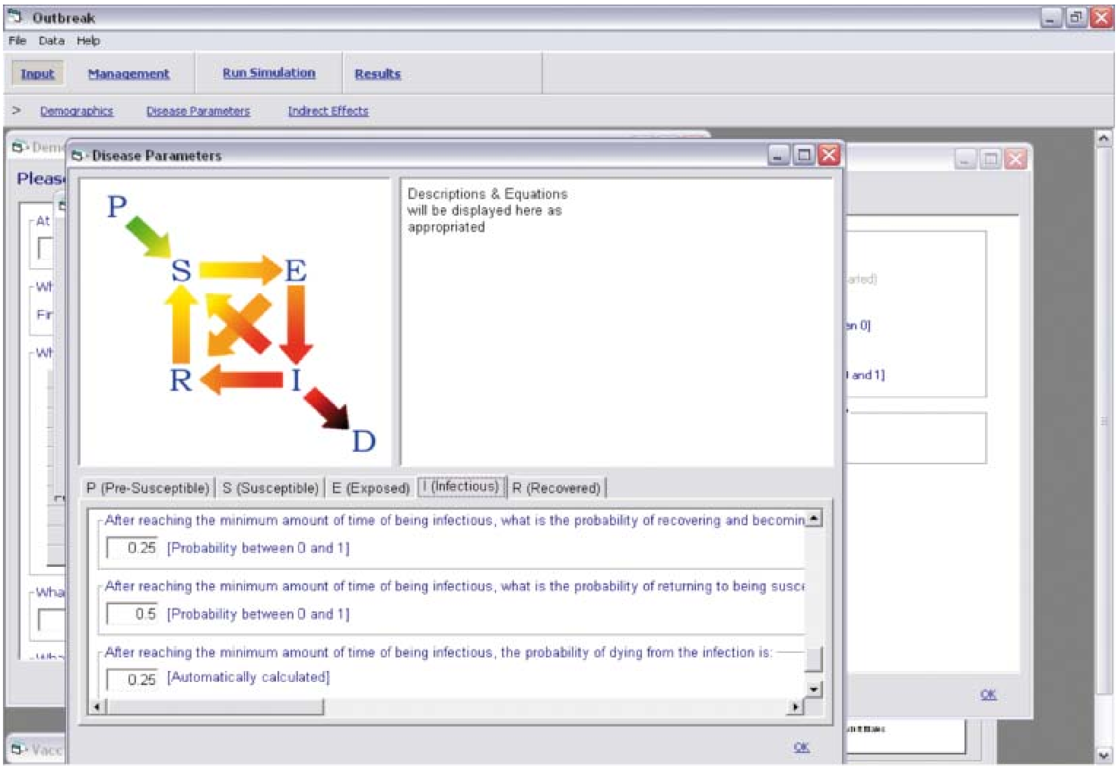
Users should be experienced in the use of computer simulation *models*, including the appropriate analysis of demographic and epidemiological data. While the software is rather simple to use at a basic level, expertise in the relevant biological and statistical fields is strongly recommended for proper 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.



Descriptions & Equations will be displayed here as appropriated

After reaching the minimum amount of time of being infectious, what is the probability of recovering and becomin
0.25 [Probability between 0 and 1]

After reaching the minimum amount of time of being infectious, what is the probability of returning to being susce
0.5 [Probability between 0 and 1]

After reaching the minimum amount of time of being infectious, the probability of dying from the infection is:
0.25 [Automatically calculated]

Fig. 27
Graphical interface for the OUTBREAK simulation software

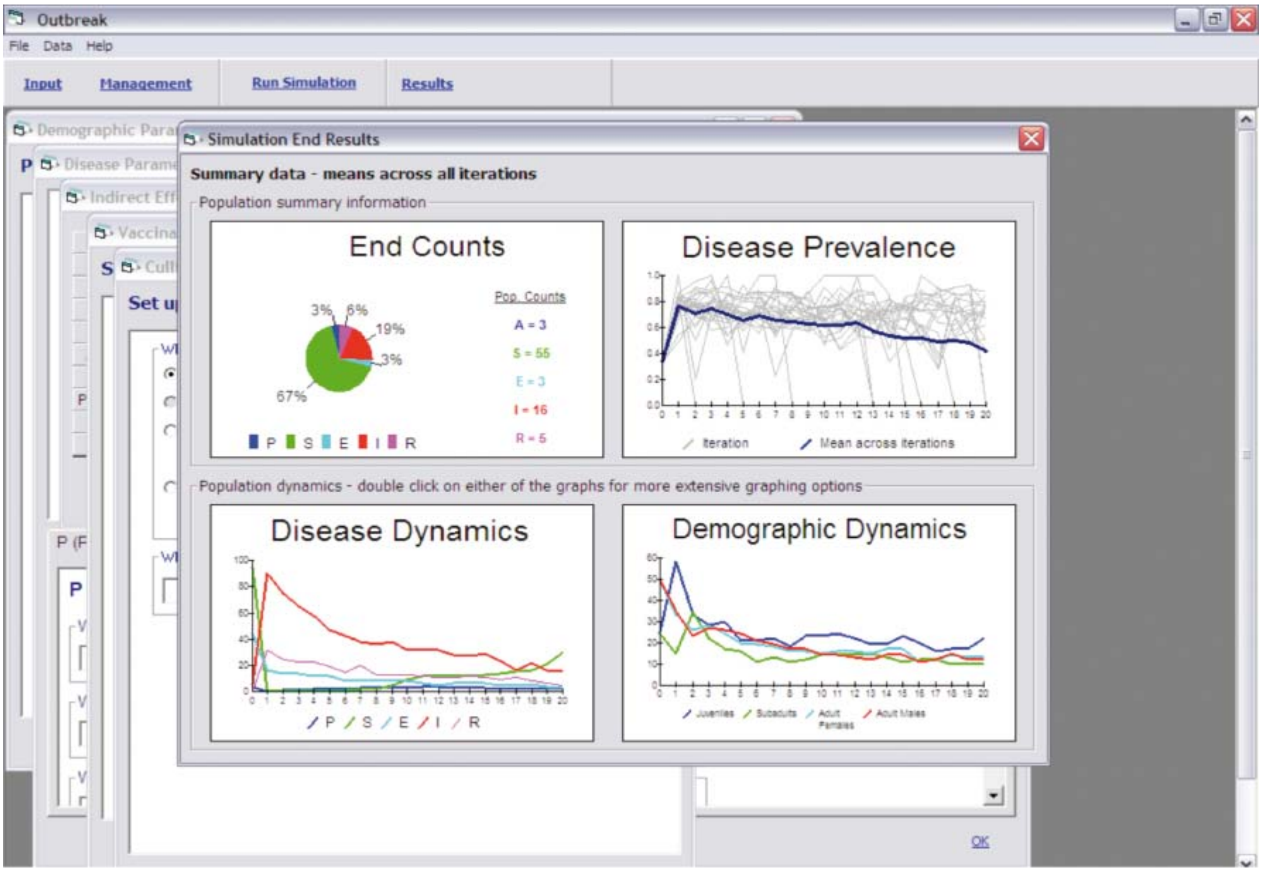


Fig. 28
Sample output from a simulation using OUTBREAK

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.

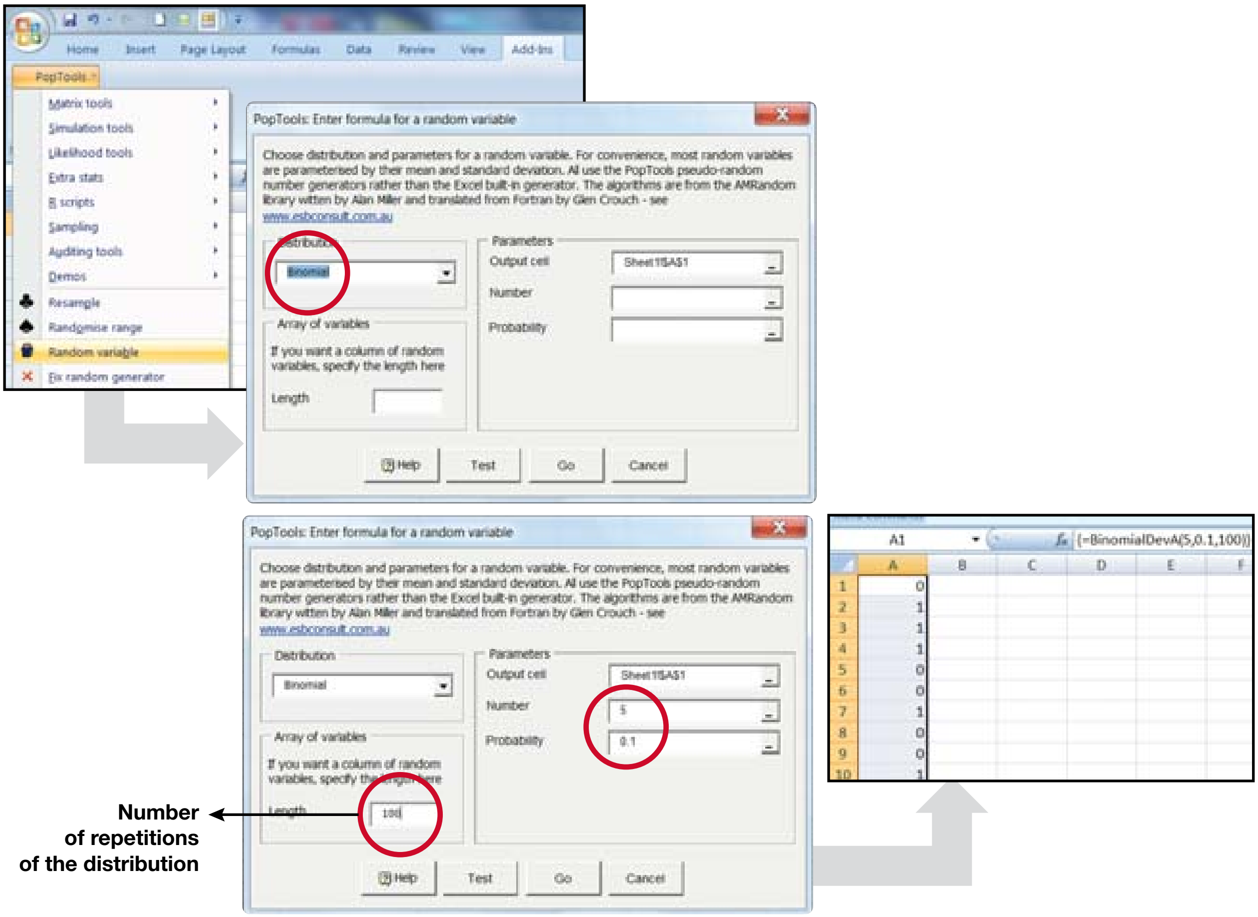
Case studies

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



PopTools: Enter formula for a random variable

Choose distribution and parameters for a random variable. For convenience, most random variables are parameterised by their mean and standard deviation. All use the PopTools pseudo-random number generators rather than the Excel built-in generator. The algorithms are from the AMRandom library witten by Alan Miller and translated from Fortran by Glen Crouch - see www.esbconsult.com.au

Distribution: Binomial

Parameters
Output cell: Sheet1!$A$1
Number:
Probability:

Array of variables
If you want a column of random variables, specify the length here
Length:

PopTools: Enter formula for a random variable

Choose distribution and parameters for a random variable. For convenience, most random variables are parameterised by their mean and standard deviation. All use the PopTools pseudo-random number generators rather than the Excel built-in generator. The algorithms are from the AMRandom library witten by Alan Miller and translated from Fortran by Glen Crouch - see www.esbconsult.com.au

Distribution: Binomial

Parameters
Output cell: Sheet1!$A$1
Number: 5
Probability: 0.1

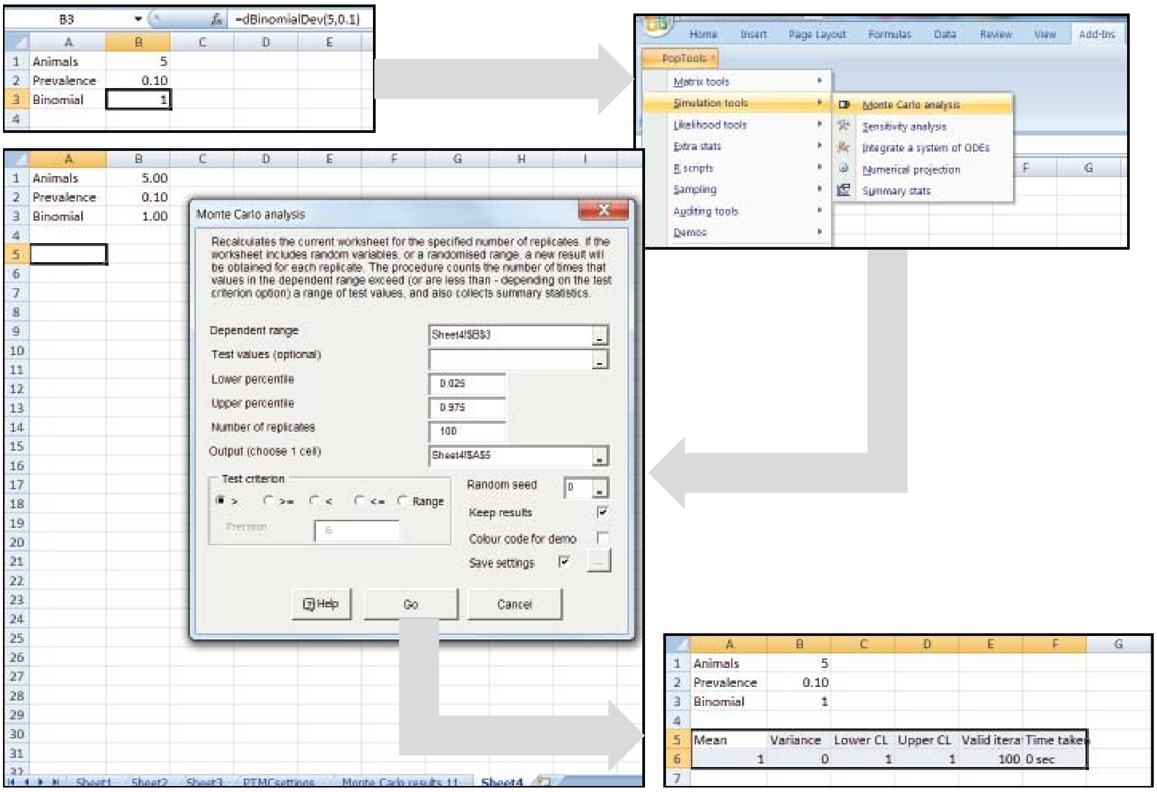
Array of variables
If you want a column of random variables, specify the length here
Length: 100

Number of repetitions of the distribution

A1 {=BinomialDevA(5,0.1,100)}

	A	B	C	D	E	F
1	0					
2	1					
3	1					
4	1					
5	0					
6	0					
7	1					
8	0					
9	0					
10	1					

Binomial distribution in PopTools



B3 =dBinomialDev(5,0.1)

	A	B	C	D	E
1	Animals	5			
2	Prevalence	0.10			
3	Binomial	1			
4					

	A	B
1	Animals	5.00
2	Prevalence	0.10
3	Binomial	1.00

Monte Carlo analysis

Recalculates the current worksheet for the specified number of replicates. If the worksheet includes random variables, or a randomised range, a new result will be obtained for each replicate. The procedure counts the number of times that values in the dependent range exceed (or are less than - depending on the test criterion option) a range of test values, and also collects summary statistics.

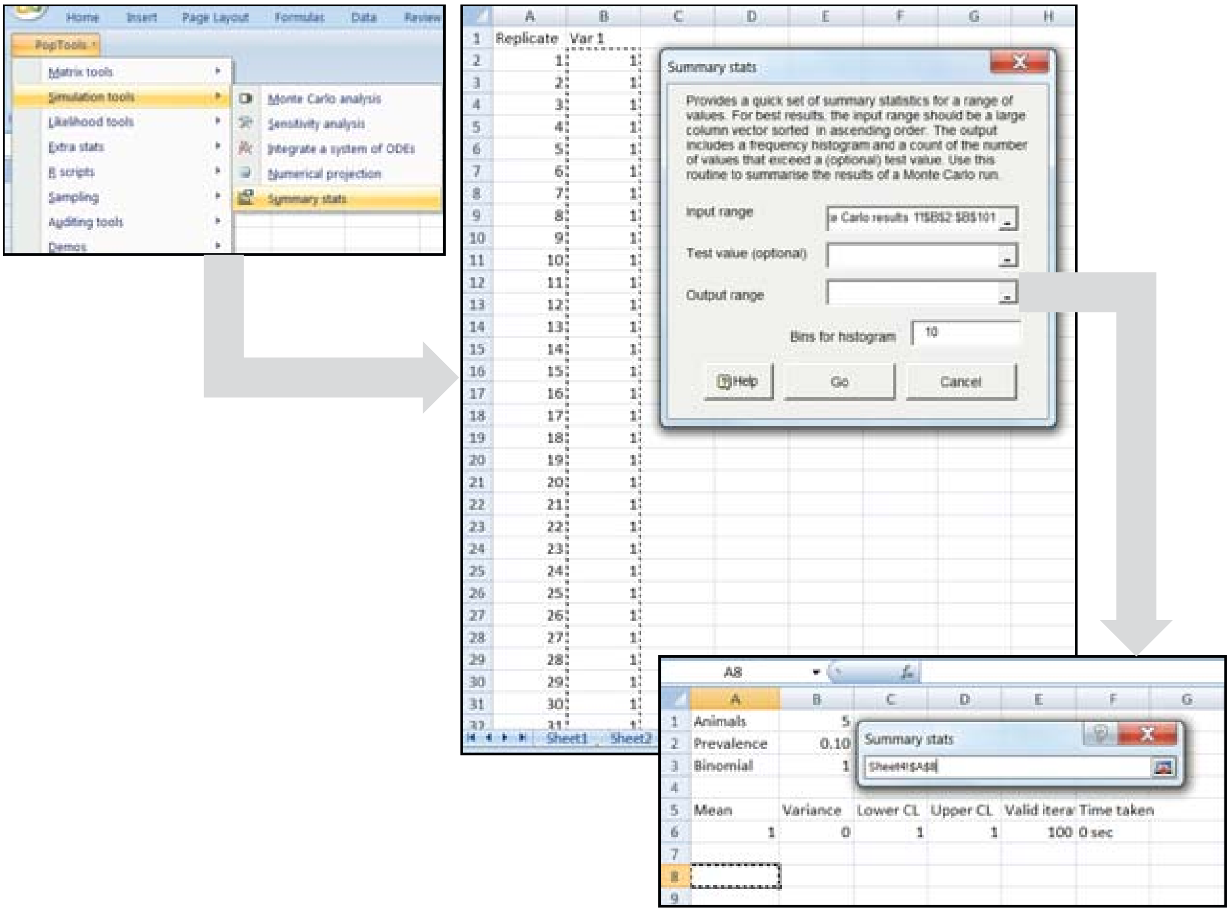
Dependent range: Sheet4!$B$3
Test values (optional):
Lower percentile: 0.025
Upper percentile: 0.975
Number of replicates: 100
Output (choose 1 cell): Sheet4!$A$5

Test criterion: ● > ○ >= ○ < ○ <= ○ Range
Precision: 6

Random seed: 0
Keep results ☑
Colour code for demo ☐
Save settings ☑

	A	B	C	D	E	F	G
1	Animals	5					
2	Prevalence	0.10					
3	Binomial	1					
4							
5	Mean	Variance	Lower CL	Upper CL	Valid itera	Time take	
6	1	0	1	1	100	0 sec	
7							

Monte Carlo simulation with binomial distribution in PopTools



Replicate	Var 1
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
16	1
17	1
18	1
19	1
20	1
21	1
22	1
23	1
24	1
25	1
26	1
27	1
28	1
29	1
30	1

Summary stats

Provides a quick set of summary statistics for a range of values. For best results, the input range should be a large column vector sorted in ascending order. The output includes a frequency histogram and a count of the number of values that exceed a (optional) test value. Use this routine to summarise the results of a Monte Carlo run.

Input range: a Carlo results 1'!$B$2:$B$101

Test value (optional):

Output range:

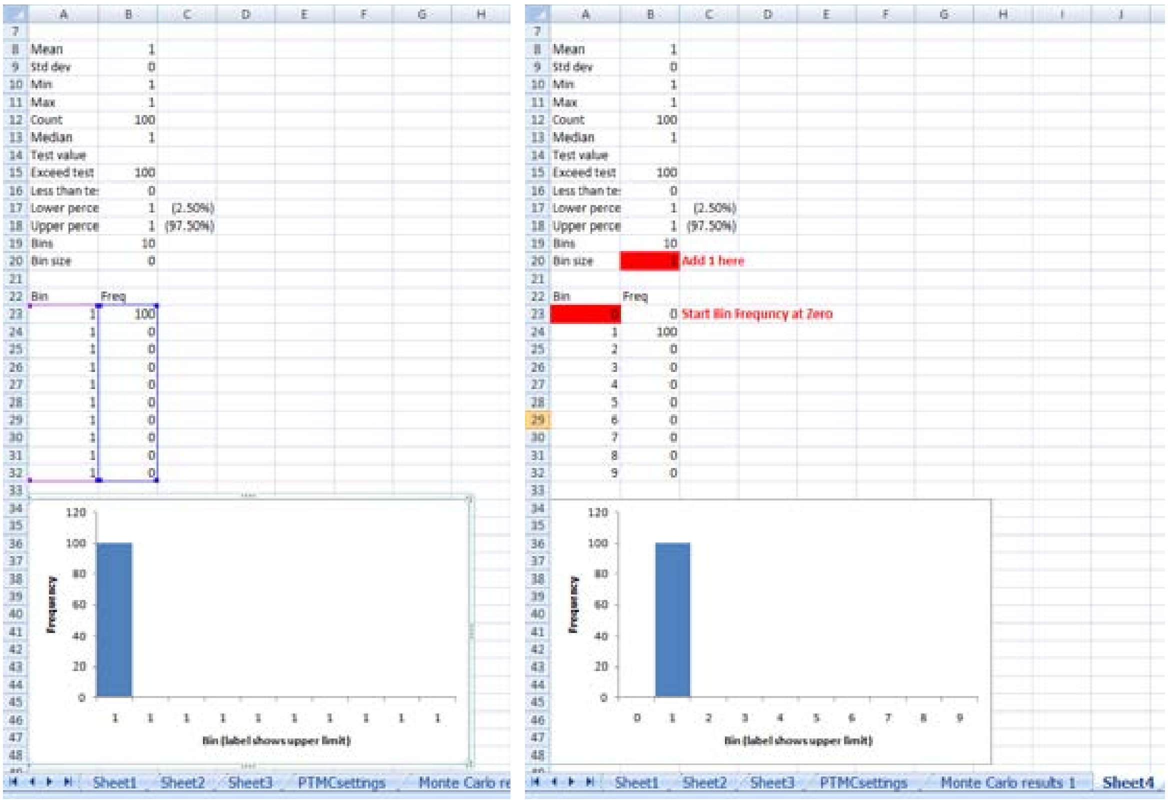
Bins for histogram: 10

Animals	5
Prevalence	0.10
Binomial	1

Summary stats: Sheet4!$A$8

Mean	Variance	Lower CL	Upper CL	Valid itera	Time taken
1	0	1	1	100	0 sec

Monte Carlo simulation with binomial distribution in PopTools



Mean	1
Std dev	0
Min	1
Max	1
Count	100
Median	1
Test value	
Exceed test	100
Less than te:	0
Lower perce	1 (2.50%)
Upper perce	1 (97.50%)
Bins	10
Bin size	0

Bin	Freq
1	100
1	0
1	0
1	0
1	0
1	0
1	0
1	0
1	0
1	0

Mean	1	
Std dev	0	
Min	1	
Max	1	
Count	100	
Median	1	
Test value		
Exceed test	100	
Less than te:	0	
Lower perce	1	(2.50%)
Upper perce	1	(97.50%)
Bins	10	
Bin size	1	Add 1 here

Bin	Freq	
0	0	Start Bin Frequncy at Zero
1	100	
2	0	
3	0	
4	0	
5	0	
6	0	
7	0	
8	0	
9	0	

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.

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[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.

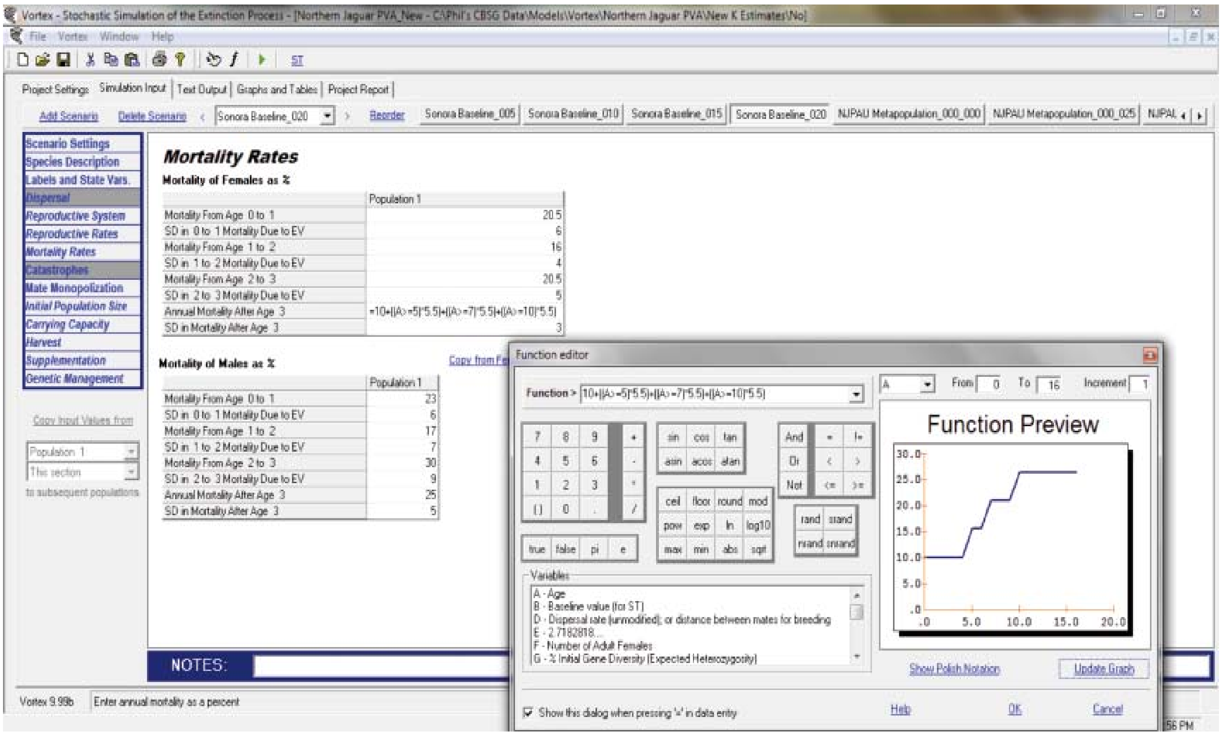
In addition to single-population analysis, Vortex has the capacity to analyse complex metapopulation dynamics with dispersal among subpopulations. In addition, Vortex models loss of genetic variation in populations by simulating the *transmission* of alleles from parents to offspring at a hypothetical 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*.



Mortality Rates

Mortality of Females as %

	Population 1
Mortality From Age 0 to 1	20.5
SD in 0 to 1 Mortality Due to EV	6
Mortality From Age 1 to 2	16
SD in 1 to 2 Mortality Due to EV	4
Mortality From Age 2 to 3	20.5
SD in 2 to 3 Mortality Due to EV	5
Annual Mortality After Age 3	=10+((A>=5)*5.5)+((A>=7)*5.5)+((A>=10)*5.5)
SD in Mortality After Age 3	3

Mortality of Males as %

	Population 1
Mortality From Age 0 to 1	23
SD in 0 to 1 Mortality Due to EV	6
Mortality From Age 1 to 2	17
SD in 1 to 2 Mortality Due to EV	7
Mortality From Age 2 to 3	30
SD in 2 to 3 Mortality Due to EV	9
Annual Mortality After Age 3	25
SD in Mortality After Age 3	5

Enter annual mortality as a percent

Function > 10+((A>=5)*5.5)+((A>=7)*5.5)+((A>=10)*5.5)

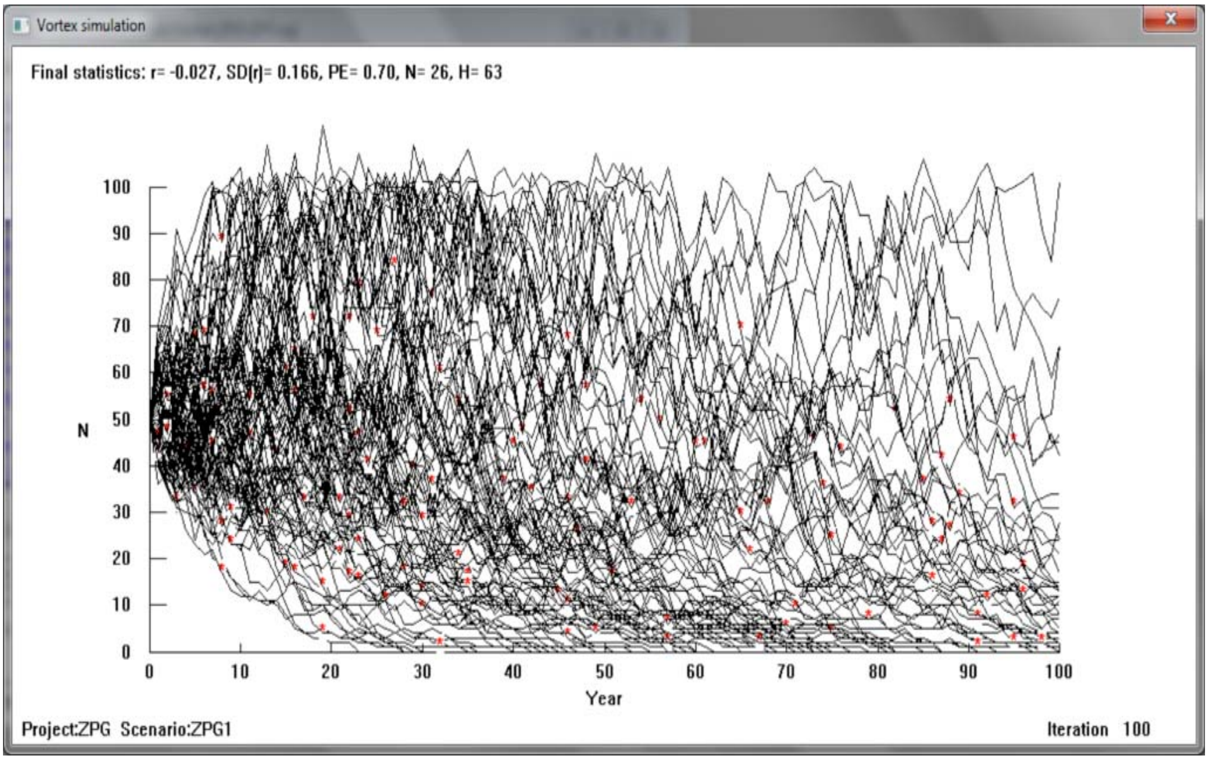
A From 0 To 16 Increment 1

Variables

A - Age
B - Baseline value (for ST)
D - Dispersal rate (unmodified); or distance between mates for breeding
E - 2.7182818...
F - Number of Adult Females
G - % Initial Gene Diversity (Expected Heterozygosity)

☑ Show this dialog when pressing '=' in data entry

Fig. 29
Sample input screen in the Vortex simulation package, showing use of function editor interface



```
Final statistics: r= -0.027, SD(r)= 0.166, PE= 0.70, N= 26, H= 63
```

Project:ZPG Scenario:ZPG1

Iteration 100

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)

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[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 assessments*. 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,

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[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.

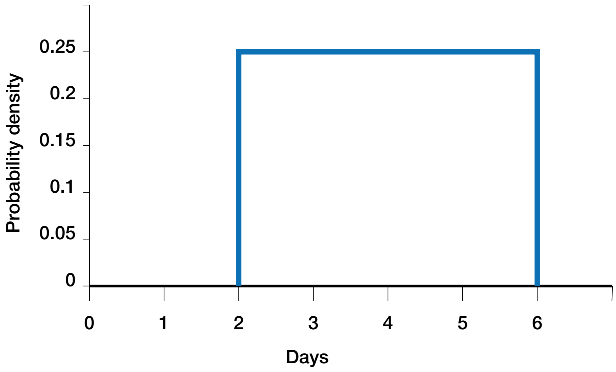


Fig. 31
A uniform distribution of the duration of viraemia where the range has been estimated to be from two to six days

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.

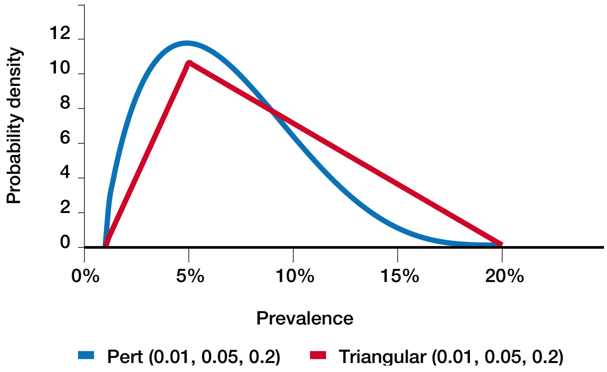


Fig. 32
Comparing a pert and a triangular distribution

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).

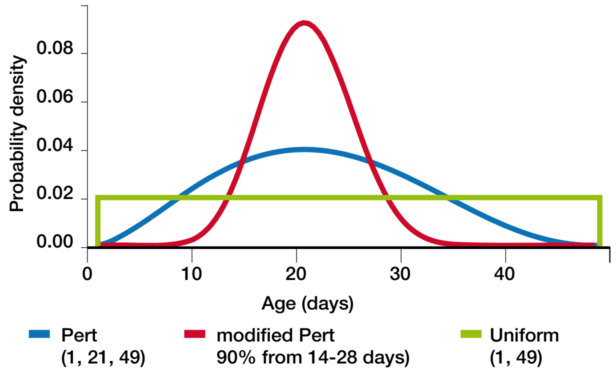


Fig. 33
A comparison of a uniform distribution, a standard pert distribution and a modified pert distribution of the age when a chicken is likely to become infected with IBD virus prior to slaughter at 49 days of age
From Murray *et al.* (2004)

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 *pi* of occurring. It is useful for replicating the shape of a set of data as shown in Figure 34.

Histogram (minimum, maximum, {pi}).

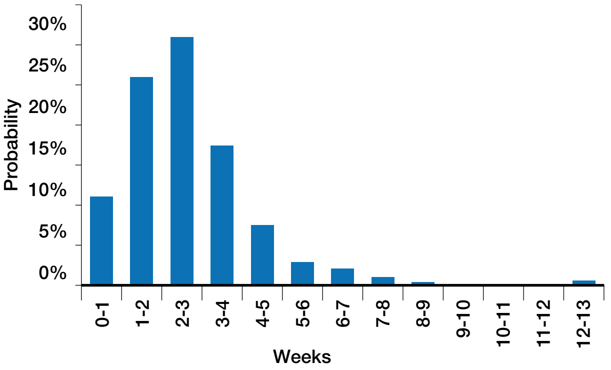


Fig. 34
A histogram probability distribution of the duration of viraemia in cattle naturally infected with bluetongue virus
From Murray *et al.* (2004)

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.

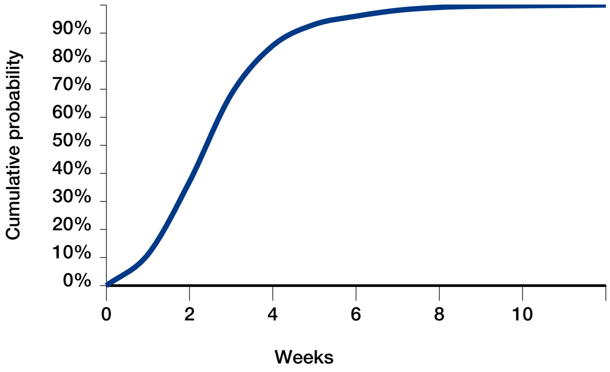


Fig. 35
A cumulative probability distribution of the duration of viraemia in cattle naturally infected with bluetongue virus
From Murray *et al.* (2004)

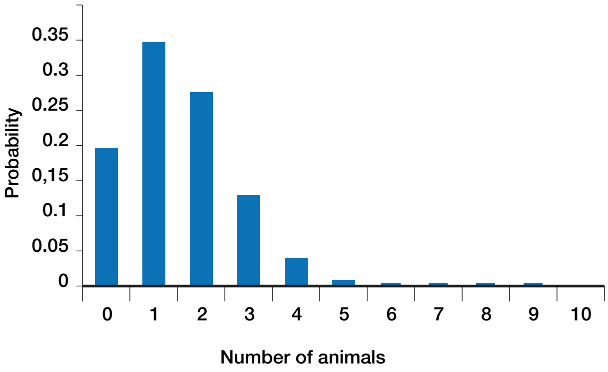


Fig. 36
A binomial distribution of the variation in the number of infected animals (x) likely to be in a sample (n = 10) drawn from a population with a disease prevalence (p = 0.15)
From Murray *et al.* (2004)

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:

$$x = \mathit{Binomial}\ (n, p).$$

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:

$$n = \mathit{Negbin}\ (x, p) = \mathit{failures.}$$

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:

$$n = x + \mathit{Negbin}\ (x, p) = \mathit{successes} + \mathit{failures.}$$

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.

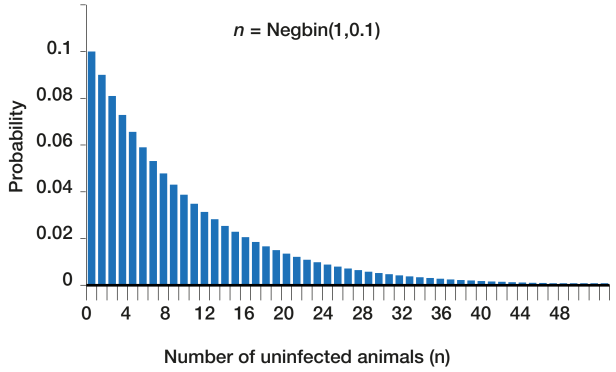


Fig. 37
A negative binomial distribution of the number of uninfected animals likely to be selected from a population with a disease prevalence of 10% before including an infected animal in the group

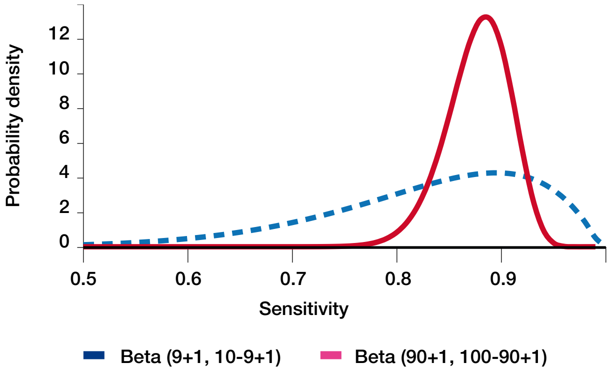


Fig. 38
Using the beta distribution function to model an uncertain parameter p, of a binomial distribution. In this case p represents test sensitivity

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 $4 \div 99 = 0.04$, whereas, if it does not, the probability would be $5 \div 99 = 0.051$. 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.

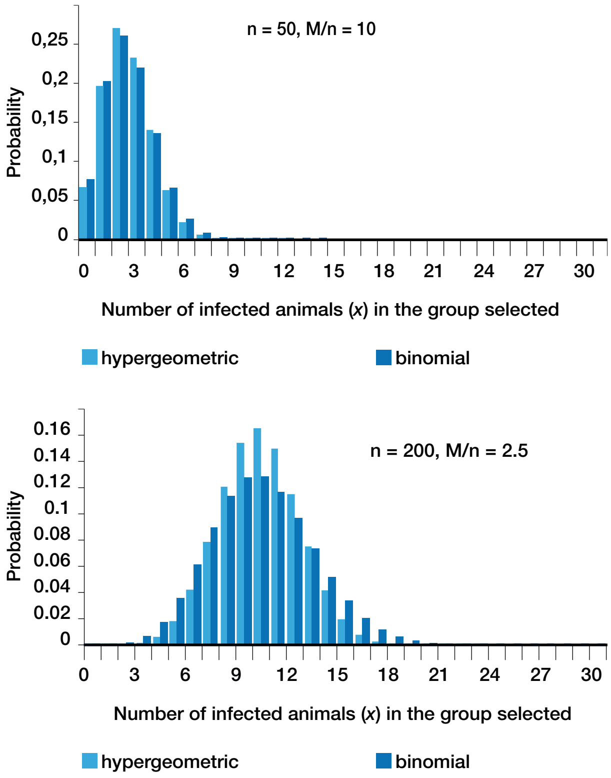


Fig. 39

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*):

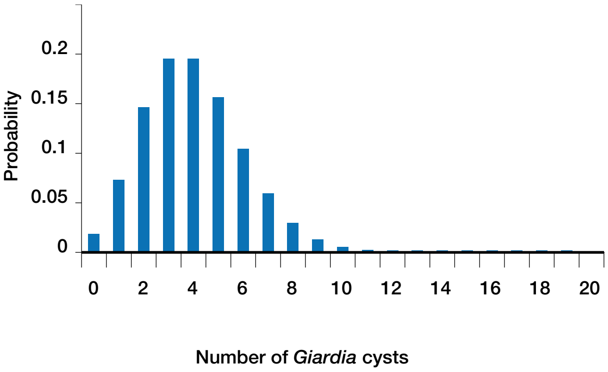
$x = Poisson\left(\lambda \times t\right)$, *or in terms of* ($\beta$),

$$x = Poisson\left(\frac{t}{\beta}\right)\cdot$$

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

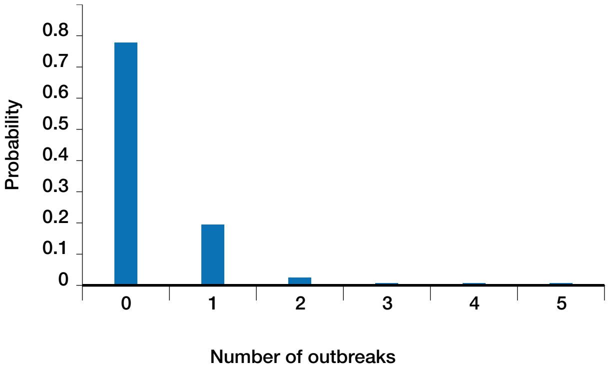


Fig. 41
A Poisson probability distribution of the number of disease outbreaks expected during the next time interval t,
where t = 6 months and the mean interval between events (β) is 24 months.

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.

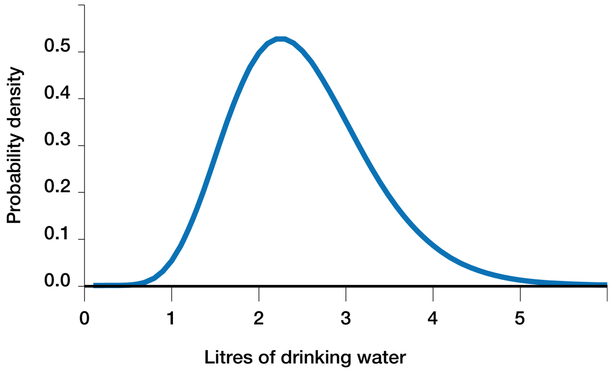
5.5.2 Estimating the amount of space or time until the next (x) events have occurred

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, $t_x = Gamma(x, \beta)$.

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).

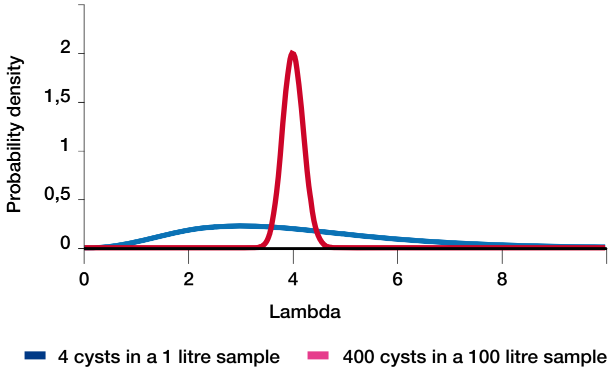


Fig. 43
Estimates of the average number of *Giardia* cysts

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.

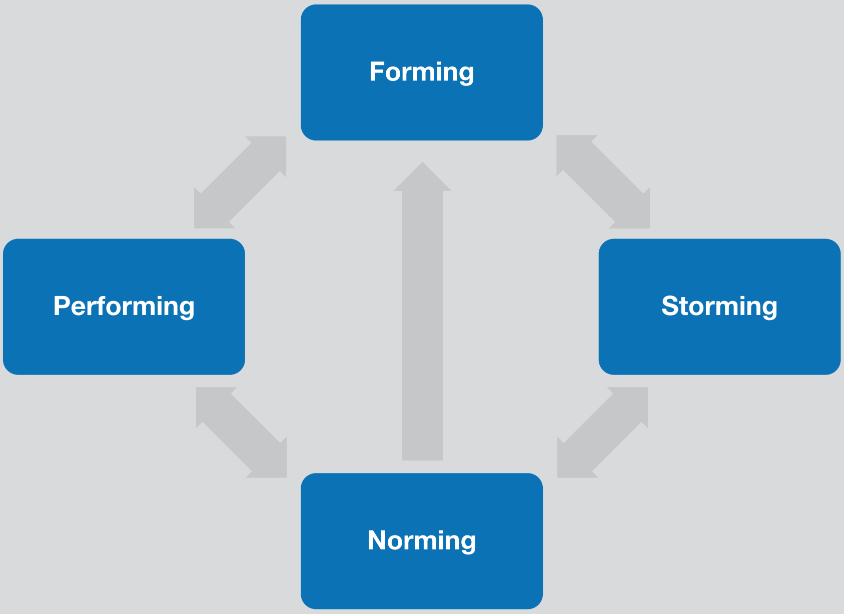


Fig. 44
Stages of team development

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

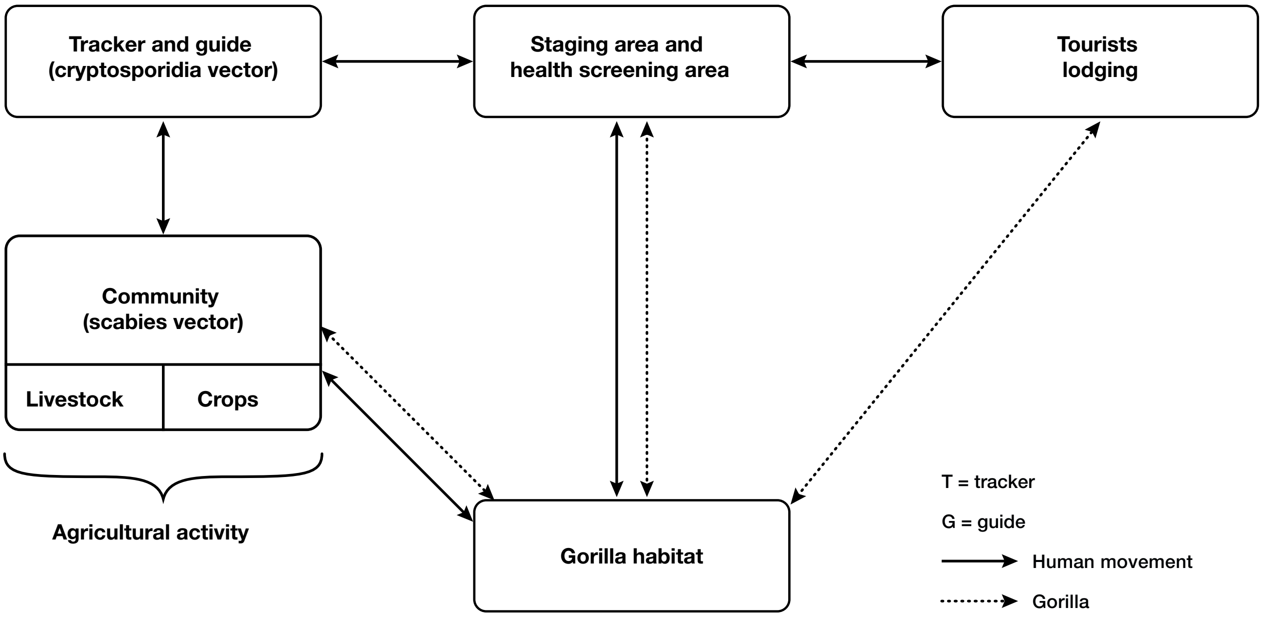


Fig. 45
Step 3 – Map the pathways

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.

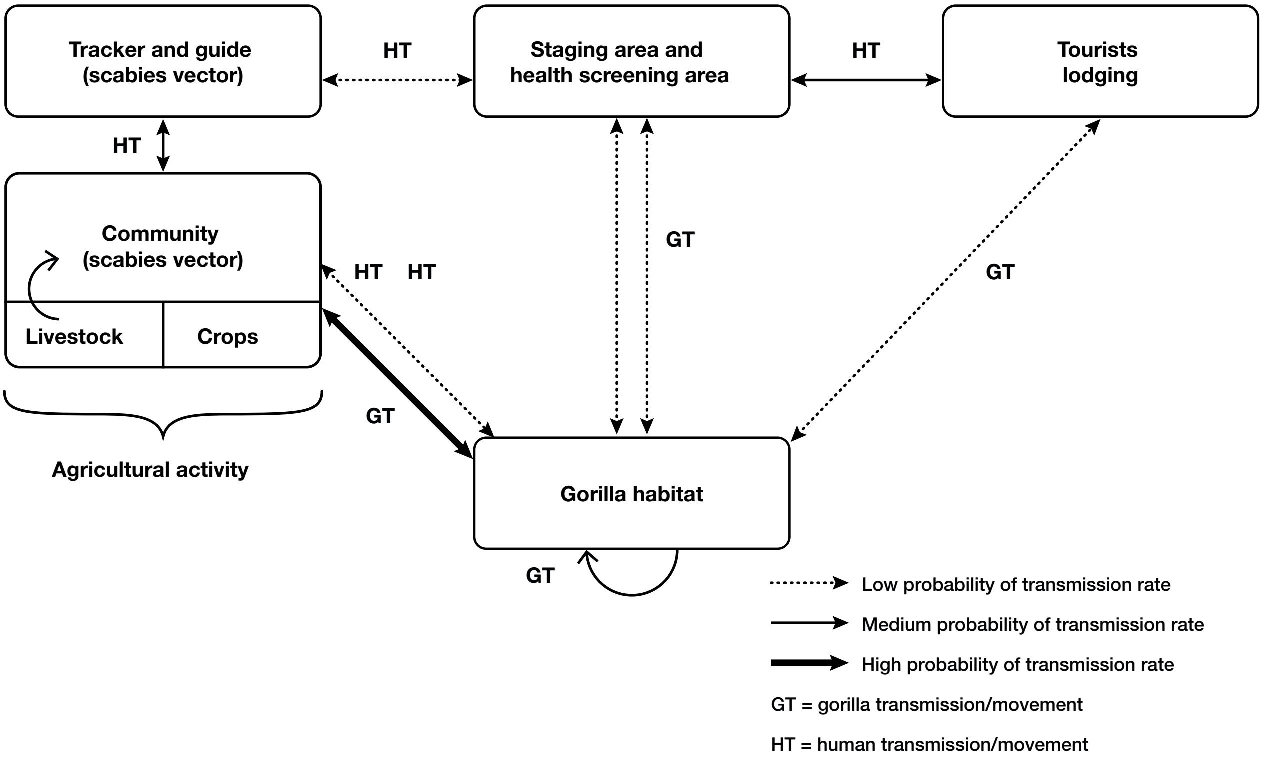


Fig. 46
a) Scabies transmission pathways

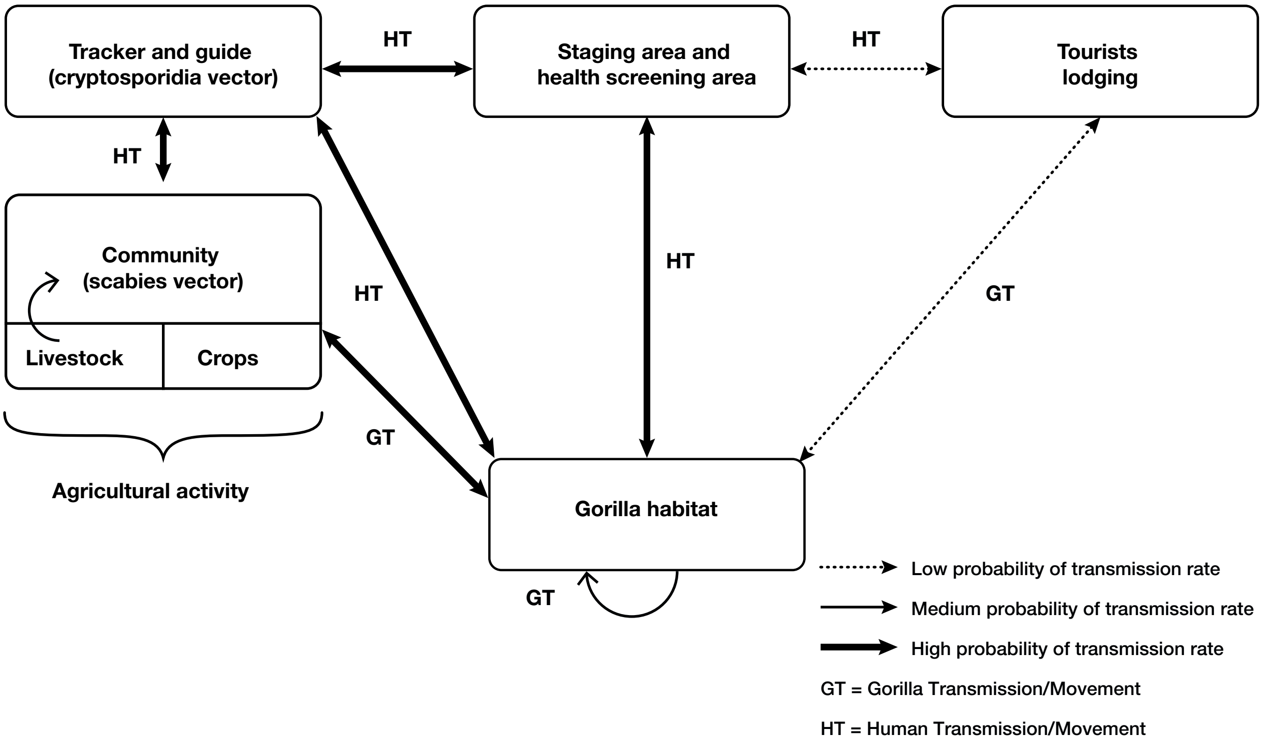


Fig. 47
b) Cryptosporidia transmission pathways

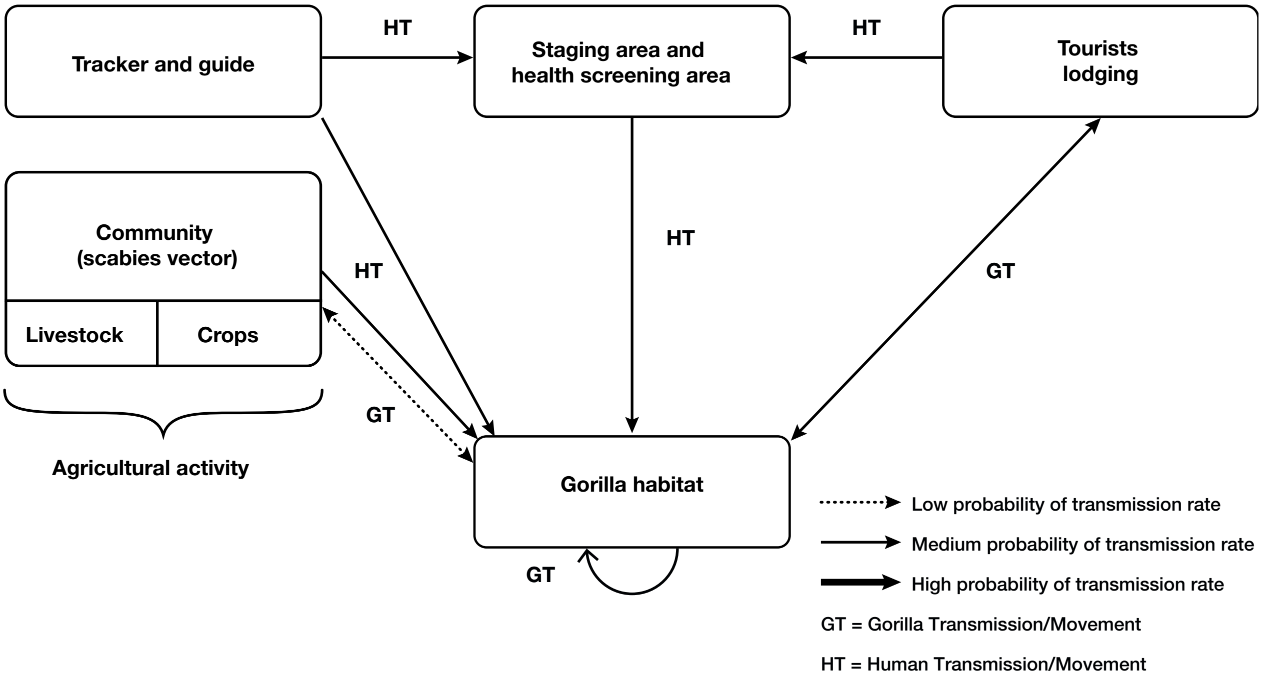


Fig. 48
c) Measles transmission pathways

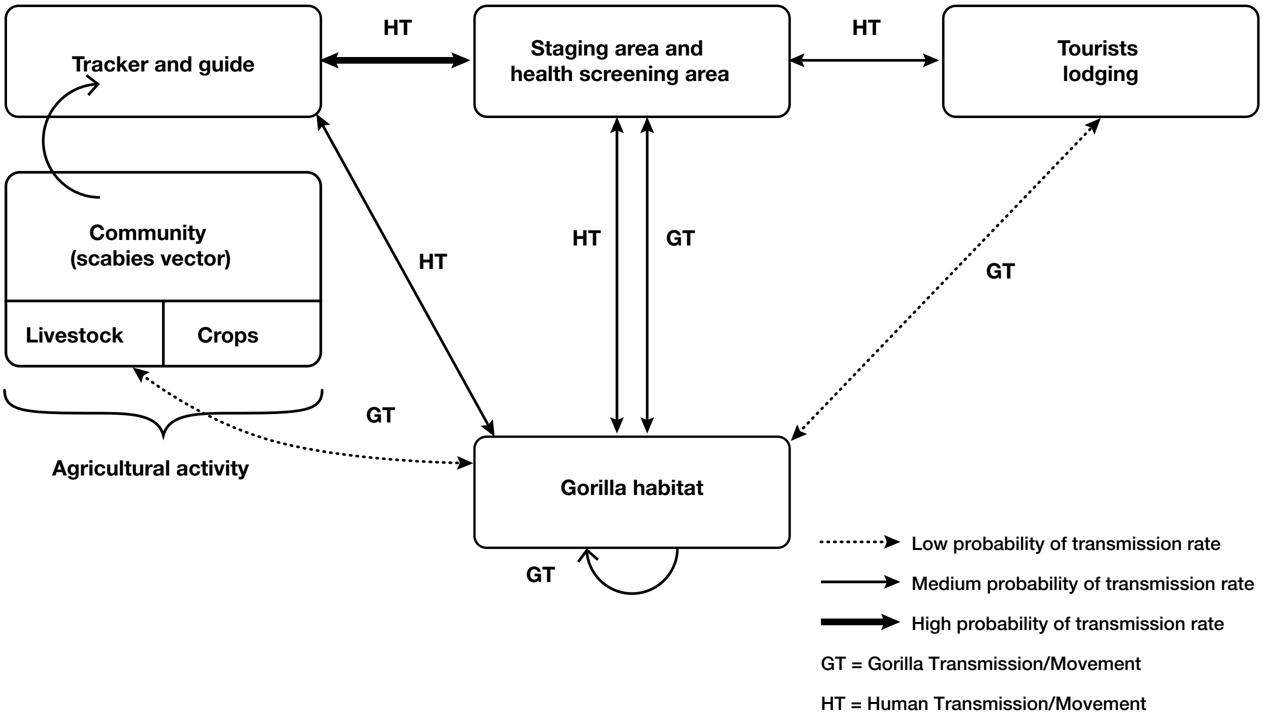


Fig. 49
d) Tuberculosis transmission pathways

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

		Severity			
		Very low	**Low**	**Medium**	**High**
Likelihood	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

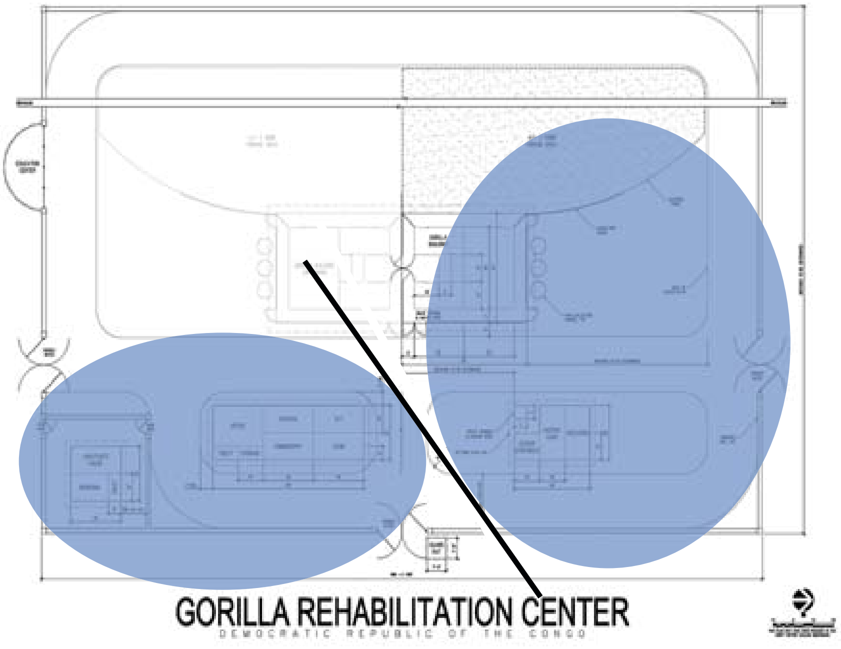


Fig. 50
Creation of epidemiological units
This highlights how your facility can be separated into areas, to prevent the spread of an outbreak to other areas of your facility.

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.

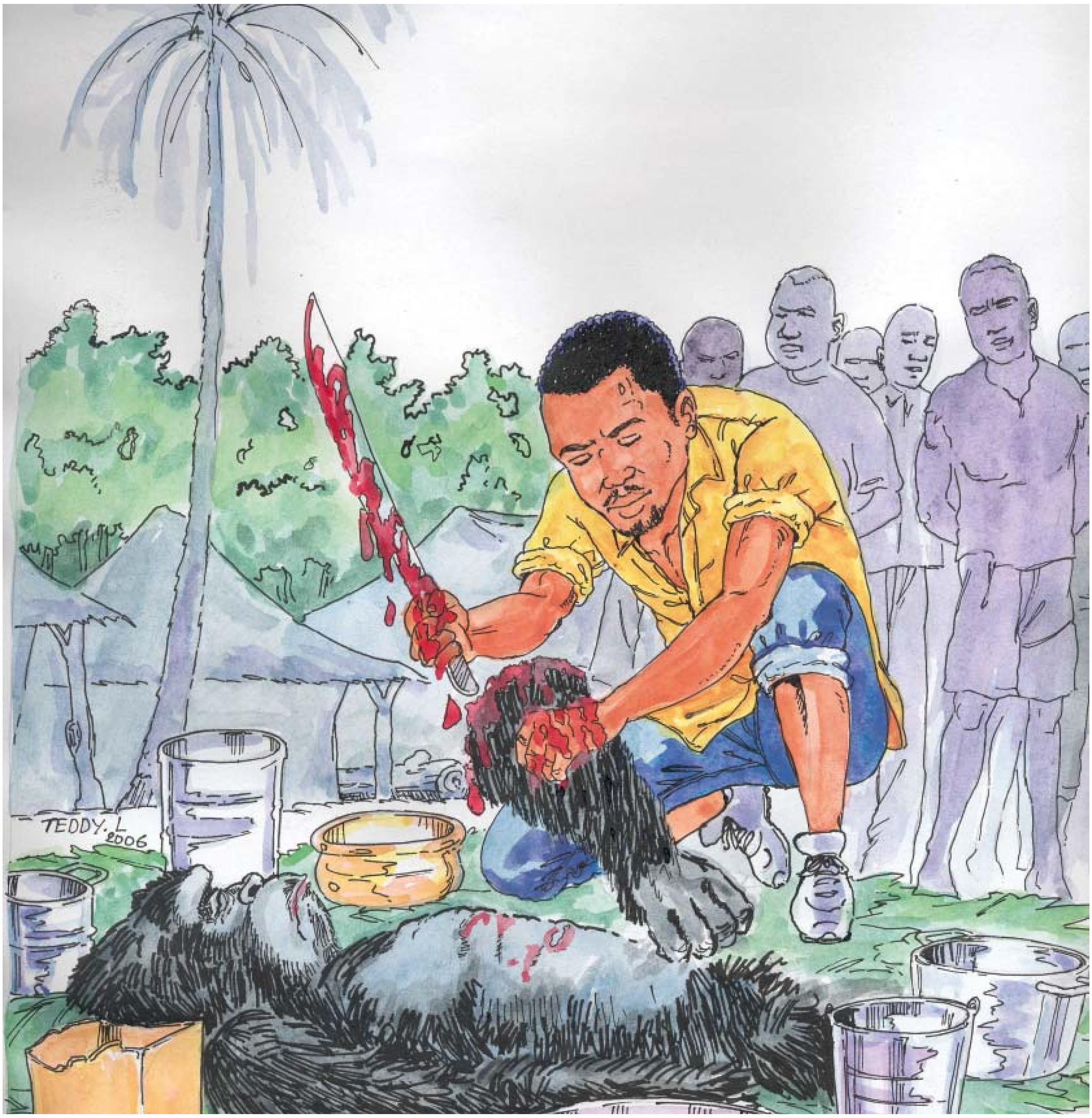


Fig. 51
Image from a series of educational cartoons on the spread of Ebola virus in the Democratic Republic of Congo
(Thanks to Ken Cameron, Wildlife Conservation Society Field Veterinarian)

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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

Manual
of Procedures 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 *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*.

**INTERNATIONAL UNION
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WORLD ORGANISATION FOR ANIMAL HEALTH
Protecting animals, preserving our future

SCTI Advisory Group Meeting (closed)

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Highlights of activities – Species Conservation Toolkit Initiative

May 2018 - September 2018

SCTI
Species Conservation Toolkit Initiative
Software
for
saving
species;

The **Species Conservation Toolkit Initiative** (SCTI) is a partnership to ensure that the new innovations and tools needed for species risk assessment, conservation planning, and managing populations are developed, are globally available, and are used effectively. The initiative leverages expertise in population biology, computer programming, and species conservation planning to: build and support modeling tools that are essential to guiding conservation actions for thousands of threatened species in the wild; facilitate the intensive management of hundreds of species that are being protected within *ex situ* programs; and integrate conservation efforts across the spectrum of management approaches.

New partners!

The Association of Zoos and Aquariums (AZA) and the European Association of Zoos and Aquaria (EAZA) have joined SCTI as major sponsors. They value both the SCTI software tools that guide scientific management of the *ex situ* populations and the contribution that a SCTI tools make to conservation and management of species in their natural habitats. We are equally excited that several more partners from Europe, Asia, and USA plan to join SCTI in 2019 (but we can’t yet tell you who they are).

Planning for the future

The SCTI team (Jon, Onnie, Bob, Taylor, and Sara) met at the CPSG offices in Minnesota to reaffirm our mission, describe the primary areas of expertise that are needed to meet our goals, identify what roles can be filled by existing SCTI staff and by colleagues at partner organizations (e.g., IUCN CPSG, Species360, and the zoo associations), and determine what additional staffing or partners are needed to fulfill our mission. The primary areas in which SCTI needs to have access to expertise either on staff or via partnerships are the development of the science of species conservation methods, software coding, training and user support, and assisting in the use of the software to improve species conservation planning. It might be tempting to see SCTI as primarily a “coding shop”. However, SCTI was formed to sustain innovation in species conservation tools, and that means that we need also to be developing the science so that we can identify the next tools. To meet this mission, SCTI also needs to make sure that practitioners can use the software and use it appropriately, and that means that we need to provide adequate documentation, training, and support. In order to understand and serve the needs of the conservationists and managers who use our tools, SCTI needs to work collaboratively with them –

especially on analyses that push the limits of our current knowledge and technologies. To enable our small team to be effective, we also need support for office management and communications and for organizational leadership and oversight.

Although we can and will rely heavily on collaborative partners to help fill some of the roles above, we recognize that currently the SCTI team is too small (with one conservation scientist programmer, one leader of our training efforts, and some donated time of two senior conservation scientists) to keep advancing and supporting the innovations that are needed by the species conservation communities. Minimally, we need to start developing technical expertise and experience in species conservation planning in a second conservation scientist-programmer, we need a person both to lead communications with our diverse audiences and to assist with creating training materials, and we need to develop more formal relationships and commitments for collaborative work from partner organizations that share our mission.

Building the capacity of SCTI to serve the conservation community

Due to the support of all the SCTI partners, we are now able to address at least one of the needs identified above: We have begun a search for a second full-time postdoctoral level conservation scientist-programmer! We know that we are looking for someone with special talents, but we are optimistic that we can find the right person to fill the position before the end of 2018.

Strategic thinking

The creation of SCTI was a bold initiative that was hatched out of discussions at CPSG (then, CBSG) meetings. We had optimism that the communities in which we work would being willing to form a partnership to support a small and flexible think-tank to sustain and grow innovation that serves the broader species conservation needs. We are now approaching the end of the first three years of the Initiative, and we need to determine how we can best serve the needs for the next three years and beyond. We need to make use of the expertise in our partners and our Advisory Group to help us think creatively about how to meet our broad mission.

Accordingly, we are planning to have a strategic thinking meeting with primary partners and advisors. We will be conveying more information about these plans soon, but we are thinking about a 2 to 3 day meeting, with an external facilitator, probably sometime in early 2019.

Advisory Group

SCTI benefits from an Advisory Group comprised of both representatives of major organizational partners of SCTI (a number of zoos, zoo associations, and conservation NGOs) and experts in the application of our tools for species conservation. The SCTI Advisory Group provides strategic advice on our mission and scope, broad priorities for tool development and support, scientific advances, technological opportunities, and new innovations that are needed to address increasingly complex conservation challenges. To provide diverse perspective and expertise on the Advisory Group, we have recently worked to recruit additional experts – from more scientific disciplines, more countries, and more kinds of institutions.

The Advisory Group had its first meeting in Berlin in October 2017, and will meet next at the CPSG annual conference in Bangkok in October 2018. The group will have a 3-hour working meeting during the CPSG conference. We are also organizing a mini-symposium for a CPSG plenary session in which several SCTI partners and colleagues will describe exciting and innovative methods that they are applying to species conservation planning.

Ensuring success for the next generation

A primary reason for the creation of SCTI was that we cannot rely on the same people forever to deliver the tools we need to succeed in species conservation and population management. We need to recruit the next generation of conservation scientists to serve our communities. SCTI is well on the way to doing just that, and perhaps just in time! We are fortunate that Jon Ballou – even a few years after his retirement from the Smithsonian Conservation Biology Institute – continues to devote substantial hours each week to work with the SCTI team on envisioning and building valuable tools. Bob Lacy has recently announced that he will be retiring from his position at the Chicago Zoological Society (CZS) in early 2019. However, Bob too will continue working with SCTI (following in Jon's footsteps, as always!). Moreover, CZS is committed to continuing its leadership in population biology and species conservation methods, and has begun a search for a Conservation Scientist with expertise in population biology and an eagerness to work with SCTI.

A manual for Outbreak

For several years, the OUTBREAK software has provided the means to model the spread (and control) of infectious disease in wildlife populations. The model can be linked with Population Viability Analysis models (such as VORTEX) to enable consideration of disease in species risk assessments and population management. However, although the program was intuitive enough that a number of scientists and students picked it up and have used it effectively (especially in Australia and Brazil), wider use of the software has been hindered by the lack of a complete manual.

Thanks to the efforts of Carlo Pacioni of Australia, Sara Sullivan of SCTI, Caroline Lees and Phil Miller of CPSG, Bob Lacy of CZS, and others (and some funding from the US National Science Foundation), we have now released the first complete manual for OUTBREAK! The manual is available on-line, is included in the latest installation of the program, and has been integrated into the software as context-sensitive Help.

Software enhancements

We continually make refinements in all of our software tools. These include improvements to the user interfaces, adjustments to algorithms for handling unusual species and data, and changes to keep current with evolving operating systems and network implementations.

Among the recent enhancements to PMx is a completely revised Selection tab in PMx, allowing much easier identification of which animals are to be included in genetic and demographic calculations. The Demography section has been steadily enhanced, with new metrics for reporting the status of the populations and completeness the data.

To Outbreak, we added the ability to describe any input rates (such as disease transmission rates and recovery times) as functions of individual and population properties, rather than only as constant values. In Vortex, improvements were made in the ways that management of captive populations can be modeled, and to the graphical analyses of sensitivity tests of uncertain parameters.

Building capacity to use the tools

At the request of the Canadian government (and with funding from them), we taught a workshop, hosted by the Seattle Zoo, on advanced uses of VORTEX. The Canadian government and several NGOs are eager to have their scientists become experts in VORTEX, so that the agencies can assess the cumulative impacts of anthropogenic threats to species and test proposed management actions.

Earlier this year, SCTI began to develop online training materials for Outbreak and PMx. Among the first products of this effort are a series of introductory videos on the OUTBREAK software, first trialed at a Disease Risk Assessment workshop in Brazil and now available at http://www.vortex10.org/Outbreak.aspx. To determine priority training needs for PMx, we distributed a Training Needs Assessment on our website and various international listservs in March 2018. Over 130 PMx users from 23 countries responded, giving us a better understanding of where additional training is most needed and in what format our users are interested in receiving that training. Currently, three online formats are being tested, and PMx users are welcome to view these materials and leave feedback using the following links:

- Short, interactive module: Creating a PMx Project with ZIMS export files
- Comprehensive overview course: The Genetics Module
- Narrated video: Who is in the Managed N?

To distribute our training materials, we are developing a dedicated training section of our website. Here, toolkit users will be able to access materials through personal accounts, track their activity through user profiles, and interact with other users in dynamic forums. Additionally, the SCTI team will be able to gain insight into learning behaviors and pinpoint areas for improvement by tracking metrics related to completion rates, learner performance, and learner satisfaction. As these e-learning materials take time to design, build, and evaluate, we will also provide quick pdf-based technical guides and make updates to the user manuals as needed. Most recently, we partnered with Species360 to produce an online guide for testing ZIMS PMx exports. This pdf is available for download using the "Walk Me" tool on the Species360 website. We will continue to collaborate with partners providing their own online or in person training related to our tools and provide daily technical assistance to queries sent to help@vortex10.org.

Working with partners

The SCTI team met with the science team of Species360 to share new developments and discuss possible areas of collaboration. We are working closely with Species360 to ensure full compatibility and exchange of data between ZIMS and PMx. In the process, this has led to a number of enhancements to both PMx and ZIMS for Studbooks, and we are now working with Species360 to export additional data fields from ZIMS to PMx.

We continue to help regional zoo associations with the new exports of data from ZIMS to PMx. Documentation of data standards and guides were created to help user groups confirm the accuracy of data exports.

We are continuing to work with a group of botanical gardens to test the use of PMx and population management methods developed by zoos for guiding collaborative breeding programs for plants. We hosted a workshop for colleagues from 6 botanic gardens on the use of PMx for plant population management. This project has led us to improve how PMx handles hermaphroditic (monoecious) species – an enhancement that will likely be useful for management of some fish and many invertebrate animal species as well.

SCTI provides expert advice (and sometimes debugging, as needed) to CPSG as it applies the latest features in Vortex to some of the most complex species risk assessments. When time permits, technical assistance is provided also to graduate students, researchers, wildlife agencies, zoos and aquariums, and others.

Go to scti.tools!

A new SCTI website is about to be unveiled. (It is still in development as of 1 October.) The site provides much more information about SCTI, downloads of software and documentation, and more. It will soon provide access to on-line training modules and videos, and forums for supporting communities of users.

Some of our plans for the next few months

SCTI is flexible and responsive. We are constantly refining software and increasing support, and adding new features and even new programs, as suggestions, new ideas, and new science are identified by our team, our partners, or the broader conservation community. Among the developments underway, and which we expect to release within the next few months, are:

SCTI is participating in the annual conferences of EAZA, AZA, and CPSG to meet with partners and users of the SCTI tools.

A training workshop on the OUTBREAK software will be conducted in conjunction with the EAZVW/AAZV/IZW joint conference, held in Prague.

We will be completely revising the PMx manual, especially to describe the many newer features.

The SCTI Team

- Jonathan Ballou
- Onnie Byers
- Taylor Callicrate
- Robert Lacy
- Sara Sullivan

SCTI Partners (as of August 2018)

- Association of Zoos and Aquariums
- Auckland Zoo
- Chicago Zoological Society
- Copenhagen Zoo
- European Association of Zoos and Aquaria
- Living Desert Zoo & Gardens
- National Zoo/Smithsonian Conservation Biology Institute
- Oceans Initiative
- Raincoast Conservation Foundation
- Saint Louis Zoo
- San Diego Zoo Global
- San Francisco Zoo & Gardens
- Seattle Aquarium
- SOS Rhino
- Species360
- IUCN SSC Conservation Planning Specialist Group
- Zoological Society of London

Contract support for specific projects:

- Canada Department of Fisheries and Oceans
- The Nature Conservancy
- US Institute of Museum & Library Services
- US National Science Foundation

IUCN

SSC
Species Survival Commission

CONSERVATION PLANNING
SPECIALIST GROUP
Changing the Future for Wildlife

Investigating patterns of international wildlife trade in ASAP species

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Investigating patterns of international wildlife trade in ASAP species

CONVENORS: Johanna Stärk, Chris Shepherd, Rita da Silva, Ioanna Alexiadou, and Dalia A. Conde

AIM: Investigate and discuss patterns of international trade in ASAP species to unveil fraudulent claims of captive-breeding.

BACKGROUND: Unsustainable and illegal wildlife trade is one of the major challenges of South East Asia (SEA) and its rapid growth is threatening many CITES-listed species. An analysis of the CITES Trade database showed that over 35 million CITES listed animals have been exported from SEA between 1998 to 2007, with 4.5 million derived from captive-breeding facilities [1]. While trade in captive bred individuals can relieve pressure on wild populations, the high number of transactions of specimens claimed to be captive-bred raise concerns about the potential illegal laundering of wild caught animals declared as produced in captivity [2]. Successful breeding of threatened species on a commercial scale requires extensive knowledge in captive husbandry, good record keeping, and high standards of veterinary care. Moreover, establishing captive breeding populations capable of producing second-generation offspring takes considerable time and effort.

This is especially the case for species with slow life histories, i.e. species that mature late and produce few offspring, as for example the case in many turtles and tortoises; hence making captive-breeding unprofitable [3]. For example, the Critically Endangered Palawan Forest Turtle (Siebenrockiella leytensis) listed on CITES Appendix II, has been commercialized as captive bred, however this is unlikely, since up until 2015 it had never successfully reproduced in captivity [4]. The Palawan Forest Turtle is only one of currently 176 species in South East Asia that have been prioritized by the IUCN SSC's Asian Species Action Partnership (ASAP) focusing on critically endangered land or freshwater vertebrates occurring regularly in the region. Of these, 39 species are species listed on CITES Appendix I and 29 species are listed on Appendix II [5]. A major challenge for many countries to meet the requirements for trade in CITES-listed species to control the illegal laundering include corruption, weak law enforcement, insufficient capacity of the authorities and lack of knowledge on species captive breeding potential. In this workshop, we will work with data from the CITES Trade database to discuss and identify ASAP species at highest risk of unsustainable trade and identify species that may be illegally laundered as captive-bred to support authorities in their fight against illegal trade.

PROCESS:

1. General presentation of trade analytics of ASAP species and the CITES Trade database
2. Division into smaller working groups divided by taxa to discuss trade patterns, identify possible fraudulent claims of captive breeding and to prioritize ASAP species at highest risk of unsustainable or fraudulent trade
3. Presentation of main findings and discussion of follow up actions

RECOMMENDED READING:

Relevant definitions of CITES source codes: Captive breeding and ranching of CITES-listed animals: EU approaches to handling imports of C, F, and R specimens
http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=33543&no=40

An example of how to identify illegal laundering based on the species reproductive potential:
Nijman, V. and Shepherd, C.R. (2015). Adding up the numbers: an investigation into commercial breeding of Tokay Geckos in Indonesia. TRAFFIC.
https://www.traffic.org/site/assets/files/6060/adding-up-the-numbers.pdf

REFERENCES:

[1] Nijman, V. (2010). An overview of international wildlife trade from Southeast Asia. Biodiversity and conservation, 19(4), 1101-1114.

[2] Nijman, V., and Shepherd, C. (2009). Wildlife trade from ASEAN to the EU: Issues with the trade in captive-bred reptiles from Indonesia. TRAFFIC Europe Report for the European Commission, Brussels, Belgium. Available at: https://www.traffic.org/site/assets/files/9837/issues-with-the-trade-in-captive-bred-reptiles-from-indonesia.pdf

[3] Iverson, J. (1992). Correlates of Reproductive Output in Turtles (Order Testudines). Herpetological Monographs, 6, 25-42. doi:10.2307/1466960

[4] https://www.traffic.org/news/captive-breeding-claims-turned-turtle/

[5] CITES Appendices I, II, III https://cites.org/eng/app/appendices.php

Captive breeding and ranching of CITES-listed animals: EU approaches to handing imports of C, F and R specimens

Captive breeding and ranching of CITES-listed animals: EU approaches to handling imports of C, F and R specimens

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Contents

Introduction

Trade in commodities of CITES-listed species has seen a general shift from being predominately wild-sourced in the early years of the Convention, to being a mixture of wild and captive-bred/artificially propagated trade, with most taxonomic groups being predominantly captive-produced[1]. For animals that have been produced in captivity, there are four potential source codes that could be applied – C, D, F or R. Consistency in the application of source codes was considered by the fifteenth meeting of the Conference of the Parties in 2010. Decision 15.52 called for a guide to assist with determining source codes to be produced, which should incorporate review and feedback from the Animals and Plants Committees. IUCN were contracted by the CITES Secretariat to produce the draft guidance, and the outputs that were developed took the form of two different types of dichotomous keys. The guidance was finalised in 2017 and can be found on the CITES website[2]

The first draft of the guide was considered at AC28, and the Animals Committee recommended that more guidance was needed in cases where there is uncertainty as to whether provisions of the relevant resolutions had been met, and recommended that Parties propose ideas for case studies on species or types of production systems to support the guide. Particular areas identified in AC28 Com.7 as requiring more scrutiny related to:

- interpretation of source code F versus codes C or W, due to the ambiguity in the definition of source code F and the different ways Parties consider parental lineage when making a determination of the source;
- differences in the interpretation of source code R versus codes W or F, particularly for Appendix II species; and
- application of source code C and D, particularly in relation to questions over the purpose of production.

To complement the existing IUCN guide, this information document summarises approaches taken by EU Member States in determining the source codes to apply to CITES import applications for specimens that are derived from different captive production systems, with a focus on the three codes C, F and R. It provides the EU interpretation of source codes, as well as some case study examples that illustrate challenges in determining source codes. Specifically it includes:

- A summary of the text of the relevant EU and CITES provisions relating to captive breeding and ranching (as laid out in articles of the EU Wildlife Trade Regulations[3] and CITES Resolutions and definitions);

- A simple flow chart to summarise the key differences in production systems to assist with determining source codes relative to the definitions in the EU Wildlife Trade Regulations;

- Four case study examples that illustrate some of the challenges in determining source codes and the approaches the EU have taken.

[1] Harfoot *et al.*, submitted. *Unveiling the dynamics of the global trade in wildlife.*
[2] https://cites.org/eng/prog/captive-breeding
[3] EC Regulation No. 865/2006; EU Regulation No. 792/2012 and EU Regulation. No. 2015/57

Captive breeding: the EU context

It is important that the correct source code is applied to CITES permits to accurately describe the nature of the trade according to the definitions of the Convention and the EU Wildlife Trade Regulations. Applying the correct source code can ensure that accurate analyses of trade data can be undertaken, for example, to identify volumes, patterns, or determine the impact of the trade on wild populations. EU Member States are required to make a non-detriment finding and determine the correct source code to apply to all specimens of Appendix I and II imports.

Summary of relevant definitions

CITES Resolution 12.3 (Rev. CoP17) on *Permits and Certificates* provides the definitions for codes to indicate the source of specimens in trade. Regulation (EU) No. 792/2012 provides the corresponding definitions for all but one of these source codes in the EU context (Table 1), the definition of source code 'X' included in Regulation (EU) No. 2015/57. With the adoption of these Regulations, the CITES and EU definitions for the source of specimens in trade are consistent. Additional definitions for terms relevant to captive breeding and ranching, and the associated CITES and EU provisions, are provided in Table 2.

Table 1. Definition of codes for source of specimens in trade as outlined in CITES Res. Conf. 12.3 (Rev. CoP17) and Regulations (EU) No. 792/2012 and (EU) No. 2015/57.

Code	CITES Res. Conf. 12.3 (Rev. CoP17)	Regulation (EU) No. 792/2012 and Regulation (EU) No. 2015/57 (amending Reg. (EU) No. 792/2012)
A	Plants that are artificially propagated in accordance with Resolution Conf. 11.11 (Rev. CoP17), as well as parts and derivatives thereof, exported under the provisions of Article VII, paragraph 5 (specimens of species included in Appendix I that have been propagated artificially for non-commercial purposes and specimens of species included in Appendices II and III);	Annex A plants artificially propagated for non-commercial purposes and Annexes B and C plants artificially propagated in accordance with Chapter XIII of Regulation (EC) No 865/2006, as well as parts and derivatives thereof
C	Animals bred in captivity in accordance with Resolution Conf. 10.16 (Rev.), as well as parts and derivatives thereof, exported under the provisions of Article VII, paragraph 5.	Animals bred in captivity in accordance with Chapter XIII of Regulation (EC) No 865/2006, as well as parts and derivatives thereof
D	Appendix-I animals bred in captivity for commercial purposes in operations included in the Secretariat's Register, in accordance with Resolution Conf. 12.10 (Rev. CoP15), and Appendix-I plants artificially propagated for commercial purposes, as well as parts and derivatives thereof, exported under the provisions of Article VII, paragraph 4, of the Convention.	Annex A animals bred in captivity for commercial purposes in operations included in the Register of the CITES Secretariat, in accordance with Resolution Conf. 12.10 (Rev. CoP15), and Annex A plants artificially propagated for commercial purposes in accordance with Chapter XIII of Regulation (EC) No 865/2006, as well as parts and derivatives thereof
F	Animals born in captivity (F1 or subsequent generations) that do not fulfil the definition of 'bred in captivity' in Resolution Conf. 10.16 (Rev.), as well as parts and derivatives thereof;	Animals born in captivity, but for which the criteria of Chapter XIII of Regulation (EC) No 865/2006 are not met, as well as parts and derivatives thereof
I	Confiscated or seized specimens	Confiscated or seized specimens[4]
O	Pre-Convention specimens	Pre-Convention specimens[3]
R	Ranched specimens: specimens of animals reared in a controlled environment, taken as eggs or juveniles from the wild, where they would otherwise have had a very low probability of surviving to adulthood.	Specimens of animals reared in a controlled environment, taken as eggs or juveniles from the wild, where they would otherwise have had a very low probability of surviving to adulthood
U	Source unknown (**must be justified**)	Source unknown (must be justified)
W	Specimens taken from the wild	Specimens taken from the wild
X	Specimens taken in "the marine environment not under the jurisdiction of any State"	Specimens taken in the marine environment not under the jurisdiction of any State

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[4] To be used only in conjunction with another source code.

Table 2. Relevant definitions relating to captive breeding and ranching based on articles of the EU Wildlife Trade Regulation and CITES Resolutions.

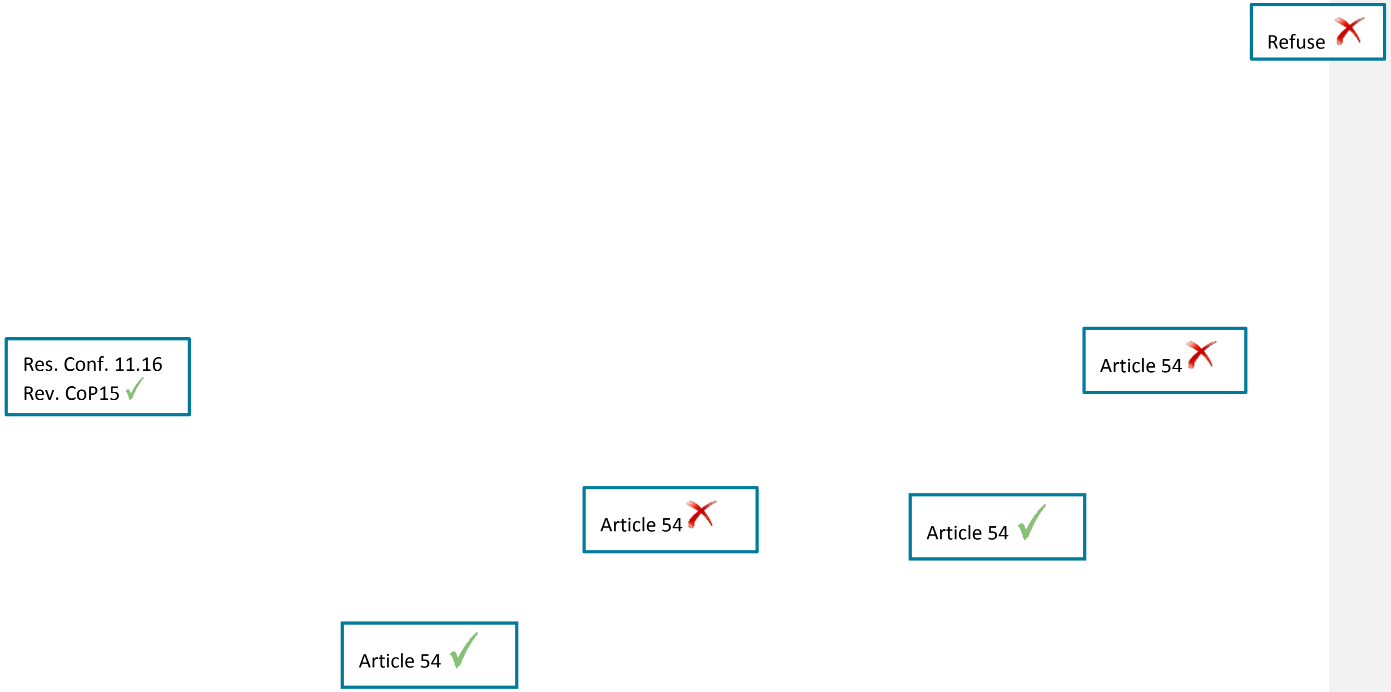
Description	Definition	Relevant provisions
Breeding stock	All the animals in a breeding operation that are used for reproduction.	Article 1 of Regulation (EC) No. 865/2006*
Controlled environment	An environment that is manipulated for the purpose of producing animals of a particular species, that has boundaries designed to prevent animals, eggs or gametes of the species from entering or leaving, and the general characteristics of which may include but are not limited to artificial housing, waste removal, health care, protection from predators and the artificial supply of food.	Article 1 of Regulation (EC) No. 865/2006*
Generation of offspring	'Second-generation offspring (F2)' and 'subsequent generation offspring (F3, F4, and so on)' means specimens produced in a controlled environment from parents that were also produced in a controlled environment, as distinct from specimens produced in a controlled environment from parents at least one of which was conceived in or taken from the wild (first-generation offspring (F1)).	Article 1 of Regulation (EC) No. 865/2006*
Ranching	The term 'ranching' means the rearing in a controlled environment of animals taken as eggs or juveniles from the wild, where they would otherwise have had a very low probability of surviving to adulthood. Note: Resolution Conf. 11.16 (Rev. CoP15) does indicate that a ranching programme must be primarily beneficial to the conservation of the local population (i.e., where applicable, contribute to its increase in the wild or promote protection of the species' habitat while maintaining a stable population); however this requirement appears to relate only to proposals to the transfer of populations from Appendix I to II for the purposes of ranching.	Resolution Conf. 11.16 (Rev. CoP15)
Specimens born and bred in captivity	Without prejudice to Article 55, a specimen of an animal species shall be considered to be born and bred in captivity only if a competent management authority, in consultation with a competent scientific authority of the Member State concerned, is satisfied that the following criteria are met: 1) the specimen is, or is derived from, the offspring born or otherwise produced in a controlled environment of either of the following: (a) parents that mated or had gametes otherwise transferred in a controlled environment, if reproduction is sexual; (b) parents that were in a controlled environment when development of the offspring began, if reproduction is asexual; (2) the breeding stock was established in accordance with the legal provisions applicable to it at the time of acquisition and in a manner not detrimental to the survival of the species concerned in the wild; (3) the breeding stock is maintained without the introduction of specimens from the wild, except for the occasional addition, in accordance with the legal provisions applicable and in a manner not detrimental to the survival of the species concerned in the wild, of animals, eggs or gametes exclusively for one or more of the following purposes: (a) to prevent or alleviate deleterious inbreeding, the magnitude of such addition being determined by the need for new genetic material; (b) to dispose of confiscated animals in accordance with Article 16(3) of Regulation (EC) No 338/97; (c) exceptionally, for use as breeding stock; (4) the breeding stock has itself produced second or subsequent generation offspring (F2, F3 and so on) in a controlled environment, or is managed in a manner that has been demonstrated to be capable of reliably producing second-generation offspring in a controlled environment. [see case study 2].	Chapter XIII, Article 54 of Regulation (EC) No. 865/2006*

*Note that definitions in Reg. (EC). No.865/2006 are consistent with those in Res. Conf. 10.16 (Rev.) on *Specimens of animal species bred in captivity*).

Flow chart for the determination of source codes

Figure 1 provides a flow chart to summarise how source codes can be determined based on the relevant CITES resolutions and definitions, and the provisions of the EU Wildlife Trade Regulations as described above in Tables 1 and 2. This flow chart provides a simple guide to aid decision-making in the EU; however, it must be noted that the considerations in Article 54 (3) and (4) that relate to whether the breeding stock is being maintained without augmentation of specimens from the wild, and whether it is being managed in a manner that is capable of producing second generation offspring [see 'Specimens born and bred in captivity' in Table 2 above], are taken into account **on a case-by-case basis**. Examples to illustrate how Article 54 (3) and (4) are applied in the EU can be found in case studies 1 and 2 respectively.

Figure 1. Flow chart for the determination of source codes based on articles of the EU Wildlife Trade Regulations and CITES definitions, with an indication of where the relevant provisions have been met (✓) or not met (✗). (* Refers to eggs or juveniles with high mortality life stages only).



Challenges to implementation: case studies

There are often factors which make determining source codes more complex, which might relate to, for example, a specific management regime for an individual species or taxonomic group. This section provides some case study examples to illustrate some of the challenges faced by EU Member States in determining the source code to apply when assessing import applications.

Case study 1. Ranching (R) vs. captive-born (source F) or captive-bred specimens (source C) – birdwing butterflies from Indonesia

Indonesia has established a number of ranching facilities for birdwing butterflies (predominantly *Ornithoptera* spp.) and has also successfully bred birdwings in captivity. The EU SRG has discussed the application of source codes on export permits for these specimens from the country. In relation to imports of *Ornithoptera croesus* and *O. rothschildi*[5], the SRG determined that in certain cases, wild specimens had been regularly added to the parental stock of the breeding facilities. The EU considers that source code F should be applied, as the production system that had been described did not appear to meet the definition of ranching outlined in Res. Conf. 11.16 (Rev. CoP15) or meet the requirements in Conf. Res. 10.16 (Rev.) or Article 54(3) of Regulation (EC) No. 865/2006 for source code C.

Whilst exports from these facilities are regularly in trade with source F, there are no general 'blanket' rules for source codes to apply on import permits for birdwings; EU Member States are required to scrutinise origin details to determine the most appropriate source code is applied on a case-by-case basis. Where facilities are breeding in controlled conditions, Member States consider whether or not there has been regular augmentation of the breeding stock with wild-taken individuals. If additional wild-taken specimens are added only very occasionally and are not comprising a large proportion of the breeding stock, then Article 54(3) could still be met and source code C may therefore be applied (assuming that all other aspects of Article 54 are met). How frequently augmentation can be considered as 'occasional' may be dependent on the reproductive capacity of the species and its rarity.

It is not the case that source code F is applied for species bred outside of the species range and source R is used for species bred inside the species range. Ranching facilities need to demonstrate that eggs or caterpillars collected from the wild in accordance with the definition in Res. Conf. 12.3 (Rev. CoP17) and Res. Conf. 11.16 (Rev. CoP15).

Case study 2: Interpretation of "*managed in a manner that has been demonstrated to be capable of reliably producing F2*" - Source code C or F?

Where an importing Member State has determined that an application for captive-bred specimens (source code C) does not met the criteria in Article 54, and the specimens are in fact only F1 generation captive-bred (source F), they may request that the export permit be changed to F to accurately reflect the actual source code. There is, however, a provision in Article 54 (and identical language in Res. Conf. 10.16 (Rev.) on *Specimens of animal species bred in captivity*) that indicates it is not necessary for a breeder to actually produce second generation offspring to meet Article 54 (and qualify for source code C). A competent authority should, however, be satisfied that the breeding stock is "*managed in a manner that has been demonstrated to be capable of reliably producing second-generation offspring in a controlled environment*."

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[5] *Ornithoptera croesus* and *O. rothschildi* are considered in AC29 Doc 13.2 Annex 1 in relation to the Review of Significant Trade following CoP16

In document AC28 Doc 12, the Animals Committee concluded that additional guidance on what is meant by the language "[*managed in a manner…*]" was needed. The EU Scientific Authority guidelines[6] (in Attachment G) provide some guidance on this issue, indicating that each application should be assessed on its own merits on a case-by-case basis, taking into account a number of factors, such as:

- the number of individuals in the breeding stock
- access to unrelated F1 specimens
- genetic management (*i.e.* considering subspecies)
- previous breeding success
- sex ratio
- age at sexual maturity
- species rarity in captivity

An assessment against Article 54(4) therefore needs to include the details of the management of the current breeding group and the potential for breeding the species to F2 and beyond. It is possible that a breeder may not have previously demonstrated that they have bred the species in question to second-generation, but, for example, they are part of a coordinated breeding programme such as a European Endangered Species Programme (EEP) and the species is therefore being managed in a manner that has been demonstrated to be capable of reliably producing second-generation offspring in a controlled environment.

The assessment for an individual species/breeder can also change over time, dependent on breeding stock management practises. For example, in the early 2000's, EU Member States did not allow source code C for applications of first-generation *Haliaeetus albicilla* from Almaty Zoo in Kazakhstan. On the basis that Almaty Zoo's breeding stock was considered sufficiently large to be self-sustaining, the presence of unrelated pairs and the practise of retaining F1 offspring for future breeding, source code C was subsequently accepted for first-generation specimens of the species. However, it is considered that to be in a position to judge whether breeding is 'managed in a manner that has been demonstrated to be capable of reliably producing second-generation offspring in a controlled environment', a substantial amount of information is required about the breeding methods and the individual species concerned, and therefore this provision is used only in exceptional circumstances.

For the criterion "species rarity in captivity", the SRG consider that it would be useful to compile an index of Appendix II/Annex B species according to ease of captive breeding. This could be based on the volume of captive-bred specimens traded globally or within the EU, the reported ease of breeding success and recorded reproductive capacity for each species, with expert input as necessary. Developing a shared understanding of rarity of species in captivity may assist Member States and other Parties in determining whether it may be appropriate to use the provision "*managed in a manner that has been demonstrated to be capable of reliably producing second-generation offspring in a controlled environment*" in Article 54 of the EU Wildlife Trade Regulations as an exceptional case. Such an index could also assist the Animals Committee in prioritising species for consideration under Resolution Conf. 17.7 *'Review of trade in animal specimens reported as produced in captivity'*.

Commented [CM1]: SRG view is needed if retained

Case study 3: Non-range State exports of animals kept in wild or in controlled environments

Assessing imports of wild-taken hunting trophies from countries that are not range States for the species provides a challenge for EU Member States in determining the correct source code to apply. South Africa, for example, exports a number of non-native ungulate species that have been introduced to the country, including: *Oryx dammah* (extinct in the wild, with a former range of northern Africa only),

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[6] *Duties of the CITES Scientific Authorities and Scientific Review Group under Regulations (EC) No. 338/97 and (EC) No. 865/2006.* http://ec.europa.eu/environment/cites/pdf/srg/guidelines.pdf

Ammotragus lervia (native to northern Africa only), and *Kobus leche*, which is found in South-Central Africa. These species are typically maintained on private ranches and are hunted and exported to the EU as trophies, yet various source codes are used for international exports. Trophies of *Oryx dammah* originating in South Africa and exported 2005-2014, for example, included sources C, F and W[7].

Where such animals are held with adequate fencing so that they cannot escape and are maintained with access to food when it is scarce and are treated by veterinarian surgeons where necessary, for example, source code F may be appropriate (or even C where the individuals meet the definition of captive-bred in accordance with Res. Conf. 10. 16. Rev. and Article 54). In contrast, some of the South African game ranches are extremely large and the animals are essentially in the wild, with no provision for food or care. Whilst source code W may not meet the definition of “wild” in the context of the actual range of the species, imports for source code W have been accepted by EU Member States based on the source code applied on the South African export permit (W), and as the import has been assessed to be non-detrimental to the conservation of the species in the wild. Similarly, *Ammotragus lervia* and *Antilope cervicapra* have also been imported to the EU from the United States as non-native hunting trophies with source code W from introduced populations. In these specific cases this approach has been taken by the EU.

Non-native species are recorded within the distribution section of Species+ as ‘introduced’ if the population is documented in the literature as introduced and as self-sustaining. Currently, this information has been located for *Kobus leche* in South Africa, and for *Ammotragus lervia* and *Antilope cervicapra* in the United States, and is reflected in Species+ as such.

Case study 4: Mixed production systems

For some taxa, breeders are simultaneously producing offspring that are:

- second generation captive bred (and therefore potentially could meet the criteria in Article 54 and Res. Conf. 10.16 (Rev.) for source code C);
- first generation captive-born individuals (source code F); and
- individuals through ranching methods (R).

If these production systems are not managed separately and resulting offspring are mixed, this presents a significant challenge for importers to determine the source code to apply. The EU has received import applications from a number of facilities that are breeding Appendix II species and are clearly not segregating individuals as F2/F1 etc. or marking individuals, as well as augmenting the breeding stock with individuals from the wild.

In cases where specimens from different production systems are mixed, one approach would be to apply the most restrictive and precautionary source code – in the case of mixed C, F and R sources this would be source code ‘R’. Although in this case, some of the exported specimens would be given the incorrect code, any trade data analysis would then provide a “worst-case scenario” in terms of the impact of the trade on wild populations. However, this is not an especially satisfactory outcome, as exports to other non-EU Member States may continue using different source codes. Facilities that are not clearly segregating specimens derived from different production systems could be encouraged to improve their management to facilitate the accurate determination of CITES source codes. Resolution. Conf. 17.7 on ‘*Review of trade in animal specimens reported as produced in captivity*’ adopted at CoP17 may assist with identifying and addressing such issues relating to mixed production systems.

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[7] Source: CITES Trade Database; data downloaded 02/01/2017.

TRAFFIC
REPORT

OCTOBER 2015

ADDING UP THE NUMBERS

An investigation into commercial breeding of Tokay Geckos in Indonesia

Vincent Nijman and Chris R. Shepherd

TRAFFIC **REPORT**

TRAFFIC, the wildlife trade monitoring network, which is the leading non-governmental organization working globally on trade in wild animals and plants in the context of both biodiversity conservation and sustainable development. TRAFFIC is a strategic alliance of WWF and IUCN .

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Front cover photograph: Portrait of a Tokay Gecko. Photo Credit: Mark Auliya/TRAFFIC

ADDING UP THE NUMBERS

An investigation into commercial breeding of Tokay Geckos in Indonesia

Vincent Nijman and Chris R. Shepherd

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Portrait of a Tokay Gecko.

The Rufford Foundation
www.rufford.org

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Tokay Geckos can easily be found for sale in markets in Indonesia, such as this one in Jogjakarta.

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
BKSDA	Regional Natural Resource Management Office
PHKA	Forest Protection and Nature Conservation
USD	US Dollar

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EXECUTIVE SUMMARY

Commercial captive breeding of wildlife is sometimes viewed as a method to remove or reduce pressures of overexploitation on wild populations. But captive breeding can also be used as a mechanism to launder wild-caught specimens. This report provides evidence that laundering of wild-caught Tokay Geckos *Gekko gecko* through legally registered captive-breeding facilities in Indonesia is taking place on a large scale.

Although Tokay Geckos are not on Indonesia's list of protected species, trade in wild-caught specimens is subject to an annual harvest and export quota system. Commercial breeding of Tokay Geckos is also permitted in Indonesia and in March 2014 the Indonesian Ministry of Forestry announced that they had given permission to six companies to export a total of over three million live captive-bred Tokay Geckos for the pet trade.

The logistics involved in breeding millions of Tokay Geckos for the export market are considerable. In order to produce one million adult-sized geckos a facility would require 140 000 breeding females, 14 000 breeding males, 30 000 incubation containers in continuous use year-round, and some 112 000 rearing cages. Basic care of these Tokay Geckos would require hundreds of staff to be employed and a constant supply of food, all of which would have significant additional costs.

Of equal importance is that the exporting companies involved are not known to ever have bred this species in commercial numbers, and are known to supply the trade in wild-caught reptiles for the medicinal and meat trade, not for pets. It is therefore suspected that the majority of Tokay Geckos are intended to be exported dried and prepared for use in traditional medicines.

We argue that the investments in terms of infrastructure, space, financial commitments and staff are not matched by the amount of money that can be made from the export of Tokay Geckos, especially if they are indeed intended for use in traditional medicines. In the authors' view it is impossible to maintain and breed these animals year-round and make a profit.

The inescapable conclusion is that if the quantities reported in trade are accurate, they can only be sustained through the routine laundering of wild-caught individuals and their export as dead specimens, rather than live for the pet trade. There is no legal trade in dead Tokay Geckos from Indonesia.

Based on the findings of this report, TRAFFIC makes the following recommendations:

- Permission for commercial captive breeding of Tokay Geckos should not be issued, as such an enterprise is clearly not feasible or economically viable. Given that captive breeding permits are currently used to avoid quota restrictions on wild-caught geckos, current permits for breeding Tokay Geckos should be revoked to prevent further laundering.
- Methods to conduct Non-detriment Findings should be developed and carried out for Tokay Gecko to determine the current status of the species in the wild and to assist in determining realistic harvest and trade quotas that would not have a negative impact on the wild populations.
- There is a strong justification to include Tokay Geckos in Appendix II of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), which would allow the international trade to be regulated and monitored. We urge Indonesia to develop a proposal to list this species in CITES Appendix II in time for submission at the next CITES Conference of

the Parties.

- The Government of Indonesia is encouraged to list Tokay Gecko in Appendix III of CITES immediately, to allow for the international trade of this species to be better monitored through the co-operation of all CITES Parties. Such a move does not require a vote at a CITES Conference of the Parties.

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Although Tokay Geckos are commonly bred in captivity in Southeast Asia, captive breeding can also be used as a mechanism to launder wild-caught specimens.

INTRODUCTION

Regulating the trade in wildlife is one of the major challenges in contemporary conservation biology, and arguably nowhere more so than in Asia (McNeely *et al.*, 2009). Captive breeding is sometimes perceived as a way to alleviate pressure on wild populations, by sourcing individuals from captive populations instead of directly from the wild. However, it has become clear that commercial captive breeding often has no conservation benefit and may even be counterproductive, being misused used as a laundering mechanism (Nijman and Shepherd, 2009; Lyons and Natusch, 2011; Shepherd *et al.*, 2012; Nijman 2014). Many countries treat the export and/or import of captive-bred individuals differently than that of their wild counterparts, for instance by legalising trade in captive-bred individuals but not in their wild counterparts or by not including the number of captive-bred individuals in export quotas. This report shows that systems allowing trade in captive-bred species are being used to launder large volumes of wild-caught specimens.

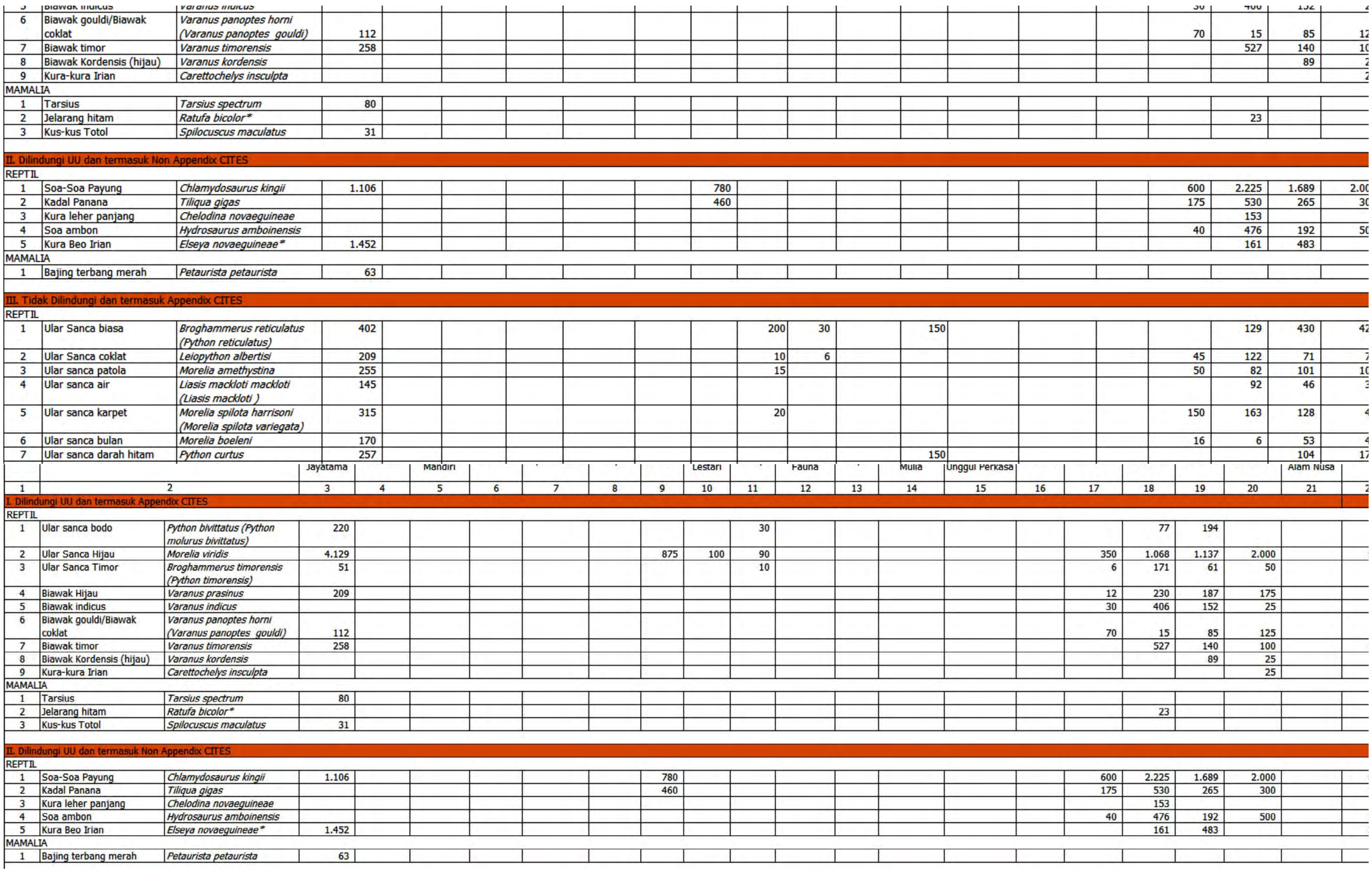
Although Tokay Geckos *Gekko gecko* is not on Indonesia's list of protected species, trade in wild-caught specimens is subject to an annual quota system, which covers both harvest and export for non-protected species to supply both domestic and international markets (Shepherd and Nijman, 2007). The Indonesian Institute for Sciences, as the national CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) Scientific Authority, is responsible for setting the quota, and the Directorate General of Forest Protection and Nature Conservation (PHKA), as the national CITES Management Authority, is responsible for the regulation and enforcement of the quota.

In an effort to relieve pressure on wild stocks, captive breeding of wildlife is encouraged by the PHKA in Indonesia. All breeders wishing to export wild-caught or captive-bred animals must be registered with PHKA. Breeders supplying exporters, but not themselves exporting, must be registered with the Regional Natural Resource Management Office (BKSDA) offices at a provincial level. Parent stock obtained by companies breeding wildlife for commercial purposes remains the property of the government, but offspring can be exported. The harvest and export quotas therefore do not include captive-bred specimens.

Large-scale illicit export of Tokay Geckos from Indonesia for purposes that were not stipulated on the permits (Nijman *et al.*, 2012) has been reported in the past; with volumes of wild-caught specimens grossly exceeding agreed quota. Set quotas allowed 24 000 wild-caught Tokay Geckos to be exported only alive as pets annually from the island of Java. However, in 2006 three traders from the eastern part of the island exported an estimated 1.2 million wild-caught geckos, slaughtered and kiln-dried to be used in traditional Asian medicine (Auliya and Shepherd, 2007; Nijman *et al.*, 2012). This figure of 1.2 million does not include numbers from two additional companies, which were not surveyed, and therefore actual volumes exported during this year would have been considerably higher.

Commercial captive breeding of Tokay Geckos

In March 2014 the Indonesian Ministry of Forestry announced that they had given permission to six companies to export a total of over three million live captive-bred Tokay Geckos (Partono, 2014). As clearly indicated on the announcement, the purpose of these captive-bred geckos was to supply the demand for the pet trade; trade for any other purposes (skins, meat, etc.) was not allowed under this permission (cf. Shepherd and Nijman, 2007). The four companies with the largest quotas were PT Manta Pratama Unggul Perkasa in Semarang, Central Java (1 000 000 geckos), UD Andira Alternatif in Probolinggo, East Java (980 000 geckos), CV Karya Abadi Reptil Mulia (750 000 geckos), and UD Karya Reptil Sentosa (250 000 geckos), the latter two both based in Sitoarjo, East Java. [1]



5	Biawak indicus	*Varanus indicus*															30	406	152	2
6	Biawak gouldi/Biawak coklat	*Varanus panoptes horni (Varanus panoptes gouldi)*	112														70	15	85	12
7	Biawak timor	*Varanus timorensis*	258															527	140	10
8	Biawak Kordensis (hijau)	*Varanus kordensis*																	89	2
9	Kura-kura Irian	*Carettochelys insculpta*																		2
MAMALIA																				
1	Tarsius	*Tarsius spectrum*	80																	
2	Jelarang hitam	*Ratufa bicolor**																23		
3	Kus-kus Totol	*Spilocuscus maculatus*	31																	
II. Dilindungi UU dan termasuk Non Appendix CITES																				
REPTIL																				
1	Soa-Soa Payung	*Chlamydosaurus kingii*	1.106						780								600	2.225	1.689	2.00
2	Kadal Panana	*Tiliqua gigas*							460								175	530	265	30
3	Kura leher panjang	*Chelodina novaeguineae*																153		
4	Soa ambon	*Hydrosaurus amboinensis*															40	476	192	50
5	Kura Beo Irian	*Elseya novaeguineae**	1.452															161	483	
MAMALIA																				
1	Bajing terbang merah	*Petaurista petaurista*	63																	
III. Tidak Dilindungi dan termasuk Appendix CITES																				
REPTIL																				
1	Ular Sanca biasa	*Broghammerus reticulatus (Python reticulatus)*	402							200	30		150					129	430	42
2	Ular Sanca coklat	*Leiopython albertisi*	209							10	6						45	122	71	7
3	Ular sanca patola	*Morelia amethystina*	255							15							50	82	101	10
4	Ular sanca air	*Liasis mackloti mackloti (Liasis mackloti)*	145															92	46	3
5	Ular sanca karpet	*Morelia spilota harrisoni (Morelia spilota variegata)*	315							20							150	163	128	4
6	Ular sanca bulan	*Morelia boeleni*	170														16	6	53	4
7	Ular sanca darah hitam	*Python curtus*	257										150						104	17

			Jayatama		Mandiri					Lestari		Fauna		Mulia	Unggul Perkasa						Alam Nusa	
1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	2
I. Dilindungi UU dan termasuk Appendix CITES																						
REPTIL																						
1	Ular sanca bodo	*Python bivittatus (Python molurus bivittatus)*	220								30							77	194			
2	Ular Sanca Hijau	*Morelia viridis*	4.129						875	100	90						350	1.068	1.137	2.000		
3	Ular Sanca Timor	*Broghammerus timorensis (Python timorensis)*	51								10						6	171	61	50		
4	Biawak Hijau	*Varanus prasinus*	209														12	230	187	175		
5	Biawak indicus	*Varanus indicus*															30	406	152	25		
6	Biawak gouldi/Biawak coklat	*Varanus panoptes horni (Varanus panoptes gouldi)*	112														70	15	85	125		
7	Biawak timor	*Varanus timorensis*	258															527	140	100		
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Figure 1. Captive-breeding production plan for reptiles, amphibians and mammals for pets for the year 2014, as produced by the Ministry of Forestry, Jakarta. Pages 3 and 4 of the document confirming potential production of over three million Tokay Geckos from six companies, for export as live pets, signed by the Directorate General of PHKA, S. Partono, 2014.

The large-scale trade in Tokay Geckos outside of Indonesia's laws and regulations has been taking place for some time. Manta Pratama Unggal Perkasa was one of three companies included in an earlier study, conducted in 2006, when it was estimated that it exported some 390 000 wild-caught dried geckos a year, in violation of the agreed purpose (for pets only) and in violation of the national allocated quota of 50 000 wild-caught live geckos (Nijman *et al.*, 2012). According to its website, viewed in 2014, it is a trading company specialising in the export of frozen snake meat, kiln-dried Tokay Geckos, snakes, tortoise and freshwater turtle shells and cardamom to mainland China, Hong Kong and Taiwan. In addition, it exports high-value wildlife derivatives such as ambergris, castoreum and civet bile. The other three companies were all registered as Tokay Gecko breeders with the East Java Regional Natural Resource Management Office in 2008 and have been involved in the large-scale export of dried geckos (Andira Alternatif and Karya Reptil Sentosa) and dried geckos and snakes (Karya Abadi Reptil Mulia) to mainland China. In 2013 it was reported that Andira Alternatif exported 300 000–400 000 dried Tokay Geckos per year; all said to be wild-caught with no mention made of breeding of Tokay Geckos (Anonymous, 2013). Given that in 2013 no quota was allocated for the export of dried Tokay Geckos this would have been in violation of the national quota system implemented by the PHKA. There are no indications that any of these four companies are, or have ever been, involved in the live pet trade.

Practicalities of breeding Tokay Geckos

What are the logistics involved in breeding such large quantities of Tokay Geckos for the export market? Based on Tokay Gecko breeders' manuals and forums, and on discussions with experts on captive breeding of Tokay Geckos, the following key reproductive parameters and housing conditions were extracted, selecting values that give the highest yields (youngest age for reproduction, maximum longevity, largest clutch sizes, etc.) at the lowest costs, ignoring any welfare issues, and assuming zero mortality of young:

- female Tokay Geckos become reproductively active after 18 months and here it is assumed that they remain reproductively active up until the age of 10 years;
- each clutch contains two eggs and females produce four clutches a year;
- eggs hatch after three months, assuming here that all eggs are successfully hatched;
- geckos grow to adult size in 18 months, but are large enough to be harvested after 12 months;
- males and females are housed in individual cages measuring 60 x 40 x 40 cm (length x height x width);
- males are introduced to females for short periods to allow mating;
- a male: female ratio of 1:10 is maintained for breeding;
- eggs are removed and put into incubation containers;
- once hatched, hatchlings are housed in groups of 10 in slightly larger rearing cages measuring 60 x 40 x 50 cm.

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[1] PT = Perseroan Terbatas [Indonesian] = Limited Liability Company; UD = Usaha Dagang [Indonesian] = Trading Company; CV = Commanditaire Vennootschap [Dutch] = Limited Partnership.

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Although sometimes traded live as pets, the demand for Tokay Geckos in traditional Asian medicines is one of the greatest threats to this species.

The amount of staff time needed to maintain this operation is impressive: the geckos need to be fed hundreds of millions of crickets a year; if a feeding session takes just 15 seconds to complete, then some 50 people/staff need to be employed, working 10 hour non-stop shifts, without having a single day off. If the cages are cleaned once a month and the whole cleaning process, including temporary removal of the geckos, takes just 10 minutes, then some 150 people/staff need to be employed, working 10 hour non-stop shifts, without having a single day off.

Under this scenario, a breeding facility aiming to export 1 million Tokay Geckos would need to produce 1.12 million adult-sized geckos per year. This would require 140 000 breeding females, each producing eight fertile eggs a year, and 14 000 breeding males. To incubate these they need some 30 000 incubation containers, all in continuous use year-round, with a 100% hatchling survival rate. Once hatched the geckos would need to be housed in approximately 112 000 rearing cages.

Wild-caught Tokay Geckos are traded in large volumes throughout Asia

The space requirements for these operations, if genuine, are impressive: Manta Pratama Unggul Perkasa's 266 000 breeding and rearing cages, if stacked in rows two metres high, would require a building with a floor space of some 35 000 m^2, or piled two metres high in height, the cages would stretch over a length of almost 24 km. This is the equivalent of almost five football pitches. The values for Andira Alternatif are similar – 248 000 cages covering 4.5 football pitches, or stretching 22 km – and those for Karya Abadi Reptil Mulia and Karya Reptil Sentosa are 195 000 cages, covering 3.5 football pitches, or 17 km, and 65 000 cages, covering more than a football pitch, or 6 km, respectively.

It is clear that if Tokay Geckos were genuinely bred in captivity in Java this would require a massive investment in terms of infrastructure, space, financial commitments and staff. This, however, is not matched by the amount of money that can be made by trade in Tokay Geckos. If the Tokay Geckos are indeed all exported as pets, the wholesale price for an adult individual is USD1.00 – 1.15 (2010 prices: Nijman *et al*., 2012) to USD2.30 (2014 price obtained from an anonymous Indonesian exporter). The permit to export live reptiles requires a payment of USD0.43 to the quarantine office, leaving less than USD1.90 to maintain and breed these animals year-round, and to pay for the cost of shipping and packing for the live export.

Profit margins are even smaller when the Tokay Geckos are (illegally) exported dried. Data from one export company indicate that they buy wild-caught geckos for USD0.16 and, assuming twenty individuals make up a kilogramme of dried gecko (Caillabet, 2013), they are exported to China for USD0.20 a piece once processed (Anonymous, 2009). Another source indicates that a wholesale dealer can sell a pair of dried Tokay Geckos in good condition for USD0.40, and half that for a damaged pair (Asprihanto, 2010). These profit margins are evidently sufficient when dealing with wild-caught geckos that need to be kept in storage for no longer than a week without the need to be fed or watered, after which they are killed and kiln- or sun-dried and prepared for export. It would, however, be impossible to maintain and breed these animals and generate a profit.

According to reptile traders in Indonesia that were questioned by Nijman *et al.* (2012), prices were far too low to make captive breeding an economically viable option as the investment and scale was far too large compared to the return, and therefore it is likely there is no commercial captive breeding of this species in Indonesia. In 2014, reptile traders in Indonesia, who wish to remain anonymous, stated that viable commercial captive breeding of this species in these volumes was not possible.

CONCLUSIONS AND RECOMMENDATIONS

In agreement with the Indonesian traders' statements above, it is concluded here that captive breeding of Tokay Geckos cannot take place in Indonesia on a sufficient scale to produce the numbers of animals for which quotas exist for live exports for the pet trade. Commercial captive breeding of Tokay Geckos would not make this an economically viable option. Clearly, the overwhelming majority of claims of captive breeding of Tokay Geckos are false. Instead, this analysis strongly suggests that captive-breeding permits are instead being used to launder wild-caught Tokay Geckos by the millions into trade, for illegal export as dried specimens.

In light of these findings, TRAFFIC makes the following recommendations:

- Permission for commercial captive breeding of Tokay Geckos should not be issued, as such an enterprise is clearly not feasible or economically viable. Given that captive breeding permits are currently used to avoid quota restrictions on wild-caught geckos, current permits for breeding Tokay Geckos should be revoked to prevent further laundering.
- Methods to conduct Non-detriment Findings should be developed and carried out for Tokay Gecko to determine the current status of the species in the wild and to assist in determining a realistic harvest and trade quotas that would not have a negative impact on the wild populations.
- There is a strong justification to include Tokay Geckos in Appendix II of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), which would allow the international trade to be regulated and monitored. We urge Indonesia to develop a proposal to list this species in CITES Appendix II in time for submission at the next CITES Conference of the Parties.
- The Government of Indonesia is encouraged to list Tokay Gecko in Appendix III of CITES immediately, to allow for the international trade of this species to be better monitored through the co-operation of all CITES Parties. Such a move does not require a vote at a CITES Conference of the Parties.

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TRAFFIC, the wildlife trade monitoring network, is the leading non-governmental organization working globally on trade in wild animals and plants in the context of both biodiversity conservation and sustainable development.

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the wildlife trade monitoring network
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WWF
IUCN

Ex situ management of ASAP species

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Ex situ management of ASAP species

CONVENORS: Sonja Luz, Danny de Man, Kathy Traylor-Holzer, and Roopali Raghavan

AIM: The aim of this working group is to discuss the Ex-Situ needs for ASAP species and the potential requirement for a more pro-active strategy for Ex-Situ management approaches.

BACKGROUND: Integrated and professionally managed Ex-Situ programs of threatened species can substantially support conservation efforts, and many notable examples exist in which Ex-Situ facilities like Zoos have helped to save species from extinction. With that there is no longer the need to discuss what roles Zoos and Aquaria can play in conservation, but rather when should such programs be considered (especially for species on the brink of extinction) and who is in the best position to do so. While comprehensive guidelines have been developed (e.g. IUCN guidelines on the use of Ex-Situ management for species conservation) to help evaluate Ex-Situ involvement, it seems we are still struggling greatly to reach agreement among relevant stakeholders and with that are often far too late in implementing such programs.

For the 175 Critically Endangered ASAP species an Ex-Situ Working Group was established, which is currently trying to better understand needs, opportunities and constraints for Ex-Situ management of ASAP species specifically.

PROCESS: The CPSG working group will be introduced to the ASAP Ex-Situ working group and receive a preliminary overview of the status of current Ex-Situ management of ASAP species. For that purpose, and to our best knowledge, ASAP species have been sorted into 3 categories:

1. None currently kept in captivity
2. Currently kept in captivity, but not clear to how well they are integrated in conservation programs/action plans
3. Currently kept in captivity, with Ex-Situ programs seemingly well integrated into conservation programs/action plans.

Furthermore, the participants will receive a brief introduction to the existing evaluation tools (e.g. IUCN Ex-Situ Guidelines and ICAP process).

Following that, we hope that specific issues and questions will be discussed:

- Are the existing tools to evaluate Ex-Situ needs of species properly used and understood, and is there a need for more specific guidelines or even protocols?
- Who should/can make the recommendation/decision on when to start Ex-Situ programs and what info is (i) necessary or (ii) highly desirable before this decision is made?
- How do we ensure that captive management programs are ethical, legal and sustainable, as well as properly integrated in In-Situ conservation of the species?

- When and where should such programs be initiated, what is the role of western zoos and how do we build appropriate capacity managing Ex-situ programs for ASAP species in range countries?

OUTCOMES: We hope that the discussions of this working group will help us improve existing programs as well as aid in prioritizing needs for Ex-Situ management programs of ASAP species. We furthermore hope to get more insights from both In-Situ and Ex-Situ stakeholders on how to optimize processes leading to a successful One Plan Approach conservation outcome.

PREPARATION: Please review the following documents:

IUCN SSC Ex Situ Guidelines

Building Global Capacity for Species Conservation Planning

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

International Union for Conservation of Nature

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

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

Five-step decision making process to decide when *ex situ* management is an appropriate conservation tool

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].

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[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.

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[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.

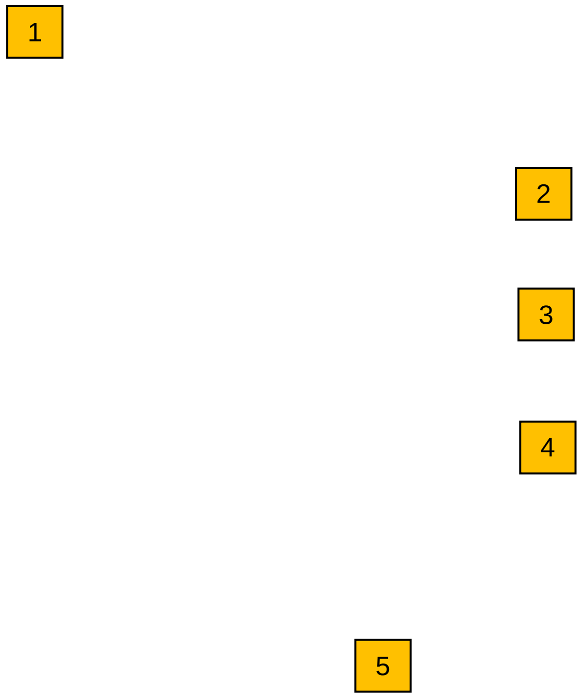
SECTION 6: Dissemination of information

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 (yellow numbers) into the species conservation planning process to develop an integrated conservation strategy for a species.



Integrated Collection Assessment and Planning (ICAP) Process

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What is an ICAP?

ICAP, or Integrated Collection Assessment and Planning, is a multi-species, rapid *ex situ* conservation assessment based on the decision process of the *IUCN SSC Guidelines on the Use of Ex Situ Management for Species Conservation*, jointly conducted by *in situ* and *ex situ* experts and designed primarily to assist regional zoo associations with setting conservation priorities for regional collection planning.

The ICAP process is designed to address some of the challenges and fill the gaps that currently hamper the effective application of the One Plan Approach in a multi-species framework, and especially targets regional or global collection planning needs. This 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 and feasible. This same process can be used to identify not only direct *ex situ* conservation contributions (specifically addressed by the IUCN *ex situ* guidelines), but also indirect conservation activities, such as *in situ* conservation support, and important non-conservation roles, if desired. Such assessments are useful to TAGs and other members of the *ex situ* community, to SSC taxonomic specialist groups, and to others involved in multi-taxa conservation planning.

Why do we need ICAPs?

Over 30 years ago the zoo community turned its attention from institutional exhibition needs to increasing focus on species conservation. Emphasis was placed on the ‘zoo ark’ paradigm targeting long-term, sustainable captive breeding programs to maintain insurance populations against potential extinction in the wild. This spurred the development of cooperative management at the regional population level. Regional zoo associations now develop Regional Collection Plans (RCPs) to prioritize species for *ex situ* management given finite resources and growing conservation needs.

While insurance populations are valuable, they often are a broad generalization of the *ex situ* conservation needs of a species. The potential spectrum of *ex situ* management for conservation includes, but is also much wider than, providing insurance populations. Rather than solely providing an ark, the zoo (and broader *ex situ* community) has the potential to provide a wide range of *ex situ* activities to meet specific *in situ* conservation needs of species. In order to develop effective conservation initiatives, zoos and aquaria need to be able to select species for management that can benefit most from *ex situ* conservation and to design their *ex situ* efforts to effectively serve the conservation needs of those species. In addition, there are numerous opportunities for organizations outside of the traditional zoo and aquarium community, such as rescue and rehabilitation centers, universities, research facilities and government breeding centers, to engage in *ex situ* conservation activities, and these need effective guidance. Finally, wildlife managers and field biologists may have limited awareness of *ex situ* options outside of long-term breeding programs and little experience matching *in situ* conservation needs with *ex situ* support.

The process of evaluating when it is appropriate to include *ex situ* management in the conservation plan for a threatened species, and the precise form this should take, is challenging, but there are tools to help. The *IUCN SSC Guidelines on the Use of Ex Situ Management for Species Conservation* (IUCN SSC, 2014) outlines a structured, informed, and transparent decision-making process on whether or not *ex situ* activities are a beneficial and appropriate component of an overall species conservation strategy (Traylor-Holzer *et al*., 2013; McGowan, Traylor-Holzer, and Leus, 2017). This reduces bias for or against *ex situ* management, and promotes *ex situ* activities that are tailored in form and function to the conservation needs of the species. These guidelines can be applied during a broader conservation planning process such as a PHVA workshop or as a separate species-focused assessment linked to other conservation planning efforts. Regardless of the process, it is vital that the *in situ* and *ex situ* communities jointly evaluate the potential benefits of *ex situ* management activities, along with other conservation solutions, and together develop one integrated species conservation plan, which may or may not end up including *ex situ* components – in essence, the One Plan Approach.

Ideally zoos would find clear direction for *ex situ* conservation needs in integrated species conservation plans developed using the One Plan Approach and the IUCN *ex situ* guidelines. However, given the high degree of threat to wildlife populations and great demand for conservation planning it will take significant time before most threatened species are covered by integrated conservation action plans. Managing living *ex situ* collections on the other hand cannot wait. The ICAP process was developed to help address this need and lend guidance more quickly to the *ex situ* community, and to regional zoo associations in particular, in setting conservation priorities and programs.

To help address this issue, a joint effort between CPSG and regional zoo and aquarium associations has resulted in a new process called ICAP, or Integrated Collection Assessment and Planning. The ICAP process is designed to address some of the challenges and fill the gaps that currently hamper the effective application of the One Plan Approach in a multi-species framework, and especially targets regional or global collection planning needs.

The ICAP Process

The ICAP process is structured around the five evaluative steps in the IUCN *ex situ* guidelines, making them more practical and streamlined when applied on a multi-species level by extracting their essential components to rapidly assess and prioritize *ex situ* resources and effort across multiple taxa. The process involves extensive pre-workshop data compilation and analysis followed by a multi-stakeholder workshop.

All taxa within the taxonomic group should be included, both threatened and non-threatened, regardless of whether or not they are currently under *ex situ* management. The process should be a joint collaboration between those coordinating regional *ex situ* activities (e.g., Taxon Advisory Group) and the appropriate IUCN taxonomic specialist group or equivalent authority linking field conservation efforts and planning.

Below is a description of the five steps of the IUCN *ex situ* guidelines and how each step is approached within the ICAP process – please consult the IUCN *ex situ* guidelines for more details.

Pre-Workshop Data Compilation

Pre-workshop preparation focuses especially on Step 1 of the IUCN *ex situ* guidelines, with extensive data compilation on *in situ* status and threat assessment, and on *ex situ* status and expertise. Step 2 is also initiated to identify potential *ex situ* conservation roles either previously identified in prior conservation plans or by *in situ* (or other critical) experts who cannot attend the ICAP workshop.

STEP 1: Conduct a thorough status assessment (of both* in situ *and any known* ex situ *populations) and threat analysis.

In situ status and threats

What is needed: *In situ* status of global and regional populations (Red List category of threat; population trend; primary threats and conservation challenges)

The details: It is not enough to know if a species is threatened; it is important to understand the nature of those threats to understand how *ex situ* management may help. The IUCN SSC Red List is a valuable resource for assessing *in situ* status and threats. The Red List gathers a plethora of information that is used to categorize the degree of threat for each species based upon specific objective criteria based on trends in population size, extent of occurrence/ occupancy, and other factors related to its risk of extinction *in situ.* To identify *ex situ* conservation roles that best address the threats and challenges faced by the species, it is important not just at the Red List category of threat but to investigate more deeply to understand factors affecting the viability of the *in situ* population. This includes consulting the detailed descriptions of threats in the Red List assessment and in additional literature as well as potentially consulting *in situ* stakeholders directly. It may also be important to consult regional or national assessments for a regional or national ICAP, as the *in situ* status of some taxa may vary widely across its range. Regional *ex situ* programs may be able to offer conservation support for regionally threatened populations or endemic subspecies that are not needed or feasible at a global level. Other potential information sources include assessments such as the Convention on Migratory Species for migrating taxa, the Convention on International Trade in Endangered Species for taxa vulnerable to international trade, and the European Bird and Habitat Directives or equivalent national threatened species legislation. PHVA reports and other conservation plans or strategies are another information source.

Where to find it:

- IUCN SSC Red List assessment (global): https://newredlist.iucnredlist.org/
- Regional or National Red List assessments
- CPSG PHVA, CAMP and other conservation planning reports: http://www.cpsg.org/document-repository
- IUCN SSC taxon-based Specialist Group action plans: https://www.iucn.org/commissions/ssc-groups
- Governmental/national action plans for threatened species
- Other past or current conservation action plans or strategies for the species
- Threat-based or regional conservation assessments relevant to the species
- Scientific publications
- *In situ* species experts

Ex situ status

What is needed: Demographic and genetic status of any *ex situ* population and its management, both globally and by region

The details: Assessment of existing *ex situ* populations and activities includes compiling information on the current and historical holdings of the taxon in captivity (as living individuals and/or as cryopreserved cells or gametes in genome resource banks (GRBs)), estimation of the genetic and demographic status of any current populations, historical evidence of breeding success, and any identified challenges to *ex situ* management such as husbandry, nutrition or health issues.

Information should be gathered, if possible, for *ex situ* status in all regions, even for a regional or national ICAP, as this information is relevant to discussions of feasibility (see STEP 4) and division of responsibilities between regions and potential for collaboration (see STEP 5).

In most cases the best resource on *ex situ* population status is a current international studbook database, as this single dataset contains information on the status of the species in all regions. Regional or national studbooks (databases or reports), breeding and transfer plans, and regional collection plans are also valuable. A valuable resource for global holding is to consult the species holdings reports and population overview reports in the Species360 Zoological Information Management System (ZIMS) global animal records database (Species360 2018), if access to that database is available. Another option is a zoo and aquarium association survey, which may be conducted specifically for an ICAP. Non-zoo or aquarium databases may be relevant for some species, such as governmental registers of zoo inventories or *ex situ* programs, registers of rescue or confiscation centers, and GRB inventories.

These sources can provide a useful summary of the genetic and demographic status of *ex situ* populations. Relevant parameters to be compiled include: current population size (by sex and/or life stage); number of living wild-born individuals, including those with living descendants (founders) and with no living descendants (potential founders); anticipated availability of new founders; current gene diversity retained; percentage of the pedigree that is known; historical and recent population trend or annual growth rate (lambda); number of holding institutions; evidence of past breeding success with the species; degree of intensive regional management; and any *ex situ* management issues. In many cases not all of this information will be available, or may be available for only some regions, but all available information should be documented.

Where to find it:

- International studbook database
- Regional or national studbook databases
- Published studbook reports
- Regional zoo and aquarium association breeding and transfer plans (BTPs)
- Global Species Management Plans (GSMPs)
- Regional Collection Plans (RCPs)
- Zoo and aquarium association surveys
- ZIMS species holdings reports: https://zims.species360.org
- ZIMS population overview reports
- Other non-zoo or aquarium databases, such as rescue center holdings

STEP 2: Identify potential roles that **ex situ** *management can play in the overall conservation of the species.*

What is needed: Past recommendations and expert opinion regarding potential *ex situ* conservation roles for the taxa, specifically from individuals not attending the ICAP workshop

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

- *By addressing the causes of primary threats* (e.g. through specifically designed research, training or conservation education activities that directly impact the causes of these threats, such as research targeting disease);

- *By offsetting the impact of primary and/or stochastic threats* on the population (e.g. through activities that help to improve survival of particular life stages, reproductive success, and/or gene diversity retention or gene flow, such as head-start programs);
- *By buying time* if the wild population is in severe decline and the chance of rapid reduction of primary threats is slim or uncertain (e.g. through rescue or insurance populations, such as Amphibian Ark populations); and/or
- *By restoring wild populations* once primary threats have been sufficiently addressed (e.g. by reintroduction, such as the Arabian oryx (*Oryx leucoryx*) recovery efforts).

The status assessment and threat analysis in STEP 1 provide the necessary background so that wildlife and population managers can consider the primary threats facing each taxon (e.g., habitat loss, poaching) and well as secondary impacts (e.g., genetic isolation, skewed sex ratio) to determine the potential roles that *ex situ* management can play in its conservation. The IUCN *ex situ* guidelines target the identification of direct conservation roles (i.e., those that act as identified in the four bullets above). To enable ICAPs to inform regional collection planning and existing species management programs, it is valuable to also identify indirect conservation roles for *ex situ* populations or the *ex situ* community, such as conservation education messaging outside of the taxon's range or support of *in situ* conservation activities through expertise or funding.

Prior* ex situ *recommendations/mandates

Prior planning efforts may already have identified *ex situ* management roles for some species, which should be taken into consideration during the ICAP process. Existing strategies and action plans (e.g. regional, national or local governmental action plans, IUCN SSC Specialist Group action plans, CPSG PHVAs and CAMPs, plans by international or local NGOs or conservation alliances) should be gathered and consulted to extract any such existing *ex situ* recommendations or mandates.

Where to find it:

- *Ex situ* management plans (BTPs; GSMPs; RCPs)
- IUCN SSC Red List assessment (global): https://newredlist.iucnredlist.org/
- Regional or National Red List assessments
- CPSG PHVA, CAMP and other conservation planning reports: http://www.cpsg.org/document-repository
- IUCN SSC taxon-based Specialist Group action plans: https://www.iucn.org/commissions/ssc-groups
- Governmental/national action plans for threatened species
- Other past or current conservation action plans or strategies for the species
- Threat-based or regional conservation assessments relevant to the species
- Scientific publications

Surveying* in situ *specialists for potential* ex situ *conservation roles

Under the One Plan Approach philosophy, *in situ* and *ex situ* specialists should work jointly to evaluate potential direct or indirect roles for *ex situ* conservation of a species. However, it may be not possible or effective for all specialists for all taxa to attend an ICAP workshop evaluating a large number of taxa. This is especially true for the field-based *in situ* specialists, who often are based in remote locations and have restrictive schedules. It is very important, however, to receive input from the larger community working with each taxon. A recommended method to achieve wider representation of the *in situ* community is to identify and electronically survey relevant *in situ* specialists prior to the ICAP workshop, especially if they will not attend the workshop.

It is important that experts are not simply asked if there should be a captive breeding (or other *ex situ* program) for a species without explaining such programs or acknowledging existing opportunities (e.g., non-releasable confiscated or rescued animals as potential founders).

An ICAP *ex situ* role survey should include descriptions of different direct and indirect conservation roles; summary data gathered in STEP 1; and a carefully-worded questionnaire guiding survey recipients through the process of identifying potential direct and indirect *ex situ* conservation roles for the taxa in which they have expertise. The survey should include both threatened and non-threatened taxa, as there may have been recent changes in status and threats (especially regionally) and also because non-threatened species potentially can play a conservation role as a surrogate species. Information accompanying the survey should acknowledge the wide range of potential *ex situ* activities, many which may not occur to *in situ* specialists (e.g. banking gametes for genetic supplementation, using *ex situ* populations for research targeting *in situ* needs such as disease epidemiology or testing field methodologies).

<u>Who to contact</u>: A good starting point is the IUCN SSC taxonomic specialist group(s) relevant to the ICAP. They themselves are often species experts and are aware of the most appropriate contacts for understanding the species biology, status and conservation needs. Regional contacts are important, as the situation for the species often varies from region to region.

<u>Where to find it</u>:
- *In situ* specialists for the species
- IUCN SSC specialist groups

All of the information collected on status, threats and potential ex situ roles is compiled into taxon-specific data sheets. These sheets can be circulated as briefing material prior to the ICAP workshop, and serve as important reference material during workshop discussions. Assessments and recommendations resulting from the workshop discussions can be added to these sheets for the final ICAP report.

ICAP Multi-Stakeholder Workshop

Both *ex situ* and *in situ* experts gather to review the status and threats information, identify potential *ex situ* conservation roles and program structure needed to achieve those roles, assess the relative benefits, costs/risks, and feasibility of achieving each role, and make recommendations regarding *ex situ* activities – all for each species or taxon. Depending upon the number of taxa addressed and time available, this process can be very rapid and general, or more lengthy and detailed.

<u>Who should attend</u>? It is very important that representatives from all major stakeholder groups attend the ICAP workshop. In most cases this includes TAG Chairs, IUCN SSC specialist group representatives, and i*n situ* experts. For some species, important participants may include representatives from rescue and rehabilitation centers, universities, NGOs and government agencies.

<u>How to structure the workshop</u>: An ICAP workshop benefits greatly from facilitation by experienced facilitators who have an in-depth understanding of the One Plan Approach, IUCN *ex situ* guidelines, *ex situ* population management, zoo association operations, population biology, and group decision making. The facilitator should be familiar with the ICAP process and with the information on the pre-workshop taxon sheets.

The workshop set-up is similar to other multi-stakeholder workshops, with an appropriate size meeting space and table set-up to facilitate discussion (i.e., small tables, U-shape table, etc.; not theater seating). Wall space to display potentially many flip chart sheets is a must for an ICAP. Projector and screen, flip charts (easel, paper, markers, tape if not self-adhesive) are all essential.

The workshop agenda begins with participant introductions followed by an overview of the IUCN *ex situ* guidelines, ICAP process and compiled taxon sheets. It is helpful to provide a list of the most common roles and definition of each, to reach a common understanding among participants regarding what is meant by each term, including “direct” and “indirect” conservation. The facilitator then leads the group discussion to complete tasks for Steps 2-5 for each taxon (see below). This can be done on flip charts and captured in notes; alternatively, group decisions can be captured on a projected template. If using a template, it is advised to summarize the recommendations for each taxon on flip charts to provide a visual summary of the workshop decisions as the group proceeds through the list of taxa. Regardless of the specific process and tools used, it is essential that all pertinent discussion, assessments and recommendations are captured and included in the workshop report. A sample ICAP workshop report, complete with sample agenda, pre-workshop survey, definition of roles, taxon sheets, and final recommendations, can be found at: http://www.cpsg.org/content/global-icap-workshop-canids-and-hyaenids

Generating potential* ex situ *conservation roles during the ICAP workshop (completion of Step 2)

All information compiled before the workshop (*in situ* status and threats, *ex situ* status, potential and recommended *ex situ* roles) is considered and discussed by workshop participants to identify potential direct and indirect *ex situ* conservation roles for each taxon.

STEP 3: Define the characteristics and dimensions of the program needed to fulfill each identified potential conservation role(s).

The details: Ideally, ICAP workshop participants should outline program specifications of each potential role for each taxon. This may include, but is not limited to, geographic scope (e.g., national, regional, global), animal needs (e.g., founders, target population size), management type and goals (e.g., breeding to minimize gene diversity loss, source population for annual releases), type of facilities needed, and length of program (see IUCN SSC, 2014). However, such detailed descriptions are impractical if a large number of taxa are being evaluated with limited time. It is important that some discussion of scale, scope and management requirements is held and documented. In some cases, these discussions may occur at a general level and only discussed in more detail when deemed important for decision making. For example, general requirements for establishing a demographically and genetically viable insurance population are well understood, while program characteristics for in-range source populations for reintroduction or populations designed to address specific research questions might need more elaboration. Such discussions are accomplished more quickly and effectively if there is a relatively high degree of knowledge regarding *ex situ* management among both workshop participants and facilitators. Discussions involving less knowledgeable participants may require more structured elaboration, perhaps with an overall *of ex situ* population concepts at the beginning of the workshop. If relatively few species are being discussed and time is available, quantitative tools such as PMx software program (Species Conservation Toolkit Initiative) may be used to help define program requirements.

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.*

The details: This discussion examines each role identified in Step 2 along with its required program structure described in Step 3, and assesses the relative benefit, costs/risks, and feasibility (likelihood of success) of achieving that program and role successful. Considerations include biological feasibility (e.g., founder availability, husbandry expertise), social feasibility (e.g., regulatory issues, interest in species), resource availability (e.g., staff, space), and risk assessment (e.g., risk to the wild population, disease risks).

One way to organize this discussion is to create a matrix for each taxon, listing each identified potential role (e.g., insurance, research, population restoration) and then rating each role as High, Moderate or Low with respect to each of the following three categories: Conservation Benefit, Feasibility, and Costs/Risks. This provides a graphical depiction that is convenient for comparison across options within and across taxa, and can be added to the taxon information sheets for the final report.

STEP 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 details: All information and analyses from Steps 1-4 are considered to make recommendations for each taxon regarding *ex situ* activities, which may include that no *ex situ* population or activities are recommended, or that such activities should be limited to a particular region. The IUCN *ex situ* guidelines are intentionally vague so as not to be too prescriptive, recognizing that priorities and criteria will differ among different groups or taxa. Resulting recommendations are documented and can serve as reference for subsequent *ex situ* or *in situ* conservation planning. These include zoo and aquarium-based programs such as TAG Regional Collection Plans and species-specific *ex situ* management plans or WAZA’s Global Species Management Plans (GSMPs) for inter-regional species management, as well as *in situ*-focused plans such as IUCN specialist group action plans and government recovery plans. All compiled status and threat data, evaluations, information on relevant issues, and final ICAP recommendations are added to each taxon sheet as part of the final ICAP report.

Prioritization of taxa for discussion during the workshop: Ideally there will be sufficient time to discuss and assess all taxa during the ICAP workshop in the way described above, including both threatened and non-threatened taxa. This may not be realistic if too many taxa fall within the scope of the ICAP. Some suggestions for prioritizing discussions given limited time:

- Species can be allotted to one of four categories: threatened vs non-threated; and those with moderate to large current holdings in captivity, vs those with very small holdings or not held in captivity. One strategy is to ensure discussion of threatened taxa with *ex situ* populations, as these are more likely to have the combination of relatively higher conservation need and feasibility, lower risk, and existing program structure and support. These taxa may benefit from more detailed discussions to ensure that existing *ex situ* populations are managed for optimal conservation contribution.
- Second priority may be for threatened species with no *ex situ* holdings or expertise, which may be able to be reviewed relatively quickly if necessary to identify any opportunities for *ex situ* management or activities (e.g., non-releasable confiscations or rescues that can provide conservation value and/or opportunities for developing *ex situ* expertise). These often may be species with conservation need but also lower feasibility and/or higher risk, depending upon the *ex situ* role and program.
- Non-threatened species held in captivity may be able to be reviewed relatively quickly to identify any conservation value as surrogates for threatened species; therefore, it may be

beneficial to evaluate similar threatened taxa first to evaluate need, or pair the discussion of such taxa with potential surrogates. These may be species with higher feasibility. If no need is identified, and/or risks are identified (e.g., competition for space or other resources with taxa of higher conservation need), then some taxa in this category may be recommended to be phased out of captivity linked with the development or expansion of programs for other taxa.

- In most cases, taxa with no *ex situ* conservation needs and not currently held in captivity may not be recommended for *ex situ* management for conservation. Exceptions might include locally threatened or culturally important subspecies recommended for local *ex situ* activities.
- When evaluating large groups of taxa, it may be feasible and prudent to group related taxa with similar characteristics (biology, threats, *ex situ* status) and discuss them as one group (e.g., 9 taxa of laughingthrush). This may facilitate discussions of expertise, feasibility and potential surrogates.

These are meant to be generalizations only and to help prioritize discussions when faced with limited time. There are exceptions to these categories, and a thorough assessment of each taxa is recommended when feasible. Also, the interaction of conservation benefit to risks and feasibility (including space and husbandry constraints) may differ on a regional level. For example, range countries are better placed to provide animals for release (population restoration) and conduct targeted education programs to effect specific behavior change. The size and composition of existing populations may dictate their value and feasibility for specific research roles or as a long-term insurance population.

Post-Workshop Tasks

Compilation and wide dissemination of the workshop results is important for their incorporation into both *ex situ* and *in situ* conservation planning and to forge important collaborations for species conservation under the One Plan Approach.

Workshop representatives should bring the ICAP recommendations to their respective organization for discussion and incorporation into their conservation planning – for example, for consideration in regional collection planning or species-specific *ex situ* planning for TAGs, and for species conservation planning for specialist groups, NGOs and wildlife authorities. ICAP workshop reports should be posted on the CPSG website and are encouraged to be posted on relevant specialist group websites and other groups involved in conservation of the species or taxa. Announcements will be made in the SSC Bulletin and other relevant venues.

ICAPs and RCPs: EAZA now uses the ICAP process for each TAG's Regional Collection Planning workshop based on its new population management structure (de Man et al., 2016). The EAZA Canid and Hyaenid TAG inaugurated this process, and several EAZA RCP-ICAP workshops were/will be conducted in 2018 for prosimians, cattle and camelids, Asian songbirds, rhinos and select terrestrial invertebrates. Because zoos also need to balance conservation needs with other important roles potentially filled by species, such as exhibit value or non-conservation related research and education, EAZA is using the same work format to evaluate potential non-conservation roles of species. For each species in the RCP requiring proactive management, an EAZA Ex situ Programme (EEP) will be developed specifically to meet the identified direct, indirect, and/or non-conservation roles. Each EEP will be guided by a comprehensive Long Term Management Plan that outlines strategies and activities to reach these goals. Several AZA and ZAA TAGs have expressed interest in the ICAP process.

The ICAP process may be particularly useful to zoo and aquarium associations that do not have an established RCP process. Many such regions coincide with biodiversity hotspots holding species with the greatest conservation need. The ICAP process may be a good option for these regions to quickly establish *ex situ* priorities with strong potential for direct species conservation benefit.

Joint TAG Chair conferences and other zoo and aquarium association meetings provide a practical forum for ICAP workshops. Such meetings provide opportunities for multi-regional or global ICAPs, which provide valuable integration of regional efforts for more effective and targeted use of resources and more effective conservation.

<u>ICAPs and Specialist Groups</u>: While the ICAP process was designed with particular focus to the collection planning needs of the *ex situ* community, the same five-step process can be applied to an *ex situ* conservation assessment for a group of taxa of interest to an IUCN SSC specialist group, or other organizations (governmental or non-governmental) dealing with species conservation, whether or not *ex situ* programs are widespread in the zoo and aquarium community. Organizations or groups seeking a multi-species, *ex situ* conservation assessment can also adopt and adapt an ICAP-like approach. No matter which organization or group leads the process, the involvement of both the *in situ* and *ex situ* communities in the *ex situ* conservation assessment is vital.

Final Points Regarding ICAPs

As a resource: ICAP reports provide a plethora of information in one place, particularly with regard to *ex situ* status, which is available for future additional discussion and more detailed conservation planning activities.

The structure and transparency of the ICAP process provides clear reasoning behind the decision. This means that the discussion may not need to be revisited if the situation has not changed, and also means that decisions can be re-assessed if new information or opportunities become available.

As a tool for collaboration: The ICAP process leads to a better understanding of potential *ex situ* contributions to conservation by all stakeholder groups. ICAP workshops to date have resulted in recommended *ex situ* roles and activities that were more varied and better tailored to meet specific conservation needs of the species than has typically occurred in traditional RCPs. This helps to integrate *ex situ* activities and *in situ* conservation.

ICAPs lead to improved communication and collaboration among regional zoo associations, field-based conservationists, and IUCN SSC Specialist Groups. This in turn fosters continued and expanded integration of all conservation efforts for a species. This helps zoos and aquariums to become more effective conservation partners, and it also help other members of the conservation community, such as specialist groups, NGOs and wildlife authorities, to recognize the zoo and aquarium community as effective conservation partners (CBSG, 2011).

ICAPs provide one way in which the evaluative process of the IUCN *ex situ* guidelines can be applied in a more rapid, multi-species method to guide decisions on *ex situ* management for conservation. This can contribute to a more One Plan Approach to *ex situ* species conservation planning.

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Supporting the implementation of CPSG's Strategic Plan

Working Group
2018 CPSG Annual Meeting
Bangkok, Thailand

Supporting the implementation of CPSG's Strategic Plan

CONVENORS: Jo Gipps and Brad Andrews

AIM: To consider ways in which the CPSG community can 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, following a meeting and workshop in Minneapolis in April 2017, and was discussed at the CPSG Annual Meeting 2017 in Berlin. Other sections of the Plan (Mission, Approach and Challenge; Introduction and Context; Governance; Finance; Fundraising) have been added subsequently. Two Fundraising Case for Support documents have also been drafted.

PROCESS: We shall quickly review the Strategic Plan, without attempting further editing. We will then review the Fundraising Case for Support documents (both the 1 page and the 12 page booklet versions, (see links below) to assess their viability, discuss appropriate audiences, and determine what, if any, additional tools may be required to assist the fundraising effort. We shall consider any major ideas, suggestions, concerns, or additions that emerge from our discussions. Some questions we will review are:

- How can CPSG best target its existing funder base while at the same time develop a new funder base to support delivery of the strategic plan?
- What potential partnerships exist for CPSG to strengthen its 'case for support'?
- Are there institutions out there that would commit significant and consistent staff time to help CPSG scale up its planning and capacity building for planning work?

OUTCOMES: Improvements in structure, reach and utility of all the work needed to deliver the Strategic Plan successfully.

PREPARATION: Please review the following documents:

Conservation Pivot Points: Building Global Capacity for Species Conservation Planning

Building Global Capacity for Species Conservation Planning

IUCN

SSC Species Survival Commission

CONSERVATION PLANNING SPECIALIST GROUP

Changing the Future for Wildlife

Conservation Pivot Points:

Building Global Capacity for Species Conservation Planning

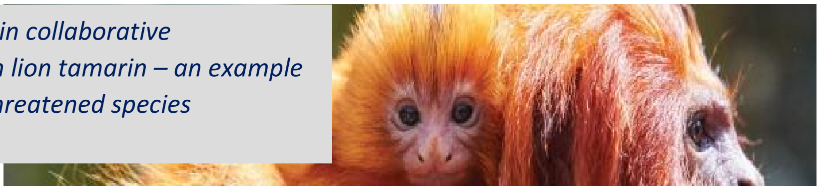
Strategic Plan 2018 – 2020

Fundraising Case for Support

http://www.cpsg.org/

A need for collaborative conservation action

Unified conservation planning results in collaborative conservation action for Brazil's golden lion tamarin – an example of CPSG's impact on the recovery of threatened species worldwide



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 by human activities, this loss is likely to increase. Unless, that is, we can develop strategies that 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 3,000, 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's** (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 the over 250 species with which we have worked to date.

We now need to scale up these efforts substantially, to catalyze actions for the more than 25,000[2] species currently threatened with extinction.

We are seeking financial support of **US$ 1.3 million** over the next three years, to help scale up global capacity for collaborative conservation planning, and to make a significant and measurable impact on the current biodiversity crisis.

We want to see many, many more of these 25,000 species moving towards a sustainable future, alongside human lives and livelihoods.

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[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

[2] http://www.iucnredlist.org/about/summary-statistics#Tables_3_4

With the help of CPSG, two groups working to conserve the Okinawa rail joined forces under a common plan and goal, giving these living national monuments a second chance to thrive. With conservation efforts, the wild population of Okinawa rails has grown to around 1,500.

Our Mission

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 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 neutral 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

CPSG provides training in the facilitation of species conservation planning workshops, and the use of a suite of planning tools, through on-line and face-to-face training courses.

Our Challenge

By 2020, the Species Survival Commission has committed to make significant impacts on the status of threatened species worldwide and, as central pillar of this plan, has asked CPSG to take the lead on scaling up species conservation planning. Therefore, over the next three years, we intend to increase the global conservation community's capacity to ensure that *every species that needs a plan is covered by an effective plan.*

CPSG's own Strategic Plan 2018-2020 has been developed to guide us toward achievement of this vision. It consists of five goals to:

1. Develop more efficient processes to move species from threat assessment, through conservation planning to 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 institutional and individual capacity for species conservation planning across IUCN SSC Specialist Groups, national authorities, zoos and aquariums, and other IUCN member organizations globally;
4. Improve the ability of governments to meet their commitments to relevant Convention on Biological Diversity Targets and United Nations Sustainable Development Goals;
5. Evaluate the impacts of species conservation planning on the recovery of threatened species to ensure continued learning and improvement

"…five or ten years down the road, everyone involved would look back on this [CPSG planning meeting] and see it as a turning point in the conservation of this endangered beetle. Ten years later that prediction is holding true."

Bob Merz, Director of the Center for
American Burying Beetle Conservation

Goal 1

Target species are prioritized, and conservation needs assessed, for conservation plan development; conservation planning efforts are expanded.

Through CPSG's Regional Resource Centers[3], SSC Specialist Groups, governments, and non-governmental organizations (NGOs), we will assist in identifying those species for which the development of conservation plans would provide greatest net return (in terms of species conservation). In collaboration with relevant stakeholders, efforts will be made to ensure plans are developed and implemented.

Tangible results:

- Processes are in place for IUCN SSC Specialist Groups and governments (a) to assess species status more rapidly and (b) to target species in need of immediate conservation action.
- There is significant and measurable up-scaling in the quantity of species conservation planning undertaken by CPSG, SSC Specialist Groups, governments, and conservation non-government organizations, more effectively and efficiently moving groups of species from assessment through to conservation action and initial signs of recovery.

Input required:

- Staff time to develop processes in collaboration with other conservation planning organizations and web-developer time to design online systems for conducting rapid species assessments.
- Additional trained species conservation planners (developed through our training program – **Goal 3)** – will widen the cohort of planners able to support species conservation planning efforts worldwide.

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[3] CPSG has Regional Resource Centers in: North America, Mesoamerica, Mexico, Brazil, South Asia, Europe, Indonesia, Southern Africa, Southeast Asia, Japan, and Australasia. These centers are convened by teams of experienced conservation planners who volunteer their time to support governments and non-government organizations in strategic organizational and species action planning.

"The gathering of well-known international experts convinced Hungarian stakeholders and authorities that the time had come for coordinated action"

Dr. Endre Sós, Budapest Zoo

Goal 2

Context-specific best practice planning methods are applied, based on a One Plan Approach.

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 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. A One Plan Approach (OPA)[4] will underpin this work.

Tangible results:

- Additional planning tools and guidelines developed are made freely available across the conservation sector, to enable all conservation organizations to plan more effectively for the recovery of threatened species, whether they are individual or large groups of species.
- The *ex situ* community will become more comprehensively integrated into conservation planning efforts to capitalize upon their skills and resources, including the animals they maintain in their care.

Input required:

- Predominantly staff time, with additional resources required to cover travel and accommodation costs incurred through our efforts to develop the tools in collaboration with other partners, and to promote the use of the tools at international meetings.

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[4] The ***One Plan Approach*** to species conservation is 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. CPSG supports an integrated approach to species conservation planning, through the joint development of management strategies and conservation actions by all responsible parties. We strive to ensure that a broad range of stakeholders is represented at each species conservation planning workshop. As a result, one comprehensive conservation plan for the species helps bridge the gap between wild and captive population management.

"…ample opportunities for hands-on practice with a diverse array of facilitation tools, engaging instructors… and an expanded network of facilitation-savvy conservationists, all made for one of the best and most relevant short courses I have ever taken."

CPSG Course participant, Facilitation Skills for Conservation Managers.

Goal 3

Species conservation planning capacity is increased across SSC Specialist Groups, governments, zoos and aquariums and other conservation organizations.

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. By 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 facilitators sufficient to respond to global conservation planning needs. We will ensure 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.

Tangible results:

- By 2020, we will have trained more than 300 conservation professionals from across SSC Specialist Groups, governments and other IUCN members who will be incorporated within a professional network of conservation planners and tracked to document their impact on scaling up planning for species recovery globally.
- Training programs will have been established that are accessible to all, to ensure that a lack of skills or knowledge is no longer a limitation on the extent to which Specialist Groups, governments and the wider conservation community can plan most effectively (and collaboratively) for threatened-species recovery.

Input required:

- This goal requires the most significant investment to deliver face-to-face training courses worldwide at minimal cost to our target audiences, and staffing to meet the need for training across Specialist Groups, governments, and NGOs globally.
- Additional resources are required to develop and deliver a suite of online training courses to maximize access to the training.

"[CPSG] created the right conditions for identifying the steps to build capacity in Tanzania prior to the toads' reintroduction".
Jenny Pramuk, Woodland Park Zoo

Goal 4

The ability of governments to achieve international biodiversity targets is improved.

We will, in collaboration with the SSC's Post-2020 Task Force, assist governments in using the SSC CPSG species conservation planning process to help them meet their obligations under Aichi Target 12 of the Convention on Biological Diversity's (CBD) Strategic Plan for Biodiversity 2011-2020 and the United Nations Sustainable Development Goal - Target 15.5.

Tangible results:

- Identification of obstacles limiting progress towards preventing extinctions and improving the conservation status of threatened species.
- Tested and revised tools that will guide and support government officials and planners in overcoming planning-related obstacles and making substantial progress towards achieving Target 12.
- Collaboration with other IUCN and SSC entities to influence policy, legislation, and conventions on species conservation planning.

Input required:

- Funding is already in place (and actions underway) to identify existing barriers to governments' ability to respond most effectively to their commitments under Aichi Target 12 and to identify solutions.
- Technical support will be provided through partnerships with colleagues across the IUCN.
- Resources will be available to cover travel and accommodation costs to meetings and to maintain a presence within the on-going discussions concerning the post-2020 CBD era.

"…protocols developed for [another species of plant]…were…used in conservation of the Governor Laffan's fern. All of this has come about, in large part, because of the [CPSG] workshop".

Marge From, Department for Plant Conservation,
Omaha's Henry Doorly Zoo & Aquarium

Goal 5

Species conservation planning methods are evaluated for impact and effectiveness, leading to continual improvement.

We will develop and implement evaluation approaches to measure, improve, and report on the impact and effectiveness of IUCN SSC species conservation planning efforts.

Tangible results:

- Systems are in place to monitor and evaluate the effectiveness of different species conservation planning processes, leading to ongoing learning and development of the processes, and the sharing of this information with conservation organizations worldwide.
- A database of planning projects, resulting plans, and evaluation of those plans will be established, providing a freely-available resource to Specialist Groups, governments and non-government conservation organizations.

Input required:

- This goal essentially requires staff time to be allocated.
- The establishment of a PhD position to undertake a comprehensive review of planning processes and their effectiveness (in terms of impacts on species recovery) would allow for a more in-depth baseline to be created and built upon.

CPSG Structure and Governance

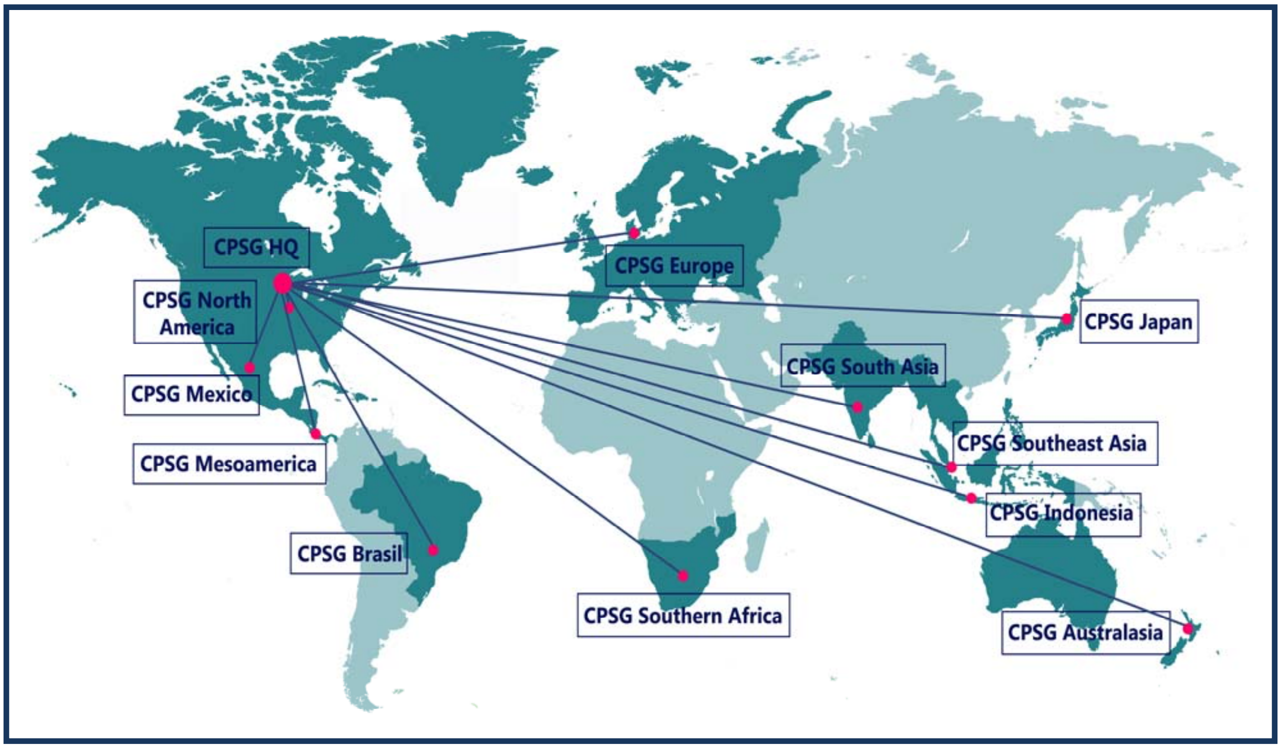
Please see our Annual Reports at: http://www.cpsg.org/latest-news/annual-reports

CPSG Staff

CPSG is led by its Chair, Dr. Onnie Byers, with a Headquarters staff of 7 (5 in in Minnesota, USA, one in New Zealand, and one in the UK).

Regional Resource Centers

A network of 11 Regional Resource Centers take 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 fulfill our mission.

CPSG Donors

The work of CPSG is made possible by our family of generous and loyal donors, a large portion of who have given annually to CPSG for over 20 years. A current list of donors to CPSG can be found at http://www.cpsg.org/support-cpsg.

Global Conservation Network

The finances of CPSG are managed by the Global Conservation Network (GCN), a USA 501c3 charity founded to support the work of CPSG. CPSG is thus financially independent from IUCN SSC, of which it is a constituent Specialist Group. GCN has a Board of 11 international Trustees who oversee all aspects of the financial and risk management of CPSG. 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

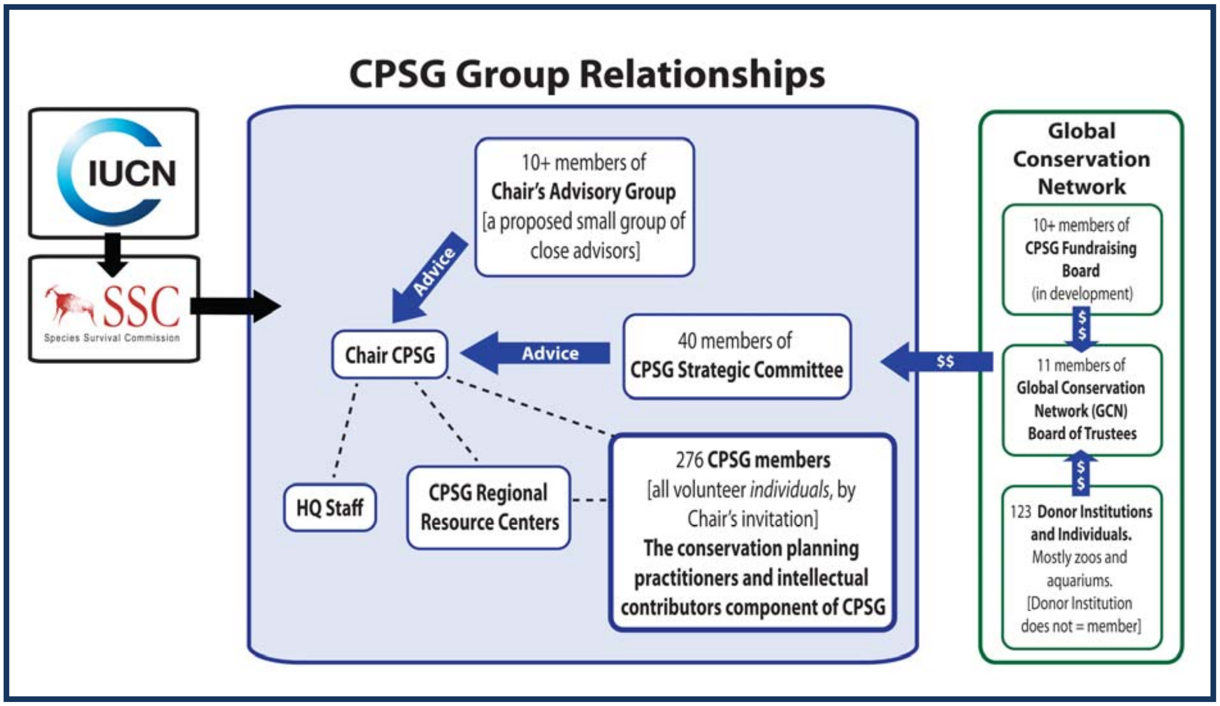
The CPSG Strategic Committee is an informal discussion group of some 40 CPSG Members, whose purpose is to discuss, with the Chair and staff, matters of future strategic interest to CPSG. A list of members can be found here: http://www.cpsg.org/about-cpsg/donors-strategic-committee.

CPSG Fundraising Committee

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, focusing on fundraising in the US and Europe respectively.

Governance Structure

The diagram below shows the relationships between the groups described above. The structure has been carefully planned to maximize 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.

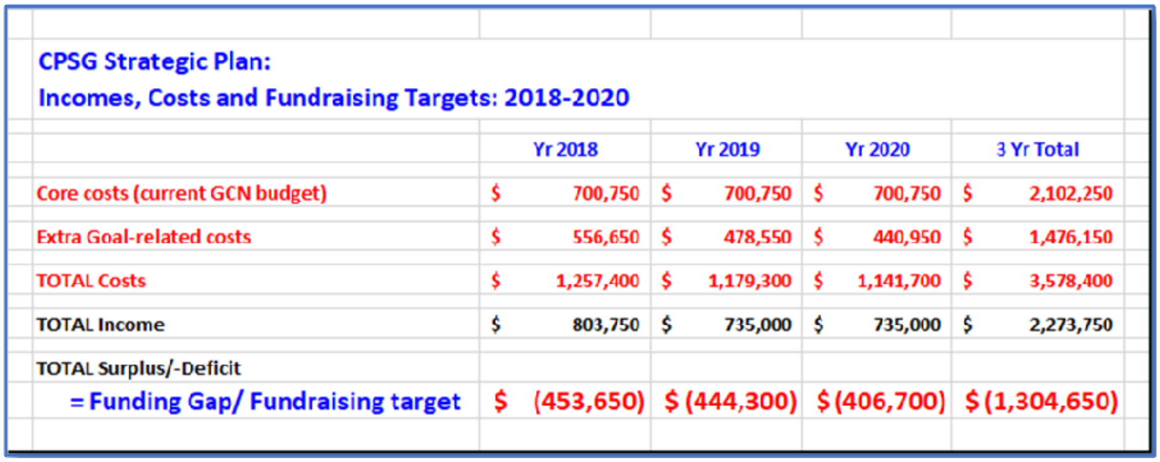


Finance

CPSG already has a 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, to fully 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)**

"I thought this tree kangaroo was just another animal to be hunted…but when I learned more about tree kangaroos from this workshop, I got excited. I will return to my village a happy man because in my wildlife area there are a lot of tree kangaroos. I am going to look after them."

Local stakeholder
Tree kangaroo conservation planning workshop
Papua New Guinea

Additional information

The Conservation Planning Specialist Group (CPSG) is a Specialist Group of the International Union for Conservation of Nature (IUCN), Species Survival Commission (SSC).

The ***International Union for Conservation of Nature*** is the world's oldest and largest global environmental organization. It brings together states, government agencies, and a diverse range of non-governmental organizations, in a unique world partnership that seeks to influence, encourage, and assist societies throughout the world in conserving the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. http://iucn.org

The ***Species Survival Commission*** is the largest of IUCN's six volunteer commissions, with a global membership of 8000 experts. The SSC advises the IUCN and its members on the wide range of technical and scientific aspects of species conservation and is dedicated to securing a future for biodiversity. http://www.iucn.org/theme/species/about/species-survival-commission-ssc

Within its Strategic Plan 2017-2020, the Species Survival Commission has 43 Key Species Results (KSRs). Seven of these refer explicitly to Conservation Planning, and therefore, to the core work of CPSG.

KSR15. IUCN SSC species conservation planning efforts are significantly expanded, especially for priority species. A method for prioritisation 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.

KSR16. 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.

KSR17. Species conservation planning capacity is built through expanded training programmes. 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.

KSR18. 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.

KSR19. 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.

KSR20. The discipline of 'Species Conservation Planning' is formally embedded in SSC's organisational 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.

KSR21. IUCN SSC is recognised 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.

IUCN

Species Survival Commission

CONSERVATION PLANNING SPECIALIST GROUP

Changing the Future for Wildlife

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.

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*

Additional Materials

2018 CPSG Annual Meeting
Bangkok, Thailand

TRAFFIC
REPORT

ILLEGAL OTTER TRADE IN SOUTHEAST ASIA

JUNE 2018

Lalita Gomez and Jamie Bouhuys

TRAFFIC **REPORT**

TRAFFIC works closely with its founding organisations, IUCN and WWF, making a critical contribution to achievement of their conservation goals through a unique partnership.

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Front cover photograph: A Small-clawed Otter pup for sale in Yogyakarta, Indonesia, November 2017.

Credit: © L.Gomez/TRAFFIC

ILLEGAL OTTER TRADE IN SOUTHEAST ASIA

Lalita Gomez and Jamie Bouhuys

A Small-clawed Otter pup for sale in Yogyakarta, Indonesia, November 2017.

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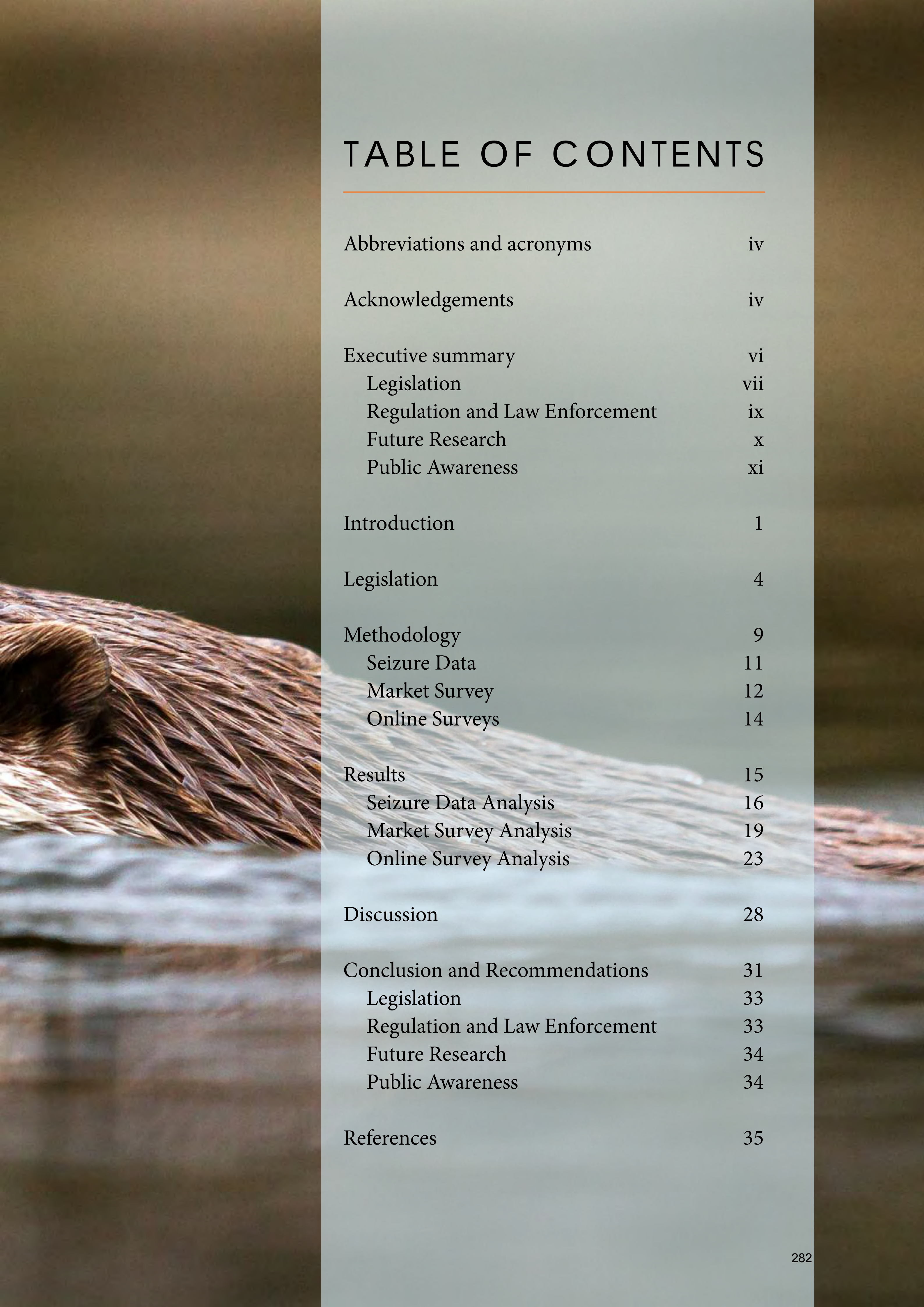
Eurasian otter



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ABBREVIATIONS AND ACRONYMS

BND	Brunei Dollar
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DNP	Department of National Parks (Thailand)
EIA	Environmental Investigation Agency
ID	Indonesia
IDR	Indonesian Rupiah
IFAW	International Fund for Animal Welfare
IOSF	International Otter Survival Found
IUCN	International Union for Conservation of Nature
JPY	Japanese Yen
KH	Cambodia
KHR	Cambodian Riel
LAK	Lao Kip
LA	Lao People's Democratic Republic (PDR)
LCES	Law for the Conservation of Endangered Species of Wild Fauna and Flora (Japan)
MA	Management Authority (CITES)
MM	Myanmar
MMK	Myanmar Kyat
MY	Malaysia
MYR	Malaysian Ringgit
NGO	Non-governmental organisation
OSG	Otter Specialist Group
PDR	People's Democratic Republic (Lao)
PH	Philippines
PHP	Philippine Peso
SGD	Singapore Dollar
SSC	Species Survival Commission
TAR	Tibet Autonomous Region
TH	Thailand
THB	Thai Baht
USD	American Dollar
VN	Viet Nam
VND	Vietnamese Dong
WCS	Wildlife Conservation Society
WFFT	Wildlife Friends Foundation Thailand
WPSI	Wildlife Protection Society of India

ACKNOWLEDGEMENTS

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The Illegal Otter Trade in Southeast Asia

SEIZURE

LIVE OTTERS
59 SEIZED
2016-2017

KEY COUNTRY; SOURCE & DOMESTIC TRADE

Thailand

High volume seized
5 seizures
35 live otters

KEY DESTINATIONS

Japan

Implicated in
3 seizures
in Thailand
amounting to
32 live otters

Viet Nam

Implicated in
3 seizures
amounting to
15 live otters

ONLINE TRADE

HIGH
ONLINE
TRADE

in Indonesia, Malaysia, Thailand, Viet Nam

560
advertisements
over 4 months
January – April 2018

Average of
960
otters
observed
for sale

KEY COUNTRIES

Indonesia

449 adverts with
an average of
711 otters for sale

Thailand

80 adverts with
an average of
204 otters for sale

Main species at risk:
Small-clawed Otter
International trade
regulated under CITES
Appendix II

TRAFFIC
the wildlife trade monitoring network

Read more: TRAFFIC Report: Illegal Otter Trade in Southeast Asia at www.traffic.org

EXECUTIVE SUMMARY

Eurasian otter

Southeast Asia is home to four species of otters: Eurasian Otter *Lutra lutra,* Hairy-nosed Otter *L. sumatrana,* Small-clawed Otter *Aonyx cinereus* and Smooth-coated Otter *Lutrogale perspicillata*. While information on the prevalence of all four species in this region is sparse, it is generally considered that populations are in decline due to the increasing loss of suitable habitat, the impact of pesticides on their wetland biomes and human–otter conflicts caused by perceived or actual threat to local and commercial fisheries. Also a significant threat to otters in the region, but less understood, is the poaching of otters for trade to meet the demand for pets, for their fur, and for parts used in traditional medicines.

This study was undertaken to provide a current understanding of the otter trade in Southeast Asia. It was underpinned by TRAFFIC's previous analysis of otter seizures from 1980–2015 that was published in 2016. Based on the findings of the seizure analysis, eight countries in Southeast Asia were recommended for further study—Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand and Viet Nam. The current study focused on three areas of work i.e. an update of otter seizure analysis (August 2015–December 2017), physical market surveys in Cambodia, Indonesia, Lao PDR and Myanmar, and online trade surveys in Indonesia, Malaysia, Philippines, Thailand and Viet Nam.

Overall, the pet trade emerged as the most pressing threat to the survival of otters, particularly in Indonesia and Thailand. A total of 13 seizure records in four countries (Indonesia, Malaysia, Thailand and Viet Nam) were recorded from 2015–2017 involving the confiscation of 59 live otters, most of which were juveniles. Of these, at least 32 animals in three separate incidents were seized en route to Japan from Thailand. Most of the seizures occurred in Thailand, followed by Indonesia, Viet Nam and Malaysia. The exploitation of otters in these four countries was reinforced by observations of the online trade. Overall a minimum of 560 advertisements were analysed over a four-month period January–April 2018, with a minimum of 734 and a maximum of 1189 otters observed for sale. Most of these advertisements were recorded from Indonesia (449 adverts amounting to, on average, 711 otters for sale), followed by Thailand (80 adverts, averaging 204 otters for sale), Viet Nam (21 adverts, averaging 27 otters for sale) and Malaysia (10 adverts, averaging 19 otters for sale). The Philippines was the only country examined where no online advertisements were found during this period.

Physical market surveys yielded very few observations of trade in Cambodia, Indonesia, Lao PDR and Myanmar, totalling five skins and two (juvenile) live otters, the latter recorded in Indonesia. Although low in numbers, otters are evidently being hunted to feed the demand, and hunting appears to target species not currently protected by national legislation such as the Small-clawed Otter and Smooth-coated Otter in Cambodia and Indonesia. In 2007, the Cambodian government removed these two species from its wildlife protection law, the reasons for which are unknown.

The Philippines was the only country that did not record a single otter seizure from 2015–2017, nor were there any trade observations in the markets or online. While Malaysia, Myanmar and Viet Nam were implicated in the illegal trade of otters, numbers recorded were small, mostly to supply the pet trade and to a lesser extent trade in skins (in reference to the two skins observed for sale in Myanmar). Overall trade data, whether from seizures, market surveys or online surveys, were however insufficient to draw any firm conclusions as to its extent.

The Small-clawed Otter was the most frequently encountered species in this study being exploited for the pet trade, followed by the Smooth-coated Otter. To a much lesser extent, the Eurasian Otter (in one incident in Myanmar) and Hairy-nosed Otter (in one incident in Indonesia) were also observed in trade. While otters are poached from the wild, it is also possible that some are being captive bred for trade. In both Indonesia and Thailand, there were unconfirmed/unverified reports of otters being bred for trade. Investigation is required to determine if captive breeding is indeed permitted and ongoing, particularly in Indonesia and Thailand, and if so, the scale of captive breeding and how this is being regulated by law—if at all.

This study shows that the commercial exploitation of otters is taking place both domestically and internationally in clear violation of national laws and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While few otters were observed in markets, the open nature of the observed trade online is considerable, clearly showing a blatant disregard for national legislation and regulations. The otter pet trade is a concern, particularly in Indonesia and Thailand, where the domestic and international demands of a flourishing exotic pet industry is a potential threat to wild otter populations. The trafficking of otters from these countries to Japan is especially concerning considering loopholes in laws in the three countries that prevent enforcement action. This, combined with loss and disruption of suitable habitat and human-otter conflict, is a risk to the survival of remaining wild otter populations in Southeast Asia.

As such, TRAFFIC makes the following recommendations to combat the illegal trade in otters and ultimately reduce the threat to this group of species:

Legislation

As the four otter species in Southeast Asia are listed in either CITES Appendix I and II, it is imperative that national legislation offers appropriate protection that enables the regulation of international trade. The high level of online trade observed in Indonesia, along with exports of reportedly captive-bred specimens, warrants the species to be regulated and protected by national legislation. *Government Regulation No. 7/1999 on Preservation of Flora and Fauna*, which is currently undergoing revision, should list both the Small-clawed Otter and the Smooth-coated Otter as protected to prevent illegal hunting, trade and possession of these species. While Indonesia has regulations in place to control the trade of unprotected species by setting annual harvest quotas, there are no provisions in the law regarding penalties or fines against those found in violation of these quotas. The *Wildlife and Wild Plants and Conservation of Natural Areas Law (1994)* of Myanmar should list the Hairy-nosed Otter as a protected species. Although it is uncertain whether the species naturally occurs in the country, observations of trade in markets in Myanmar is an indication of international trade in a non-native CITES listed species, for which regulation is necessary. The removal of Small-clawed Otter and the Smooth-coated Otter as protected species in 2007 from Cambodia's *Law on Forestry (2002)* should be rectified, and the species should be afforded protection, as without it, illegal harvest and trade cannot be regulated.

National legislation in all countries should also include provisions to regulate online wildlife crime; this would also be in line with CITES Decision 17.92[1] on Combating wildlife cybercrime. The seriousness of the illegal trade should be reflected in both wildlife and online trade laws, particularly through high penalties for any transgressions of the law. Online trade undermines law enforcement efforts and complicates efforts to take regulatory action. Strong penalties could favour law enforcement agencies by serving as a strong deterrent, especially as online trade also encourages opportunistic trade, which should be weeded out.

Regulation and Law Enforcement

The high levels of online trade, particularly in Indonesia and Thailand, signal the need to enhance pro-active investigation into the growing demand and online trade of otters as pets. Despite their protected status in most countries, otters are not only widely available, but easy to purchase. Arrests and seizures arising from online trade, for a range of species, are taking place in many Southeast Asian countries, but it is imperative that these arrests are followed through with investigations to determine players involved along the trade chain, from source to supply.

Claims of the existence of captive breeding activities taking place in Indonesia and Thailand need investigation and verification. Given there are no harvest quotas for wild otters in Indonesia, it should be made clear and transparent how parent stock is obtained for commercial breeding of otters.

Law enforcement knowledge and capacity should be enhanced across Southeast Asian countries to enable investigations, arrests and convictions of criminals trading in protected species to the full extent of the law. TRAFFIC and the IUCN Otter Specialist Group stand ready to assist relevant enforcement agencies in providing enforcement support and training with regards to identification of otter species and body parts, including distinguishing between the skins of the different otter species. Increasing the capacity of local law enforcement agencies has yielded positive results in curbing illegal trade of wildlife.

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[1] **https://www.cites.org/eng/dec/valid17/81840**

Collaboration between enforcement agencies in Indonesia, Malaysia, Thailand and Viet Nam should be enhanced to curb the illegal trading of wildlife occurring online. Incidents of illegal trade should be reported to the relevant law enforcement agencies for action. Alternatively, reports can be made directly to TRAFFIC, via the Wildlife Witness App which can be downloaded for iPhone https://itunes.apple.com/us/app/wildlife-witness/id738897823?mt=8) or Android (https://play.google.com/store/apps/details?id=com.taronga.wildwitness). If taking place on Facebook, a direct report there is in line with Facebook's Community Standards via its policy against any illegal activity, including wildlife crime (https://www.facebook.com/help/1814959686448557?ref=communi%20ty_standards). Reports can involve posts, messages, groups and other elements that can be a violation of legislation.

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Future Research

Conservation organisations, particularly those focussing on wetland conservation, and research institutions should continue monitoring and reporting on any trade and demand for otters in Southeast Asia. This will not only support enforcement efforts but aid in the effort to understand better and gauge levels of illegal offtake and trade and detect emerging trends. This will also help guide and shape enforcement actions, conservation actions, decision making, and policy interventions.

Smooth-coated otter

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Further research by conservation organisations, particularly those focussing on wetland conservation, and academic institutions is urgently needed into the status of wild populations of otter species in Southeast Asia to establish national conservation threat levels and guide conservation and law enforcement actions. This should also be increased at known strongholds of otter populations (e.g. southern regions of Thailand, Prek Toal conservation area in Cambodia, Nakai-Nam Theun National Protected Area, Lao PDR).

Considering their threatened status in Southeast Asia, along with incidents of international trade (including from TRAFFIC's previous analysis of otter seizures from 1980–2015), the Parties to CITES should decide whether the up-listing of otters, from Appendix II to Appendix I is merited against criteria under CITES.

Public Awareness

Given that the observed trade is mostly illegal, governments and non-governmental organisations (NGOs) are encouraged to raise awareness and educate the public about the consequences of capture and trade of otters, particularly as online trade appears actively to target young animals for the pet trade. Arrests and criminalisation of those found to be hunting or trading in otters illegally should be publicised, along with the penalties being meted out, to serve as a deterrent to other would-be offenders.

Given the high demand in Indonesia and Thailand, governments and conservation organisations there are urged to explore and pursue avenues to educate consumers and reduce the demand for otters as pets. This may warrant the implementation of long-term consumer behaviour change campaigns on the live animal trade.

Eurasian otter

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INTRODUCTION

Asian small-clawed otter

Southeast Asia is home to four species of otters: Eurasian Otter *Lutra lutra*, Hairy-nosed Otter *L. sumatrana*, Small-clawed Otter *Aonyx cinereus* and Smooth-coated Otter *Lutrogale perspicillata*. While information on the prevalence of all four species in the wild is sparse, it is generally considered that populations are in decline due to increasing loss of suitable habitat, influence of and misuse of pesticides in man-made and natural wetlands and human–otter conflicts caused by perceived or actual threat to local and commercial fisheries (Aadrean *et al.*, 2015; de Silva *et al.*, 2015; Roos *et al.*, 2015; Wright *et al.*, 2015). Also a significant threat to otters in the region, but less understood, is the poaching for trade to meet the demand for pets, furs, and for parts used in traditional medicine (de Silva, 2011; IOSF, 2014; Gomez *et al.*, 2016).

There is very little information on the illegal otter trade in the region (e.g. magnitude, trafficking hotspots, whether the trade involves wild or captive-bred otters), perhaps because they are relatively low-profile species and not high on the conservation agenda (de Silva, 2011; IOSF, 2014). The potential threat trade to wild otter populations in Asia became more evident in 2006 when remarkable quantities of otter skins were incidentally discovered during a joint study by the Environmental Investigation Agency (EIA) and the Wildlife Protection Society of India (WPSI) into the big cat skin trade in China (Banks *et al.*, 2006). Openly for sale in local markets, otter skins were often found alongside Tiger *Panthera tigris* and Leopard *P. pardus* skins (in two years, no fewer than 1800 otter skins were recorded in a single market in Linxia, China) (Banks *et al.*, 2006). In response to this, the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Otter Specialist Group (OSG) launched its Asian Otter Task Force in 2007 to develop recovery strategies for otters in Asia. In 2015, TRAFFIC in partnership with the IUCN-SSC-OSG, conducted an analysis of otter seizures in Asia between 1980 and 2015 to understand the scale of the illegal trade and species impacted in this trade (Gomez *et al.*, 2016)[2].

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[2] ***The study titled Illegal Otter Trade*** **– An analysis of seizures in selected Asian countries between 1980 and 2015, was published and launched at the 13th International IUCN Otter Congress that was held in Singapore in July 2016 and can be downloaded at: http://www.traffic.org/home/2016/7/5/otters-in-asia-at-risk-from-demand-for-their-skins-and-incre.html.**

That study, hereinafter referred to as the "otter seizure analysis", revealed that tropical Asian otters were encountered in illegal trade, with 161 recorded otter seizures across 15 countries, involving an estimated 5881 individuals (Gomez *et al*., 2016). Most of the cases involved skins, especially in China, India and Nepal, and mostly involved the Eurasian Otter and Smooth-coated Otter. That said, there was a large number of seized skins (82%) which were not identified to species level owing to the difficulty of distinguishing between the skins of different otter species, and possibly to a lack of interest/prioritisation by law enforcement agencies in determining the species. There was also a rise in the number of otter skin seizures over the study period, but a decrease in the quantities being seized i.e. from two to three cases a year averaging 50 individuals per seizure, to eight seizures a year of about 30 individuals each. While more seizures could mean an improvement in enforcement efforts or increasing trade in otters, the lower quantities could imply declining otter populations.

The otter seizure analysis also showed that in Indonesia, Malaysia, Thailand and Viet Nam, otters were being captured to supply demand for the growing pet trade, in which the Small-clawed Otter and Smooth-coated Otter were evidently popular. The emerging trend of otters being traded and kept as pets was further revealed through preliminary surveys of social media websites in 2016 (e.g. Indonesia and Viet Nam).

While this initial study provided a preliminary understanding of the illegal otter trade in parts of Asia, it also highlighted significant knowledge gaps in the trade of otters in many Southeast Asian countries. To fill this gap, this study examines the otter trade in eight Southeast Asian countries (i.e. Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand and Viet Nam) encompassing updated seizure analysis, market surveys and online trade monitoring.

Eurasian Otter

© Duplaix

LEGISLATION

In general, the Eurasian Otter, Hairy-nosed Otter, Small-clawed Otter and Smooth-coated Otter are nominally protected by legislation in most otter range states in Southeast Asia either by nationally accorded protection status as a threatened native species (i.e. the case in most range states) or by laws that prohibit the hunting, killing, capturing and selling of any wild animal (e.g. Singapore). However, this legal protection does not always extend to all otter species that may occur in a particular country. **Table 1** provides the relevant national wildlife legislation for each of the eight Southeast Asian (SEA) countries assessed in this study along with the protection status of each species.

Asian Small-clawed otter

© IUCN-OSG

Most of the eight-assessed range states have legislations that are believed generally to meet the requirements for the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (assessed as Category I by the CITES National Legislation Project). The few exceptions include the Philippines (Category II), Lao PDR (Category III) and Myanmar (Category III), meaning that national laws in these countries do not meet the requirements necessary to implement CITES properly. In the case of Lao PDR and Cambodia, however, their wildlife laws are reportedly being amended to incorporate higher fines and criminal liability where lack of compliance with CITES is concerned. However, that said, Indonesia and Thailand, despite their Category I listing, have loopholes in their respective national wildlife laws that prevent the effective implementation of CITES. Once non-native CITES-listed species or CITES-listed species that are not listed in national legislation have entered the country, wildlife crimes involving these animals cannot be adequately prosecuted.


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Asian Small-clawed otter

Table 1. Protection Status of Otters in Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand and Viet Nam

Country/ territory	Otter Species Present	Protection Status	Legislation	Notes
Cambodia	Eurasian Otter Hairy-nosed Otter Small-clawed Otter Smooth-coated Otter	Protected Protected Not protected Not protected	Law on Forestry (2002)	Under this law it is prohibited to hunt, possess, process, transport, import and engage in trade of listed species or their parts and derivatives. Captive breeding of listed species is only allowed with a permit issued by the Forestry Administration upon agreement with the Ministry of Agriculture, Forestry and Fisheries. Violation of the law can result in fines of up to five years imprisonment and/or a fine of up to KHR100 million (USD24 896). Both the Small-clawed and Smooth-coated Otters were removed from the revised Protected Species List (2007).
Indonesia	Eurasian Otter Hairy-nosed Otter Small-clawed Otter Smooth-coated Otter	Protected Protected Not protected Not protected	Act of the Republic of Indonesia No.5 of 1990 concerning conservation of living resources and their ecosystems Government Regulation No 7/1999 on Preservation of Flora and Fauna. Government Regulation No. 8, 1999 on Utilization of Wild Plants and Animals.	Calls for the legal protection of all Indonesian otter species (Kusumawardhani *et al.* 1994) led to respective commitments given at the First Symposium on Otters in Indonesia in 1994 to assign all four otter species the status as a protected species (Melisch *et al.*, 1994). However, legal follow-up by Indonesia in 1999 only partially implemented these steps by granting full protection status to two of the four species only. Under the Conservation Act No 5/1990, wildlife falls into two categories i.e. protected or unprotected. Protected has been defined as wildlife that is considered endangered or rare (but the criteria used to classify them as such are unknown). Offences are punishable by a five-year prison sentence and a fine of IDR100 million (USD7 200). Government Regulation No 7/1999 lists species that are protected in the country in which the only otter species included are the Eurasian and Hairy-nosed Otters and states that it is prohibited to catch, keep, possess, care for or transport protected animals without permission. That said, under Government Regulation No. 8, 1999, the trade of a Protected species is permitted if the specimens are captive-bred. Captive-bred animals are also subject to regulations under the Decree of the Ministry of Forestry, No.P.19/Ministry of Forestry-II/2005 concerning captive management of wild plant and animal species which defines that only second and subsequent generations of captive-bred Protected animals may be traded. Hunting and trade in animals that are not protected is regulated under Regulation of the Minister of Forestry No. 447/Kpts-II/2003 concerning administration directive of harvest or capture and distribution of the specimens of wild plant and animal species. The regulation states that a yearly provincial quota is set for all animals that can be captured in the wild. Catching animals for which no quota has been set, in excess of quota that have been set, or outside provinces for which quotas have been set, is deemed illegal, even when the species concerned is not considered protected. No harvest quotas have been established for otters. No punishments for transgressions are stated however, and therefore this regulation is difficult to enforce.

Country/ Territory	Otter Species Present	Protection Status	Legislation	Notes
Lao PDR	Eurasian Otter Hairy-nosed Otter Small-clawed Otter Smooth-coated Otter	Protected Protected Protected Protected	Wildlife and Aquatic Law (2007) (currently being amended)	All otter species are protected under Category 1 (Prohibition) of this law which prohibits, the catching, hunting (including removal of carcasses, organs and parts), trading and possession of animals under this Category, unless authorised by the government. This Law also prohibits the trade of Category I species unless they are second or third generation captive-bred. Previously, violations in the law resulted in a penalty of about USD72. The Lao National Assembly is revising its Penal Code, to incorporate higher penalties for wildlife trafficking.
Malaysia	Eurasian Otter Hairy-nosed Otter Small-clawed Otter Smooth-coated Otter	Protected Protected Protected Protected	Wildlife Conservation Act (2010) Wild Life Protection Ordinance (1998) Wildlife Conservation Enactment (1997) International Trade in Endangered Species Act (2008)	All four otter species are listed in the highest protection category, Totally Protected, in the *Wildlife Conservation Act 2010* of Peninsular Malaysia, whereby species may only be traded for non-commercial purposes, pending approval/permission from the Ministry. Hunting or keeping such wildlife without permits is punishable by a maximum fine of MYR100 000 (USD23 462) and/or a maximum jail sentence of three years. Under the *Wild Life Protection Ordinance (1998)* of Sarawak all otter species are listed as Protected, the second highest protection category. Hunting, capturing, possessing, selling, offering for sale or even claiming to offer such an animal for sale without a licence, is prohibited. Offences result in a one year prison sentence and a MYR10 000 (USD2346) fine. Sabah's *Wildlife Conservation Enactment (1997)* does not list Eurasian Otter (Southeast Asian subspecies *L. lutra barang*) as Protected, unlike the other three species. However, since CITES Appendix I listed species are treated similarly to Totally Protected species if the violation involves cross-border trade, and Eurasian Otter is listed in Appendix I, it is treated as Totally Protected in such cases. Hunting otters in Sabah results in a fine of up to MYR100 000 (USD25 644) and/or up to five years imprisonment. For the Eurasian Otter, fines of up to MYR250 000 (USD64 110) and up to five years imprisonment. Malaysia's CITES-implementing legislation, the *International Trade in Endangered Species Act (2008)* is applicable in Peninsular Malaysia, Sabah and Sarawak. Anyone found guilty, including businesses, of illegally importing or exporting any CITES-listed species can be liable to a fine of up to MYR2 million (USD516 941) and a seven year jail term.

Country/ Territory	Otter Species Present	Protection Status	Legislation	Notes
Myanmar	Eurasian Otter Hairy-nosed Otter Small-clawed Otter Smooth-coated Otter	Protected Not protected Protected Protected	Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law (1994).	The Hairy-nosed Otter is not listed as a protected species as it is not recognised as occurring in Myanmar. The other three species are listed as Completely Protected whereby, hunting, killing, possession, selling, transport or transfer of wildlife and wildlife parts is prohibited along with commercial transactions. Conviction of such crimes results in a fine of up to MMK50 000 (USD37), a prison term of up to seven years or both.
Philippines (Palawan)	Small-clawed Otter	Protected	Wildlife Resources Conservation and Protection Act RA9147 (2001)	The Small-clawed Otter is protected under the Wildlife Resources Conservation and Protection Act, Republic Act No. 9147 (2001), which lists it as Endangered. Imprisonments of between one year and two years and/or fines of PHP20 000 (USD380) to PHP200 000 (USD3932) are adjudged on conviction of trading, collecting, hunting or possessing otters without a permit. Permits are only given for scientific or breeding purposes for endangered species if the best available information or scientific data show that these activities are not detrimental to the species's survival and its habitat. A permit is needed for commercial breeding and only progeny and unproductive parent stock may be traded.
Thailand	Eurasian Otter Hairy-nosed Otter Small-clawed Otter Smooth-coated Otter	Protected Protected Protected Protected	Wild Animals Preservation and Protection Act (1992)	This law prohibits the possession and trade of protected wild animals and their carcases unless listed in Section 17 of the Act (which pertains to wildlife that can be bred, however otters are not included). Protected species are listed in the Regulation annexing *List of Protected Species, B.E. 2546* and all otter species are listed as protected therein. Violations are punishable by a maximum prison sentence of four years and a maximum fine of THB40 000 (USD1278) or both.
Viet Nam	Eurasian Otter Hairy-nosed Otter Small-clawed Otter Smooth-coated Otter	Protected Protected Protected Protected	Decree No.32/2006/ND-CP Decree No.160/2013/ND-CP Decree 157/2013/ND-CP Law No. 12/2017/QH14 Penal Code No. 100/2015/QH13	All species of otters in the country are protected under the list of endangered, precious and rare forest plants and animals. Decree 32 (Group IB) and Decree 160, prohibit the exploitation and use of otters for commercial purposes. Violations are punishable by measures set out in either the Penal Code No. 100/2015/QH13 (along with Law No. 12/2017/QH14 Amending and Supplementing a number of articles in the Penal Code No.100/2015/QH13) for criminal offences or the Government's Decree no. 157/2013/ND-CP for administrative offences. The highest penalties under the Penal Code are fines up to VND2 billion (USD87 817) and a prison term up to 15 years while the highest penalties under Decree 157 are fines up to VND500 million (USD21 954) for individuals and VND1 billion (USD43 908) for organisations.

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METHODOLOGY

Eurasian otter

Seizure Data

Following-on from the previous otter seizure analysis which covered the period between 1980 and July 2015, this study looks at otter seizures occurring between August 2015 and December 2017 for eight Southeast Asian countries assessed in this study i.e. Cambodia (KH), Indonesia (ID), Lao PDR (LA), Malaysia (MY), Myanmar (MM), Philippines (PH), Thailand (TH) and Viet Nam (VN). Data were extracted from various sources, including TRAFFIC seizure data records, CITES trade database, media reports, grey literature and records from other non-governmental organisations (NGOs). Formal requests for otter seizure data were also sent to CITES Management Authorities (MA) in each of the eight countries. Only the CITES MAs of Indonesia, Malaysia and Myanmar responded to our request with only Malaysia providing data, while Indonesia and Myanmar responded that they had no otter related seizure data. Records of seizures of live or dead otters, their parts and derivatives across Southeast Asia were collected and compiled including where available information on date and place of seizure, origin and destination as well as commodities and quantities seized. Where species identifications were reported, these were accepted as given without further verification.

A "seizure country" was defined as the country where the seizure took place and could be either a source, transit or destination country.

A "source country" was defined as the first known point of a trade route.

A "transit country" was defined as a country which had functioned or was intended to function as both an importing and a re-exporting country in the trade route.

A "destination country" was defined as the last known reported point of a trade route.

Given the inconsistent manner in which seizures, enforcement actions and resulting prosecutions are reported and recorded by the different countries, it is unlikely that this dataset is representative of the complete set of seizures involving otters in Southeast Asia. Due to the inherently covert nature of the illegal wildlife trade, its true extent is unlikely to be reflected by the reported seizure data alone. Seizure records are an indirect measure of trafficking levels, but the data are inherently biased. This is due to a number of factors, including varying levels of law enforcement in each country, different reporting and recording practices of both law enforcement and media, variability in NGO behaviour and advocacy, language biases etc. Therefore, more seizures in one country may not necessarily translate into higher wildlife trafficking levels in comparison to other countries. It is acknowledged that the above-mentioned factors, among others, will ultimately influence the results of any seizure analysis, however, there is currently no comparable approach to gauge wildlife trafficking levels.

Market Survey

Surveys were conducted over a one year period between 2016 and 2017 in Cambodia, Indonesia, Lao PDR and Myanmar (Figure 1). These countries were chosen for market surveys based on the findings of the previous seizure analysis (1982–2015) i.e. in Cambodia, seizures were mostly of dead animals indicating otters being poached for their skin or traditional medicine trade; in Lao PDR and Myanmar, there was a scarcity of seizure data on otters but otters have been observed in trade in previous market survey studies in these countries; and in Indonesia, seizure data revealed a large domestic market for pet otters. Surveyed locations in each country were selected based on findings of previous research and market surveys undertaken by TRAFFIC and other organisations which had identified important wildlife trade areas. Information collected include price, origins and sources (wild or captive-bred), uses, turnover, etc. Table 2 provides details of areas surveyed for each country.

Table 2. Details of physical market surveys undertaken in each country between 2016 and 2017

Country	Dates	Locations Surveyed
Cambodia	2–21 Nov 2016	Based on otter research in the country (Dong *et al.*, 2010; Hon *et al.*, 2010: Royan, 2010; Heng *et al.*, 2016; Willcox *et al.,* 2016) and discussions with local NGOs on areas where otters are hunted and areas known for wildlife trade, 16 locations around the country were identified for surveys. At each location all wildlife markets were visited and, where possible, additional information was gathered on the otter trade from local wildlife vendors.
Indonesia	16 Nov–8 Dec 2017	Based on online surveys of the trade in otters, a large number of advertisements selling otters were located on the island of Java. Where this exceeded 10 or more advertisements, and where the presence of large wildlife markets have been recorded based on previous market surveys around the island (Profauna, 2009), 17 cities around the island of Java were selected for surveys. In each location, all wildlife pet markets were surveyed i.e. a total of 30 markets were visited.
Lao PDR	18–28 Apr 2016, 19–22 Jul 2016, 6–20 Dec 2016, 25 Feb–18 Mar 2017	Based on previous studies in selected locations that identify Lao PDR as an important/potential wildlife trade hub (Nijman and Shepherd, 2012; EIA, 2015) and the scarcity of otter trade data, a country-wide survey was conducted across Lao PDR in which 50 locations were surveyed around the northern, central and southern regions of the country. Surveyed locations were selected based on findings of previous research into Lao PDR's illegal wildlife trade, which had identified them as important/potential wildlife trade hubs. In the northern part of the country, a wider variety of retail outlets were encountered and surveyed, and included public markets, shopping malls, street stalls, traditional medicine shops, hotel shops, tourist markets and tourist shops. In the central and southern parts of the country, only markets and street stalls were surveyed as these were most prevalent. Shops/markets were selected based on the general type of wildlife product observed openly for sale and visited opportunistically, meaning that no predetermined list of shops was used during the survey.
Myanmar	19–22 Jun 2017	Based on previous market surveys in Myanmar, two wildlife trading hotspots were identified for surveys i.e. Tachilek and Mong La. Tachilek was successfully surveyed in June. Mong La however was inaccessible during the survey time due to political issues there and no foreigners were allowed access to Special Region No. 4 where Mong La is located. Surveys were instead undertaken in neighbouring Kengtung. A roadside stall near the village of Parng Law was opportunistically observed with otter skins and this too was recorded.

Figure 1. Market survey locations in Cambodia, Indonesia, Lao PDR and Myanmar between 2016 and 2017

Source: TRAFFIC

Online Surveys

Based on the previous otter seizure report, five countries in Southeast Asia were selected for online surveys i.e. Indonesia, Malaysia, Philippines, Thailand and Viet Nam as seizures in these countries mostly involved live otters for the pet trade. Online surveys were conducted over a 19 week period, between 1 January and 13 May 2017, focussing on Facebook groups and commercial trade portals advertising otters for sale. Only advertisements posted from 1 January 2017 onwards were gathered. Surveys consisted of one hour of research per week, gathering as many adverts on otters as possible. Websites advertising otters for sale were identified using a search engine and searching for combinations of words like "otter", "sale", "buy", as applicable in the local language of each country. A similar method was used within Facebook to find groups in which trade of otters was likely to take place. Facebook groups were the main online market places that were looked at, with other commercial trade platforms only being looked at after Facebook groups had been surveyed. This protocol was maintained to maximise the number of advertisements that could be found in the allocated time.

Data extracted from each post/advertisement included location/base of operation of seller (if available), species of otter (accepted as stated where no pictures were provided), quantity, size and age of otters, price of item(s), method of communication and preferred method of payment. Posts/advertisements that did not display any intent of sale were left out of the data collection.

To avoid any inflation of numbers, care was taken to review every advertisement and eliminate all duplicates, including those that appeared with different dates. Different advertisements likely showcasing the same animals were marked as such i.e. estimations have been made both considering them as separate individuals and as the same individuals, to account for the fact that sometimes online traders re-use pictures for sale of different individuals. A distinction has also been made between actual number of otters advertised and where estimations have had to be made (not all posts/adverts relate the exact number of otters offered for sale). Estimations were based on the lowest number possible or counting them from pictures. For example, if a post advertised "otters" for sale without disclosing the numbers, a conservative estimate of a minimum and a maximum of two otters are recorded as being for sale.

RESULTS

Asian small-clawed otter

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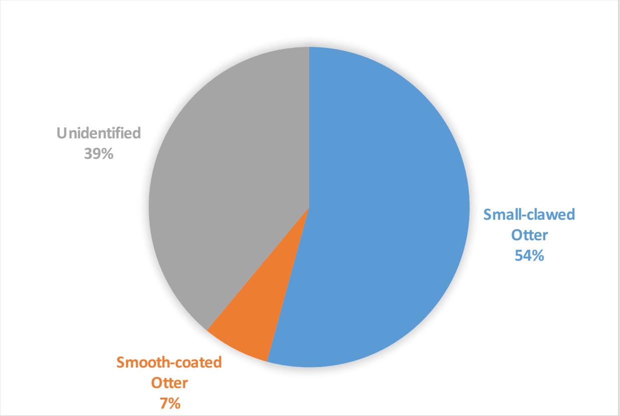
Seizure Data Analysis

A total of 13 seizure records were found between August 2015 and 2017. The majority of these occurred in 2017 (n=10 incidents) with only two occurring in 2016 and one in 2015. All seizures involved live otters amounting to 59 individuals. A relatively large number of juvenile otters were seized in these incidents (n=6 incidents amounting to 37 individuals). The Small-clawed Otter was the most frequent species seized (identified in at least seven incidents), the Smooth-coated Otter was identified in one incident and in five incidents, the species of otter seized was not reported (Figure 2).

There were only four countries in Southeast Asia that had recent records of otter seizures i.e. Indonesia, Malaysia, Thailand and Viet Nam (Table 4). These were the same countries identified in the previous otter seizure report as connected to a recent spike in the seizure of live otters i.e. the trade in live otters seemed to have begun in the early 2000s in Southeast Asian countries with numbers increasing in the four years (2011–2014) in terms of quantities being seized (averaging six individuals per seizure in comparison to previous years which averaged three to four individuals per seizure) (Gomez *et al.*, 2016).

Figure 2: Species of otter seized in Southeast Asia between August 2015 and 2017



Note: A total number of 59 seized specimens. Identification of species is based on information reported and is assumed to be accurate.

Country	No. of Seizures	Species	Quantity	Total
Indonesia	3	Smooth-coated Otter Unidentified	4 3	7
Malaysia	2	Small-clawed Otter	2	2
Thailand	5	Small-clawed Otter Unidentified	24 11	35
Viet Nam	3	Small-clawed Otter Unidentified	6 9	15
Total	**13**			**59**

There were at least five incidents indicating the international trafficking of otters for the pet market. Four of these occurred in Thailand and all in 2017 (n=2 incidents at Don Mueang Airport, Bangkok; n=1 incident at Suvarnabhumi Airport, Bangkok; and n=1 incident at Hat Yai Airport)—all three airports service international routes. In at least three of these incidents, Japan was the intended destination, with 10–12 otters seized within the personal luggage of Japanese passengers in each case. A Japanese national was arrested in one of these incidents and claimed to have bought the animals at the notorious Chatuchak weekend market (long known for the availability of wildlife being sold illegally) for THB15 000 (~USD475) with the intention of raising them as pets back home in Japan. In the fourth incident which occurred at Hat Yai Airport, two Small-clawed Otters were seized from an 18-year old passenger but the intended destination was not reported. The fifth incident occurred in Viet Nam in December 2015, in which a Vietnamese man was arrested in Ho Chi Minh City attempting to sell nine Small-clawed Otter pups and other wildlife species. He claimed to have smuggled the wild animals from Thailand to sell as pets in Viet Nam and is considered to be a member of a larger wildlife smuggling ring by the Vietnamese authorities who have fined him several times previously for selling protected wildlife (An, 2015).

In an additional incident which occurred in Indonesia, four Smooth-coated Otters were seized from a truck at the Soekarno-Hatta Port in Makassar. While the shipment reportedly originated from East Kalimantan, the intended destination, whether catering to a domestic market or international market, was unknown.

Comparing the data from the previous otter seizure report, most of the seizures in Southeast Asia took place in 2002 onwards (barring two incidents that occurred in Lao PDR in 1987 and 1999 which are not reflected in the figure below) (Figure 3). The data also include additional seizure records not included in the previous study as these were newly found records obtained after the study was completed. This involved four additional seizures for Cambodia that occurred in 2008 and 2009 of four live Hairy-nosed Otters; and eight additional seizures for the Philippines between 2002 and 2014 involving 20 Small-clawed Otters, although it was not reported whether these were of live or dead specimens.

In total, there were 67 seizure records involving 178 otters for the eight countries between 2002 and 2017. The data show that the number of otter seizures in Indonesia, Thailand and Viet Nam increased after 2016, with a notable rise in 2017, including in Malaysia, along with quantities of otters seized. Most of this was attributed to the three seizures in Thailand en route to Japan which, combined, totalled 32 live Small-clawed Otters.

Asian small-clawed otter

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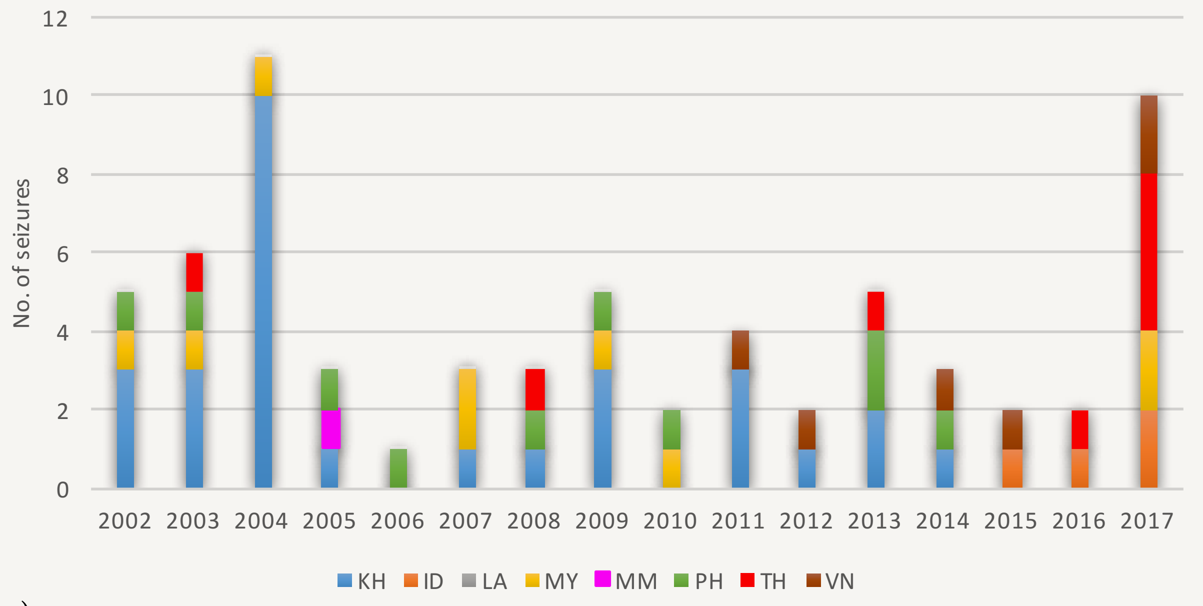
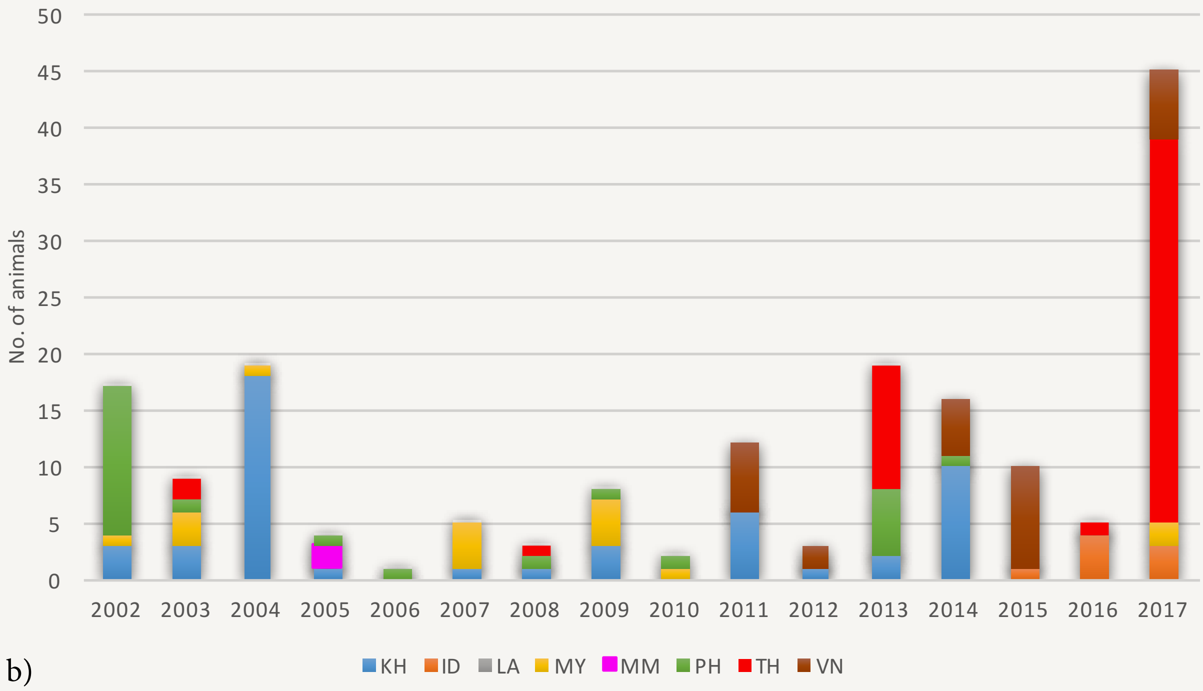
Figure 3. The number of (a) otter seizures per country and (b) quantity of otters seized per country from 2000 to 2017



a)



b)

Notes: KH - Cambodia, ID - Indonesia, LA - Lao PDR, MY - Malaysia, MM - Myanmar, PH - Philippines, TH - Thailand, VN - Viet Nam

Market Survey Analysis

Otters were found in all four countries surveyed, albeit in relatively small numbers (Table 5). This included five skins and two live otters, the majority of which were identified as Small-clawed Otter (n=5 specimens) followed by Eurasian Otter (n=2 specimens).

Table 5. The open availability of otters observed during the market surveys between 2016 and 2017 in selected countries.

Date	Countries	No. of locations	Species	Commodity	Quantity	Notes
11 Nov 2016	Cambodia	1	Small-clawed Otter	skin	1	Village elder's home in the town of Andoung Meas (Photo 1). He reported that it was an old piece of skin that he had had for several years, bought from a local hunter for USD50. He sold the skin in small pieces to people in the village in the belief that it assists with childbirth.
11& 22 Nov 2017	Indonesia	2	Small-clawed Otter	live	2	Wildlife traders in Serang (Photo 2) and Yogyakarta (Photo 3), Java. Juveniles between three and five months old being sold as pets, priced between IDR1.2million and 1.5million (USD90–115). Trader in Serang claimed the otter was captive-bred, and the trader in Yogyakarta claimed it was wild-caught.
22 Apr 2016 & 8 Mar 2017	Lao PDR	2	Small-clawed Otter	skin	2	One skin was found in Boten, drying on a clothes rack behind a row of shops. The owner of the skin was not known (Photo 4). The second skin was found in a traditional medicine stall in a wet market in Phonsavan (Photo 5). The stall owner was not around for further information to be obtained
20 Jun 2017	Myanmar	1	Eurasian Otter	skin	2	Two stuffed otters were found in a shop in Parng Law (Photo 6). They were for sale for medicinal use for MMK300 000 (USD224) each. According to the owner, he bought the otters from local hunters from the Akka tribe. He said he had had them for two years.

Photo 1. Dried skin of a Small-clawed Otter sold to women who believe it assists with childbirth by the village chief in Andoung Meas, Cambodia, 11 November 2016.

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Photo 2. A juvenile Small-clawed Otter for sale in a pet shop located in the town of Serang, Indonesia, 18 November 2017

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Photo 3. A juvenile Small-clawed Otter for sale in a pet shop at a wildlife pet market in Yogyakarta, Indonesia, 22 November 2017

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Photo 4. The skin of a Small-clawed Otter observed drying on a clothes rack behind a row of shops in Boten, Lao PDR, 22 April 2016

©O. Ching/TRAFFIC

Photo 5. The skin of a Small-clawed Otter observed at a traditional medicine stall in a wet market in Phonsavan, Lao PDR, 8 March 2017

© L. Gomez/TRAFFIC

Photo 6. Two stuffed Eurasian Otters observed for sale for medicinal use at a roadside convenience store in Parng Law, Myanmar on 20 June 2017

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Online Survey Analysis

A minimum of 560 advertisements were recorded over a four month period (this excludes any duplicates or re-posting of the same advert). The majority of these were recorded in Indonesia, followed by Thailand, Viet Nam and Malaysia (Table 6). The Philippines was the only country surveyed where no online advertisements were found over the study period.

Table 6. The number of online advertisements and estimated minimum and maximum number of animals involved

Country	No. of traders	No. of Adverts	Species	Min No. of animals	Est. Max No. of animals	Average
Indonesia	221	449	Small-clawed Otter	503	917	710
			Hairy-nosed Otter	1	1	1
Thailand	44	80	Small-clawed Otter	182	221	202
			Smooth-coated Otter	3	3	3
Malaysia	8	10	Small-clawed Otter	14	16	15
			Smooth-coated Otter	4	4	4
Viet Nam	7	21	Small-clawed Otter	12	12	12
			Unknown otter species	15	15	15
Total	**280**	**560**		**734**	**1189**	**962**

In Indonesia 221 sellers were identified, eight in Malaysia and 44 in Thailand. In Viet Nam seven sellers were identified of which one was an online fashion store and another was an online pet store. All advertisements for otters were observed on Facebook with the exception of the above two mentioned store advertisements in Viet Nam.

A minimum of 734 and a maximum of 1189 otters were observed for sale across all four countries. On average, the highest numbers of otters for sale were recorded in Indonesia, followed by Thailand, Viet Nam and Malaysia (Table 6). This consisted mostly of Small-clawed Otters (98%), followed by Smooth-coated Otter (1%) and Hairy-nosed Otter (n=1 individual). There were an additional 15 advertisements for individual otter fur coats for sale, exclusively in Viet Nam, but these could not be identified to species level and neither could their origins be determined (explained further below). Apart from these fur coats, all other advertisements were for live otters, accounting for 98% of the observed trade. Furthermore, the majority of advertisements were for juvenile otters (<12 months), averaging around three-months of age.

Eurasian otter

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There were 449 advertisements recorded for Indonesia, offering a minimum of 504 and a maximum of 918 otters for sale over the 19 week study period. Barring one advertisement selling a Hairy-nosed Otter, all other advertisements were for Small-clawed Otters (Photo 7). The majority of online traders appeared to be located around the provinces of West Java (42.6%), followed by Jakarta (21.7%) and Banten (18.2%) (Figure 4).

Photo 7. Advertisements for (a) Small-clawed Otter (b) Hairy-nosed Otter posted on Facebook in Indonesia

Otter 2 ekor usia 3 bulanan mandiri udah makan ikan. Jenis kelamin belum tau, masih hissing kama baru dapet anggap aja semi 340/ekor nego. Lokasi Balaraja Tangerang pin 5F273FD8 Wa 089696113168

Lutra/ Giant Otter/ anjing sungai
Rp 123
Kota Surabaya

Mau tanya harga berapa ya?

Photo 8. Advertisements for (a) Small-clawed Otter (b) Smooth-coated Otter on Facebook in Thailand

หน้าตาอาจจะกวนแต่ขี้เล่น ขี้อ้อนครับ😂
กินเก่ง พุงป่อง ตัดเล็บแล้ว
เครดิตเดียวกับ เย็น นม ครับ อยากเป็นพ่อค้ากะเค้าบ้างไรบ้าง 🙏🙏🙏

Most of the online advertisements in Thailand were from locations in Bangkok (39.6%) followed by Songkhla (27.1%) (Figure 4). The majority (90%) of otters offered for sale online however are reportedly sourced from the southern parts of the country (Department of National Parks (DNP) Thailand, pers comm, 2018). There were at least 80 advertisements recorded in Thailand offering a minimum of 185 and a maximum of 224 otters for sale over the study period (Photo 8). The majority of these were for Small-clawed Otters with only three animals identified as Smooth-coated Otters.

Figure 4: Location of online traders recorded in Indonesia, Malaysia, Thailand and Viet Nam between January and April 2017.

In Viet Nam, 21 advertisements were recorded over the study period. Six of these were for Small-clawed Otters amounting to at least 12 animals. A further 15 advertisements were for otter fur coats offered for sale by an online fashion store (Photo 9). It is impossible to tell from the advertisements whether the coats were made from genuine otter fur let alone from which otter species. There were also no other details regarding origins i.e. whether these were produced locally or imported (e.g. otter coats are manufactured and traded legally from North America). There were only ten advertisements from Malaysia (Photo 10) over the study period offering a minimum of 18 and a maximum of 20 otters for sale. Two of these were for Smooth-coated Otters and the remaining were for Small-clawed Otters. In comparison to Indonesia and Thailand, the demand for otters as pets seems to be relatively low in scale in Malaysia and Viet Nam.

Photo 9. Advertisements for (a) otter fur coat (b) Small-clawed Otter for sale in Viet Nam

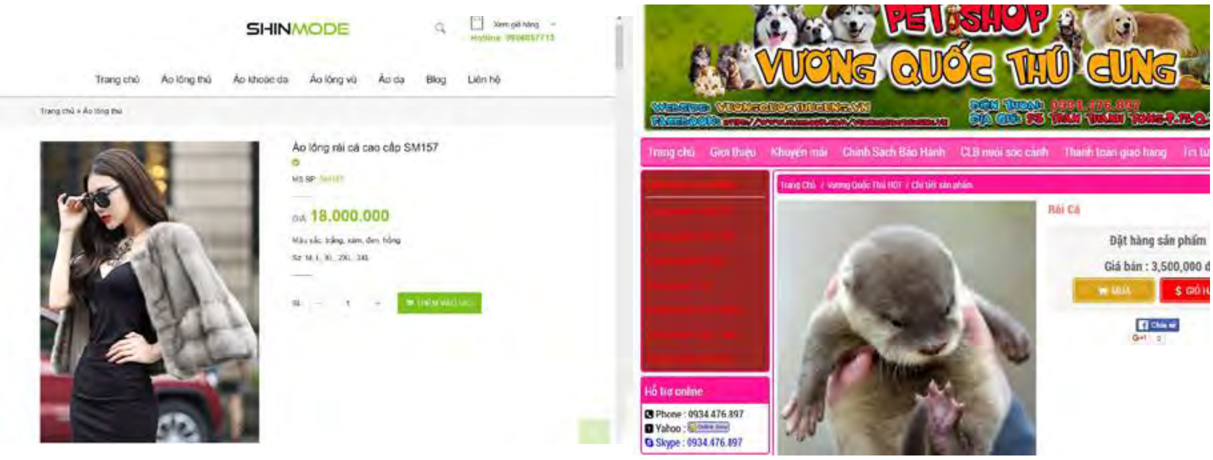
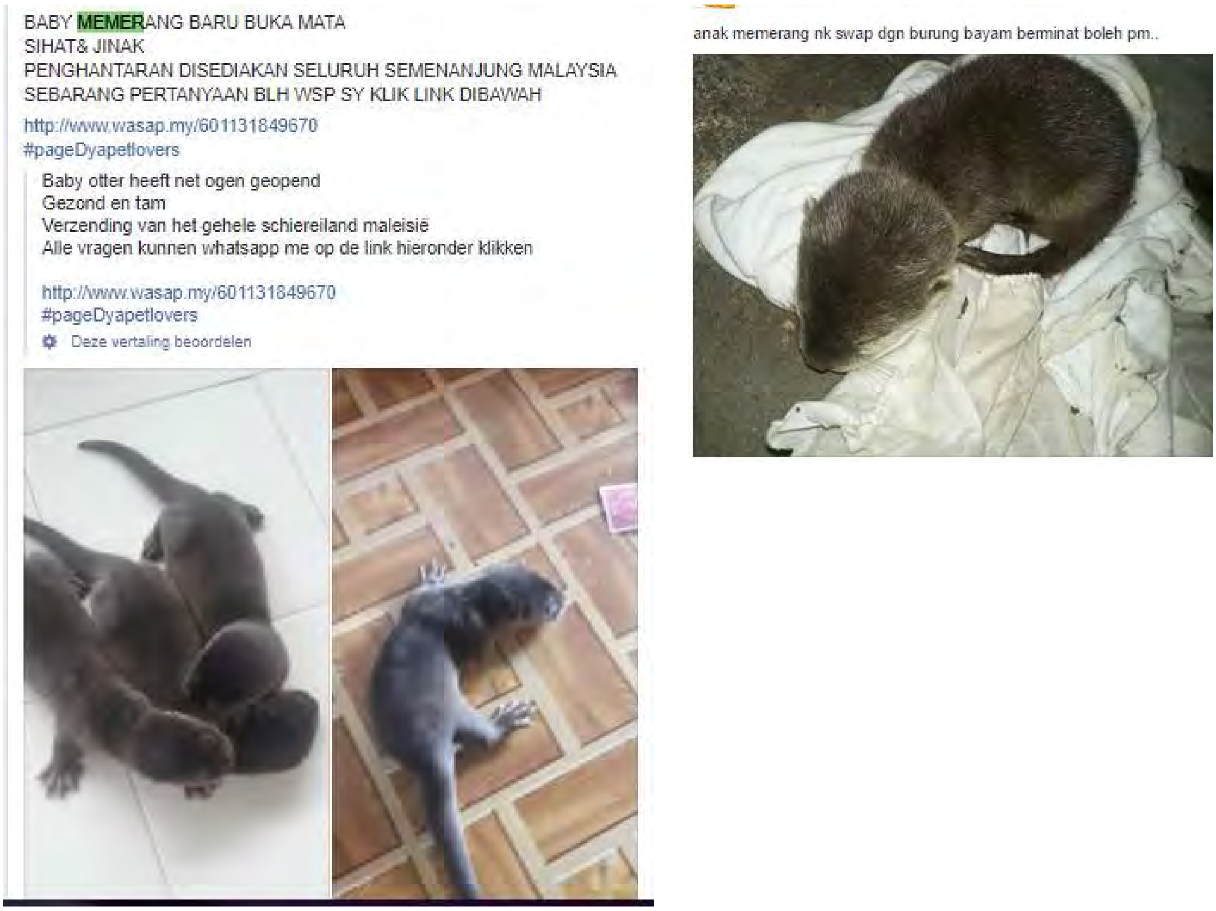


Photo 10. Advertisement of (a) Smooth-coated Otter (b) Small-clawed Otter for sale on Facebook in Malaysia



BABY MEMERANG BARU BUKA MATA
SIHAT& JINAK
PENGHANTARAN DISEDIAKAN SELURUH SEMENANJUNG MALAYSIA
SEBARANG PERTANYAAN BLH WSP SY KLIK LINK DIBAWAH
http://www.wasap.my/601131849670
#pageDyapetlovers

Baby otter heeft net ogen geopend
Gezond en tam
Verzending van het gehele schiereiland maleisië
Alle vragen kunnen whatsapp me op de link hieronder klikken

http://www.wasap.my/601131849670
#pageDyapetlovers

Deze vertaling beoordelen

anak memerang nk swap dgn burung bayam berminat boleh pm..


© Duplaix

Hairy-nosed otter

DISCUSSION

The primary threat to otters in Southeast Asia from the illegal wildlife trade would appear to be exploitation for the pet industry, evident through the seizure and online data analysis which revealed the relatively high demand for live otters, a large proportion of which were juveniles. The Small-clawed Otter was the species most encountered during this study i.e. it was the species with the highest number of online advertisements with over 900 individual animals recorded over the space of four months and a survey effort of one hour per week (Table 6). It was also the most seized species and the one most encountered during the market surveys.

Indonesia and Thailand appear to play the most active role of source and demand countries for otters in the region. The pet industry in both countries is flourishing. Indonesia dominated, by a high margin, in the number of online advertisements for otters in comparison to the other countries assessed. Here, there are numerous "pet lovers" groups on Facebook dedicated to otters i.e. in February 2018, at least 14 groups were observed specifically dedicated to the keeping of otters with a combined number of 19 514 members. While few otters were observed for sale during the market surveys, traders expressed a willingness to acquire otters for the right price. Several traders claimed to have sold otters in the months preceding the market surveys. At least five traders claimed that otters were sourced from the wild as well as bred in captivity but the latter could not be verified. One wildlife trader at the Sukahaji Market in Bandung in West Java believed that all otters were captured from the wild, caught by local people using targeted otter traps. He also claimed previously to breed otters for the pet trade but had since switched to the more profitable trade in birds. It is possible there may be some limited breeding of otters taking place although the scale of this cannot be quantified. It would appear to be cheaper to trap wild otters than breed them; in addition, there did not appear to be a steady supply of otters into the pet markets visited, suggesting that breeding was not actively and consistently supplying the market.
While Indonesia is home to four species of otters, under the current wildlife

laws, only the Eurasian Otter and Hairy-nosed Otter are listed as protected species. That said, both the Small-clawed Otter and Smooth-coated Otter, are technically afforded some level of protection under *Regulation of the Minister of Forestry No. 447/Kpts-II/2003 concerning administration directive of harvest or capture and distribution of the specimens of wild plant and animal species* which governs the hunting and/or harvesting of non-protected species. Within this Regulation, yearly provincial quotas are set for all animals that can be captured in the wild. No harvest quotas have been established for either of the two unprotected otter species found in Indonesia and therefore it should technically be illegal to hunt/or trade in these two species.

In Thailand, the Wildlife Friends Foundation, a non-governmental organisation that rescues captive animals, has steadily been receiving calls from owners seeking healthcare for their pet otters or refuge for unwanted pets, reportedly purchased from captive-breeders or off social media sites (WFFT, 2017). Exotic pet cafes (that display wildlife) have also become more prominent in Thailand (Yee, 2017), which could be fuelling the demand for exotic animals like otters. All four otter species are completely protected in Thailand and under current legislation they cannot be hunted, traded, owned, propagated/bred, imported or exported. Yet there seems to be little control or enforcement action taking place given their easy and open availability on social media. Much like Indonesia, there are unverified accounts of otter captive-breeding facilities that supply the market demand in Thailand. However, the DNP reports that there are no legal otter farms in the country and that only zoos have permits to keep otters (DNP Thailand, pers *comm*., 2018).

Both Indonesia and Thailand are also implicated in the trafficking of otters to Japan. There were three seizures in Thailand alone of 32 live otters en route to Japan. Small-clawed Otters have also been observed for sale at exotic pet shops and reptile fairs in Japan (TRAFFIC, unpubl. data). In January 2018, a spot survey of Japan's biggest reptile fairs found two adult Small-clawed Otters for sale for JPY1.7mil/pair (~USD13 000) and three pups for JPY950 000/pup (~USD7 200). The seller claimed the two adults were a breeding pair and that the pups were bred domestically, although not from the two adults on display (Keiko Wakao and Tomomi Kitade, TRAFFIC, pers *comm*., 2018). Additionally, there was one pet shop in Tokyo that reported to import captive-bred otter pups from what was claimed to be the only government approved otter breeding facility in Indonesia (Keiko Wakao and Tomomi Kitade, TRAFFIC, pers *comm*., 2018). However, upon further questioning of staff at the shop regarding the licensed facility, the response received raised doubts as to whether the pups were actually bred in captivity or taken from wild parents and raised in captivity, making them illegal specimens.

In 2016, there were at least three records in the CITES Trade Database showing the export of captive-bred Small-clawed Otters from Indonesia; two were to Japan (eight animals reported to be for commercial and personal purposes), and one to China (six animals for commercial purposes). The existence or otherwise of a licensed captive-breeding facility in Indonesia is yet to be verified. However, given there are no harvest quotas for wild otters in Indonesia, it is highly questionable how parent stock would have been obtained for any captive-breeding facility. This is further compounded by loopholes in Japan's wildlife law i.e. the Law for the Conservation of Endangered Species of Wild Fauna and Flora (LCES), which only protects species that are listed in CITES Appendix I. There are no provisions in the law to take action against traders who illegally import and subsequently trade in CITES Appendix II species, like otters, once they are in the country. This also means that Japan is unable to implement and comply with CITES requirements effectively to regulate non-native CITES-listed species entering international trade.

There seems to be minimal open trade of otters in physical markets in Indonesia, Cambodia and Lao PDR. Despite the extensive areas covered during the market survey (with the exception of Myanmar), very few otters were observed openly for sale. This could be due to depleted otter populations in the wild as noted by Duckworth and Hills (2008) in Cambodia, Lao PDR and Myanmar. It could also be due to successful enforcement efforts in some areas. Conservation NGOs like Wildlife Alliance in Cambodia and Scorpion in Indonesia for example have been active in supporting enforcement efforts to curb the poaching and trafficking of protected species. Cambodia had the highest recorded number of otter seizures compared to any other Southeast Asian country between 2001 and 2014. In Indonesia, at least three traders remarked during the market survey that they no longer sold otters as they were considered to be protected species. In Cambodia, however, recent research by the Wildlife Conservation Society (WCS) on otter populations around the Tonle Sap area in 2015–2016, found that otters were the fifth most mentioned animals that traders could capture there (the first four all being reptiles) and these were typically reported to be traded to China through Viet Nam, with little domestic demand for otters (Mahood and Brooks, *in prep.*). This is concerning considering neither the Small-clawed Otter nor the Smooth-coated Otter are protected in Cambodia. They also note that while traders could generally supply otters on demand, the trade in otters in Cambodia has declined in recent years in both quantity and price. Similar findings were observed by Coudrat (2016) in a preliminary assessment of otter populations in the Nakai-Nam Theun National Protected Area in Lao PDR, who stated that trapping pressure on otters has reduced to a certain extent due to less demand for otter skins, although they are still targeted by Vietnamese hunters.

While Malaysia, Myanmar, the Philippines and Viet Nam were implicated in the illegal trade of otters, numbers of otters in trade recorded were small, mostly to supply the pet trade and to a lesser extent trade in skins (in reference to the two stuffed observed for sale in Myanmar and online advertisements of otter fur in Viet Nam). Overall trade data, whether from seizures, market surveys or online surveys, were however insufficient to draw any firm conclusions as to the extent of otter trade in these countries.

Smooth-coated otter

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CONCLUSION & RECOMMENDATIONS

Smooth-coated otter

This assessment provides a snapshot of the commercial exploitation of otters taking place both domestically and internationally in clear violation of national laws and CITES regulations, with a large proportion of the trade apparently feeding a local demand within Southeast Asia. While few otters were observed in the markets, the online trade in otters is clearly considerable and appears to be the most immediate threat. The open nature of the observed online trade clearly shows a blatant disregard for national legislation and regulations. Otters' popularity as pets, especially Small-clawed Otters, is a concern, particularly in Indonesia and Thailand. This flourishing demand is not just illegal, but a potential threat to the long-term survival of wild otter populations. Regarding international trade, the trafficking of otters from these countries to Japan is especially concerning considering loopholes in Japanese law that prevent enforcement action. Unsurprisingly, there are few data available on the four otter populations that would allow understanding of population sizes or densities in the wild. This makes it difficult to determine how significantly otters are being impacted by trade. However, with the relatively high frequency (that is potentially increasing) of the trade in live animals, combined with the loss of suitable habitat, the impact of pesticides on wetlands and human–otter conflict, the trade is likely a risk to the long-term survival of remaining wild otter populations in Southeast Asia. In light of this, and the findings from this study, TRAFFIC makes the following recommendations:

Legislation

As all four otter species in Southeast Asia are listed in either CITES Appendix I or II, it is imperative that national legislation offers appropriate protection that enables the regulation of international trade. The high level of online trade observed in Indonesia, along with reported exports of captive-bred specimens, warrants the species to be regulated and protected by national legislation. *Government Regulation No. 7/1999 on Preservation of Flora and Fauna*, which is currently undergoing revision, should list both the Small-clawed Otter and the Smooth-coated Otter as protected to prevent illegal hunting, trade and possession of these species. While Indonesia has regulations in place to control the trade of unprotected species by setting annual harvest quotas, there are no provisions in the law regarding penalties or fines against those found in violation of these quotas. *The Wildlife and Wild Plants and Conservation of Natural Areas Law (1994*) of Myanmar should list the Hairy-nosed Otter as a protected species. Although it is uncertain whether the species naturally occurs in the country, observations of trade in markets in Myanmar is an indication of international trade in a non-native CITES listed species, for which regulation is necessary. The removal of Small-clawed Otter and the Smooth-coated Otter as protected species in 2007 from Cambodia's *Law on Forestry* (2002) should be rectified, and the species should be afforded protection, as without it, illegal harvest and trade cannot be regulated.

National legislation in all countries should also include provisions to regulate online wildlife crime; this would also be in line with CITES Decision 17.92[3] on Combating wildlife cybercrime. The seriousness of the illegal trade should be reflected in both wildlife and online trade laws, particularly through high penalties for any transgressions of the law. Online trade undermines law enforcement efforts and complicates efforts to take regulatory action. Strong penalties could favour law enforcement agencies by serving as a strong deterrent, especially as online trade also encourages opportunistic trade, which should be weeded out.

Regulation and Law Enforcement

The high levels of online trade, particularly in Indonesia and Thailand, signal the need to enhance pro-active investigation into the growing demand and online trade of otters as pets. Despite their protected status in most countries, otters are not only widely available, but easy to purchase. Arrests and seizures arising from online trade, for a range of species, are taking place in many Southeast Asian countries, but it is imperative that these arrests are followed through with investigations to determine players involved along the trade chain, from source to supply.

Claims of the existence of captive breeding activities taking place in Indonesia and Thailand need investigation and verification. Given there are no harvest quotas for wild otters in Indonesia, it should be made clear and transparent how parent stock is obtained for commercial breeding of otters.

Law enforcement knowledge and capacity should be enhanced across Southeast Asian countries to enable investigations, arrests and convictions of criminals trading in protected species to the full extent of the law. TRAFFIC and the IUCN Otter Specialist Group stand ready to assist relevant enforcement agencies in providing enforcement support and training with regards to identification of otter species and body parts, including distinguishing between the skins of the different otter species. Increasing the capacity of local law enforcement agencies has yielded positive results in curbing illegal trade of wildlife.

Collaboration between enforcement agencies in Indonesia, Malaysia, Thailand and Viet Nam should be enhanced to curb the illegal trading of wildlife occurring online. Incidents of illegal trade should be reported to the relevant law enforcement agencies for action. Alternatively, reports can be made

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[3] https://www.cites.org/eng/dec/valid17/81840

directly to TRAFFIC, via the Wildlife Witness App which can be downloaded for iPhone https://itunes.apple.com/us/app/wildlife-witness/id738897823?mt=8) or Android (https://play.google.com/store/apps/details?id=com.taronga.wildwitness). If taking place on Facebook, a direct report there is in line with Facebook's Community Standards via its policy against any illegal activity, including wildlife crime (https://www.facebook.com/help/181495968648557?ref=communi%20ty_standards). Reports can involve posts, messages, groups and other elements that can be a violation of legislation.

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Future Research

Conservation organisations, particularly those focussing on wetland conservation, and research institutions should continue monitoring and reporting on any trade and demand for otters in Southeast Asia. This will not only support enforcement efforts but aid in the effort to understand better and gauge levels of illegal offtake and trade and detect emerging trends. This will also help guide and shape enforcement actions, conservation actions, decision making, and policy interventions.

Further research by conservation organisations, particularly those focussing on wetland conservation, and academic institutions is urgently needed into the status of wild populations of otter species in Southeast Asia to establish national conservation threat levels and guide conservation and law enforcement actions. This should also be increased at known strongholds of otter populations (e.g. southern regions of Thailand, Prek Toal conservation area in Cambodia, Nakai-Nam Theun National Protected Area, Lao PDR, etc).

Considering their threatened status in Southeast Asia, along with incidents of international trade (including from TRAFFIC's previous analysis of otter seizures from 1980–2015), the Parties to CITES should decide whether the up-listing of otters, from Appendix II to Appendix I is merited against criteria under the CITES.

Public Awareness

Given that the observed trade is mostly illegal, governments and non-governmental organisations (NGOs) are encouraged to raise awareness and educate the public about the consequences of capture and trade of otters, particularly as online trade appears actively to target young animals for the pet trade. Arrests and criminalisation of those found to be hunting or trading in otters illegally should be publicised, along with the penalties being meted out, to serve as a deterrent to other would-be offenders.

Given the high demand in Indonesia and Thailand, governments and conservation organisations there are urged to explore and pursue avenues to educate consumers and reduce the demand for otters as pets. This may warrant the implementation of long-term consumer behaviour change campaigns on the live animal trade.

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Hairy-nosed otter

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