Accounting for conservation: Using the IUCN Red List Index to evaluate the impact of a conservation organization

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A B S T R A C T

Global and project-level biodiversity indicators have received considerable attention, but indicators of the conservation actions and impacts of programmes and institutions appear to be under-developed. The IUCN Red List Index (RLI) has potential to be a useful indicator at an organizational-level to evaluate long-term impact of conservation on the extinction risk of species, thereby supporting institutional decision-making and communications. However, it has not yet been tested for its utility in tracking changes in extinction risk of a set of species targeted specifically by an individual conservation agency. Here, we examine the feasibility of using the RLI as one metric of the conservation impact of the Durrell Wildlife Conservation Trust, a conservation charity which runs multi-decadal programmes on a modest number of globally threatened terrestrial vertebrate species. Of 17 target amphibian, bird and mammal species, eight underwent improvements in Red List category (reductions in extinction risk) owing to conservation. This drove a 67% increase in the value of the Red List Index between 1988 and 2012. This contrasts with a 23% decline in a counterfactual RLI showing projected trends if conservation had been withdrawn in 1988. For organizations that target sets of species with circumscribed geographic distributions and that are regularly assessed by the IUCN Red List, the RLI is a useful indicator for measuring and demonstrating long-term conservation impact to technical and non-technical audiences.

1. Introduction

Monitoring and evaluation is an increasingly integral component of biodiversity conservation practice and policy. It enables the setting of management and policy objectives, adaptation of interventions, measurement of effectiveness and demonstration of results to donors, supporters and other stakeholders (Yoccoz et al., 2001; Stem et al., 2005; Sutherland et al., 2010; Jones et al., 2013). It requires the development of individual and sets of indicators, the desirable properties of which depend on the monitoring objectives (Jones et al., 2013). In general terms, however, indicators should be scientifically robust, objectively verifiable, practical to implement, cost-effective and easy to communicate to non-technical as well as technically-minded audiences. Indicators that are scalable between (and therefore informative at) different levels of conservation implementation such as projects, programmes and institutions, nationally and globally are particularly valuable. Whilst the development of indicators at global and project-levels has received much attention (e.g. Conservation Measures Partnership’s Open Standards for the Practice of Conservation (CMP, 2004); Cambridge Conservation Forum’s Harmonizing Measures of Conservation Success (Kapos et al., 2008)), indicators of conservation actions, outputs and impacts at programme and institutional-levels appear to be particularly under-developed.

An important suite of policy-relevant indicators (Walpole et al., 2009) was developed to measure biodiversity status, threats and responses at the global-level in response to the Convention of Biological Diversity’s target to reduce the rate of biodiversity loss by 2010 (and these indicators were used to demonstrate that it was not met: Butchart et al., 2010). These formed the basis for a revised set (CBD, 2010a) recommended for tracking progress against the 20 ‘Aichi Targets’ in the CBD’s Strategic Plan on Biodiversity (CBD, 2010b). Among these, Target 12 states that “By 2020, the
extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained" (CBD, 2010b). The principal indicator used to report on progress towards this target is the IUCN Red List Index (RLI), which shows trends over time in the aggregate extinction risk of sets of species (Butchart et al., 2004, 2005, 2007).

The RLI is calculated from data in the IUCN Red List of Threatened Species (IUCN, 2013a), which is considered the most authoritative and objective system for categorizing the extinction risk of taxa (Hambler, 2004; de Grammont and Cuárón, 2006; Rodrigues et al., 2006). Species are assessed against criteria with quantitative thresholds for geographic range and population size, structure and trends (IUCN, 2012) and then assigned to categories of extinction risk (ranging from Least Concern through to Critically Endangered and Extinct). The RLI is based on the proportion of species that move through the IUCN Red List categories between periodic assessments, either away from or towards extinction, as a result of genuine improvements or deterioration in status. It excludes changes in category resulting from taxonomic revisions, changes to the IUCN Red List criteria, or improvements in knowledge (Butchart et al., 2004, 2006b, 2007). Index trends therefore relate to how survival probability of a set of particular species changes over time.

Global RLIs showing trends in extinction risk for all species within a particular taxonomic group have been calculated for the world’s birds (Butchart et al., 2004, 2010; BirdLife International, 2013b), amphibians (Stuart et al., 2004), mammals (Schipper et al., 2008), and warm water reef-building corals (Carpenter et al., 2008), bringing global attention to the concerning declines in amphibians and corals in particular. However, there are no other groups in which all species have been assessed against the IUCN Red List criteria at least twice, although reassessments of all conifers, cycads, mangroves, seagrasses, cartilaginous fishes, lobsters, crayfish and freshwater crabs are planned or underway (IUCN, 2013b). Further, hyperdiverse invertebrate orders such Coleoptera, Diptera and Hymenoptera are particularly under-represented within the Red List (Cardoso et al., 2012), although regionally comprehensive assessments are now underway for some groups within the latter, and for other invertebrate groups. To account for the under-representation of these and other highly speciose and poorly known taxonomic groups a sampled approach to red listing has been developed (Baille et al., 2008; Lewis and Senior, 2011), through which a representative sample of species have been assessed for reptiles, fishes, butterflies, dragonflies, and plants (monocots, legumes, bryophytes and ferns), with other invertebrate assessments underway. Repeated assessments will allow sampled RLIs to be developed in due course (IUCN, 2013b).

National RLIs have also been developed based on repeated application of the Red List categories and criteria at a national scale in order to assess national extinction risk, including for Australia (Szabo et al., 2012), Sweden (Gärdenfors, 2010), Finland (Juslen et al., 2013) and Paraguay (López, 2011). Global RLIs have been disaggregated to show trends in different biogeographic realms (Butchart et al., 2004, 2005), for different taxonomic groups (BirdLife International, 2013a), in relation to different international agreements (e.g. Ramsar Convention on Wetlands, the Agreement on the Conservation of Albatrosses and Petrels: BirdLife International, 2013a; UN Millennium Development Goals: UN, 2013), to show the contribution of different threats (Butchart, 2008; McGeoch et al., 2010; Almond et al., 2013), to assess the effectiveness of protected areas (Butchart et al., 2012), and to quantify the impact of conservation action (Hoffmann et al., 2010).

The latter study contrasted RLIs for birds, mammals and amphibians with alternative ‘counterfactual’ RLIs that excluded those improvements in status driven by conservation interventions that led to species being downlisted to lower categories of extinction risk. The magnitude of this difference underestimated the impact of conservation as it does not take into account species which would have deteriorated in status without conservation efforts (Hoffmann et al., 2010). To fully evaluate the impact of conservation actions, it is necessary to ask what would have happened if there had been no intervention, i.e. a counterfactual outcome that is not observed (Ferraro and Pattanayak, 2006). A counterfactual approach to programme impact evaluation has been broadly lacking within the conservation sector, hampering efforts to properly assess the outcomes of conservation funding programmes, intervention types, projects and institutions (Ferraro and Pattanayak, 2006).

A number of impact evaluation methods are available to disentangle the effects of the intervention from the wider dynamics of the system, including randomized controlled trials and quasi-experimental designs such as “natural” experiments (e.g. Rosenzweig and Wolpin, 2000), instrumental variable methods (e.g. Edmonds, 2002) and matching (e.g. Clements et al., 2014). However, many barriers to implementing such experimental approaches often exist, including programme resource levels, ethical considerations, non-random allocation of treatment units, lack of available controls, lack of data, among many others (see Ferraro and Pattanayak, 2006). An alternative when these experimental options are not possible is to construct counterfactual scenarios based on target species population histories, threat levels and the socio-economic and management context of the programme just before the intervention commenced to predict the counterfactual outcomes for species in the absence of conservation (e.g. Butchart et al., 2006a).

Given its scalability and objectivity, the RLI has potential to be a useful indicator at an institutional level to help assess organizational conservation impact, inform institutional decision-making, and to provide evidence to donors and other institutional stakeholders of the ‘return on their investment’. However, the RLI has not yet been used to track extinction risk in a set of species targeted specifically by an individual conservation agency, or with reference to a counterfactual scenario in this way. Here, we aim to test the feasibility of employing the RLI on a modestly sized set of species as a metric of institutional-level conservation impact, using Durrell Wildlife Conservation Trust as a case study. This international charity focuses on the conservation of globally threatened terrestrial vertebrate species and is characterized by running intensive multi-decadal conservation programmes on a relatively small number of species. We discuss the benefits and limitations of using the RLI for this purpose and examine in what contexts the approach may be effective.

2. Materials and methods

2.1. The institution and species selection

The Durrell Wildlife Conservation Trust (Durrell) is a non-profit organization based in Jersey, Channel Islands, whose mission is ‘saving species from extinction’. It runs long-term field programmes targeting globally threatened terrestrial vertebrate species on island ecosystems (www.durrell.org). For example, Durrell has been running programmes in Madagascar for over 25 years and in Mauritius for over 35 years. Over its history, Durrell has led, or supported a national-level partner organization to conduct, species-specific conservation interventions on 53 vertebrate species, including fish (n = 1), amphibians (n = 2), reptiles (n = 17), birds (n = 16) and mammals (n = 17), for which detailed documentation exists. Durrell has also previously run field-based programmes on approximately 10 other species which are insufficiently documented to consider in this study.
Here, we define species-specific interventions as: (1) habitat protection, management and restoration (that explicitly accounts for the conservation needs of a target species, e.g. by establishing or zoning a protected area based on the distribution of a target species); (2) invasive alien species management (when conducted to directly benefit a target species to e.g. reduce nest predation rates by invasive species); (3) anti-poaching patrols to reduce rates of poaching of target species; (4) reintroduction back to the wild and translocation from wild populations to new sites; (5) supplemental feeding of target species; (6) nest site provision/management through the establishment and maintenance of nest boxes; (7) disease management where individuals of target species are captured, examined and treated for infection if required; (8) ‘head-starting’, i.e. harvesting eggs or young individuals and captive rearing them through a risky life stage before release back to the wild; and (9) captive breeding programmes (if animals are released back into the wild as part of multi-annual releases complemented by long-term in-situ management actions). More information on the different conservation actions conducted for each of the species included in this analysis is given in Table A1.

For the purposes of this study, we only included those species for which Durrell or a national-level partner organization has implemented long-term (>10 years), intensive and sustained conservation efforts across all or the majority (>50%) of the species’ range. National-level partners were either national NGOs or government departments with which Durrell forms a long-term strategic partnership to assist in the leadership and delivery of conservation programmes and to develop institutional capacity. The period of >10 years was chosen to be in line with the minimum time period over which population trends are assessed under IUCN Red List criteria (i.e. 10 years or 3 generations, whichever is longer). We chose a standard threshold for determining long-term, rather than using species-specific periods of three generation lengths because, for the longer-lived species, programmes would have to be run for nearly 30 years to be considered long-term. Further, because trends from 10 years can be extrapolated to a rate over three generations for application to the Red List criterion thresholds, following IUCN (2012). The species in the study have a mean generation length of 5.7 years, ranging between 3.6 (e.g. Mauritius fody Foudia flavicax; Rodrigues fruitbat Pteropus rodericanus; Rodrigues warbler Acrocephalus rodericanus); Madagascar (Alaotran gentle lemur Helamur alaotrensis; Malagasy giant jumping rat Hypogeomys antimena; Meller’s duck Anas melleri; Narrow-striped mongoose Mungoictis decemlineata; Meller’s duck A. melleri), Brazil (Black lion tamarin; Golden lion tamarin Leontopithecus rosalia; India (Pygmy hog Porcula salvania), and Spain (Malorcan midwife toad Alytes muletensis) (Fig. 1). The main threats to the target species were invasive species, habitat loss driven by agriculture and logging, and hunting, with the relative importance of these threats varying between locations (see Fig. 2a and Table A1 for more information on the different threat types). The main national-level partners (or international partners with permanent national-level programmes) for each species are given in Table 1.

2.2. Calculating the Red List Index

Red List categories and the associated documentation were taken from IUCN (2013a) and BirdLife International (2013b). The RLIs were calculated following the methodology outlined in detail by Butchart et al. (2007). In summary, index values were calculated from the number of species in each IUCN Red List category in a particular assessment year multiplied by a category weight (5 Extinct/Extinct in the wild; 4 Critically Endangered; 3 Endangered; 2 Vulnerable; 1 Near Threatened; 0 Least Concern). The sum of the scores is then expressed as a fraction of the maximum possible sum (the score obtained if all species had gone extinct) such that an overall score of 0 on the RLI would mean that all species in the set are extinct, whereas a score of 1.0 equates to all species being Least Concern, i.e. that none are expected to become extinct in the near future. The numbers of species in each category for years prior to the most recent assessment were calculated based on the number of species that underwent genuine status changes in each time period between assessments.

We followed Hoffmann et al. (2010) in determining which of Durrell’s target mammal, bird and amphibian species have undergone Red List category changes owing to genuine improvements or deteriorations in status. Hoffmann et al. (2010) used the current Red List criteria and retrospectively applied them to all mammal, bird and amphibian species back to the year in which they were first assessed. This effectively excluded changes in the Red List category of species and therefore the RLI trends that were as a result of changes in Red List criteria rather than the changes to the status
Table 1: Species targeted by Durrell with information on the duration of the conservation intervention, Durrell’s role within the programme and the national-level partners. The current Red List category along with the estimated counterfactual 2012 Red List category, which assumes all Durrell-led or supported conservation actions had ceased in 1988, are indicated. For those species undergoing a genuine status change the relevant previous Red List categories are also given (from Hoffmann et al. (2010)).

<table>
<thead>
<tr>
<th>Species, programme duration and role of Durrell within partnership</th>
<th>Current and counterfactual Red List categories. For species undergoing status change the adjusted Red List category history is given (from Hoffmann et al. (2010)).</th>
<th>Reasons for 2012 counterfactual Red List category</th>
</tr>
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<tbody>
<tr>
<td>Mauritius kestrel <em>Falco punctatus</em>. 1976-ongoing. Programme partner focusing on in-situ population management, captive breeding, research and capacity building; provision of strategic, technical and financial support to MWF. Other local partner: NPCS</td>
<td>CR</td>
<td>EN VU VU EX</td>
</tr>
<tr>
<td>Echo parakeet <em>Psittacula eques</em>. 1986-ongoing. Programme partner focusing on in-situ population management, captive breeding, research and capacity building; provision of strategic, technical and financial support to MWF. Other local partner: NPCS</td>
<td>CR</td>
<td>EN EN EX</td>
</tr>
<tr>
<td>Meller’s duck <em>Anas melleri</em>. 1988-ongoing. Lead implementing agency. Main local partner: DREF</td>
<td>VU</td>
<td>EN EN</td>
</tr>
<tr>
<td>Olive white eye <em>Zosterops chloronothos</em>. 1990-ongoing. Strategic, technical and financial support to MWF. Other local partner: NPCS</td>
<td>CR</td>
<td>CR CR</td>
</tr>
<tr>
<td>Pink pigeon <em>Nesoenas mayeri</em>. 1982-ongoing. Programme partner focusing on in-situ population management, captive breeding, research and capacity building; provision of strategic, technical and financial support to MWF. Other local partner: NPCS</td>
<td>CR</td>
<td>EN EN Ew</td>
</tr>
</tbody>
</table>

Captive breeding and release programmes would either not have happened or occurred much later through another agency. Despite impacts from invasive predators at several isolated populations, the species was found in 13 gorse locations (Buley and Garcia, 1997) and is predicted to have persisted in the wild until 2012. Probable criteria met: B2ab (iv)

Ceasing invasive predator control in Black River Gorges NP is likely to have led to elevated nest predation rates and lower productivity. Captive breeding and release onto Ile aux Aigrettes would not have happened. In 1988, the wild population was estimated at 100–200 pairs and so we predict the population would have persisted until 2012 (Safford and Jones, 1998). Probable criteria met: D

Ceasing invasive predator control, nest site protection and nest box provision would have resulted in high juvenile mortality and low productivity in remaining Black River Gorges population. Ceasing captive breeding and release programme means the reestablishment of a population in Bambous Mountains in eastern Mauritius would not have happened. In 1988, an estimated 60 individuals were in the wild (C. Jones, pers. comm.) and therefore we predicted it would have become EX by 2012

Ceasing invasive predator control, provision of nest boxes, and supplementary feeding in Black River Gorges and stopping the captive breeding and release programme would have resulted in very low productivity and downward population trends. Only 25 birds were left in the wild in 1988 (C. Jones, pers. comm.) and therefore we predicted the species would have become EX by 2012

Captive breeding would not have happened but this would not have affected wild population as no animals released back to wild (from Durrell or any other institution). No site protection and development of local management plans is likely to have led to losses of local populations but no clear evidence the species would have met any CR criteria. Probable criteria met: C2a (ii)

Captive breeding would not have happened but this would not have affected wild population as no animals released back to wild (from Durrell or any other institution). No site protection and development of local management plans is likely to have led to losses of local populations but no clear evidence the species would have met any CR criteria. Probable criteria met: C2a (ii)

Probable criteria met: C2aii

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<tr>
<td>Rodrigues fody Foudia flavicans. 1982-ongoing. Programme partner focusing on captive breeding, research and capacity building; provision of strategic, technical and financial support to MWF. Other local partner: NPCS</td>
<td>EN VU NT Ew</td>
<td>Ceasing habitat protection and restoration would have significantly jeopardized the population recovery. Only 5–6 pairs left in wild in 1968 (Impey et al., 2002) and probably not significantly above 100 birds in 1988 (C. Jones, pers. comm.) and therefore we predicted it would have become EW before 2012. By 1988, it was held by one zoological institution other that Durrell and so we assume it would have persisted in captivity until 2012</td>
</tr>
<tr>
<td>Rodrigues warbler Acreocephalus rodricanus. 1982-ongoing. Programme partner focusing on research and capacity building; provision of strategic, technical and financial support to MWF. Other local partner: NPCS</td>
<td>CR EN NT EX</td>
<td>Ceasing habitat protection and restoration would have significantly jeopardized the population recovery. 8 Pairs were known to exist in 1979 (C. Jones, pers. comm.) and probably not significantly above 100 birds in 1988 (C. Jones, pers. comm.) and therefore we predicted it would have become EX before 2012</td>
</tr>
<tr>
<td>Alaotran gentle lemur Hapalemur alaotrensis. 1990-ongoing. Lead implementing agency. Main local partners: DREF; WWF Madagascar; Madagascar Wildlife and Conservation</td>
<td>CR CR</td>
<td>Site protection, conservation payments, and local policies and regulations would not have happened probably leading to significantly increased habitat loss through burning and agricultural encroachment, and continuation of poaching. However, with an AoO of approximately 300 km² and a population size of possibly 1000–2500 in 1988 we predicted the population would have persisted until 2012. Probable criteria met: B1ab (iii, v)</td>
</tr>
<tr>
<td>Malagasy giant jumping rat Hypogeomys antimena. 1998-ongoing. Lead implementing agency. Main local partners: DREF; WWF Madagascar; Madagascar Wildlife and Conservation</td>
<td>EN CR Site protection, site management, conservation payments, compliance and enforcement, and local policies and regulations would not have happened leading to continuation of high deforestation rates in Menabe Antimena dry forest, the only site at which the species exists. A PHVA model (Sommer et al., 2002) predicted rapid population declines and extinction within 24 years if rates of deforestation and feral dog predation continued unabated. Probable criteria met: E</td>
<td></td>
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<tr>
<td>Narrow-striped mongoose Mungotictis decemlineata. 2002-ongoing. Lead implementing agency. Main local partners: DREF; Fanamby; CNFREF</td>
<td>VU VU Site protection, site management, conservation payments, compliance and enforcement, and local policies and regulations would not have happened leading to continuation of high deforestation rates in Menabe Antimena, representing approximately 30% of species’ AoO (Woolaver et al., 2006). Species has persisted in other areas of its range with little effective habitat conservation and no clear evidence the species would have met any EN or CR criteria. Probable criteria met: B1ab (iii)</td>
<td></td>
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<tr>
<td>Rodrigues fruitbat Pteropus rodricensis. 1982-ongoing. Programme partner focusing on captive breeding, research and capacity building; provision of strategic, technical and financial support to MWF. Other local partner: NPCS</td>
<td>CR CR</td>
<td>Cessing Durrell's captive breeding would not have affected wild population as no animals were released back to wild (from Durrell or other institution). Ceasing site management and habitat restoration is likely to have led to some habitat loss. We assume the moratorium on hunting would have remained in place. By 1988, this species had recovered from a low of 70 individuals in 1979 to around 800 (C. Jones, pers. comm.) and therefore we predicted its population would have persisted until 2012. Probable criteria met: B1ab (iii)</td>
</tr>
<tr>
<td>Pygmy hog Porcula salvania. 1996-ongoing. Lead implementing agency. Main local partners: Ecosystems India; Assam Forest Department</td>
<td>CR CR</td>
<td>Captive breeding and release programme would not have happened and therefore new populations in Sonai Rupai Wildlife Sanctuary and Orang National Park would not have been established. Work to improve site management in Manas National Park to ensure the grasslands are more suitable for pygmy hogs would not have happened which could have led to further declines in the last remaining wild population. Probable criteria met: C2a (ii)</td>
</tr>
<tr>
<td>Black lion tamarin Leontopithecus chrysopygus. 1985-ongoing. Partner in collaborative recovery programme focusing on captive breeding and release, and training staff from national-level partners. Main local partner: Instituto de Pesquisas Ecológicas (IPÊ); International Committee for the Conservation and Management of Lion Tamarins (ICCM)</td>
<td>EN EN</td>
<td>Cessing Durrell's captive breeding programme, technical support and training of national-level partner staff is likely to have jeopardized the first releases in Morro do Diabo NP in 1999–2001. Financial support to national-main level partner would not have happened, which helped fund habitat corridor restoration. However, no clear evidence the species would have met any CR criteria without this support. Probable criteria met: B2ab (ii)</td>
</tr>
<tr>
<td>Golden lion tamarin Leontopithecus rosalia. 1975-ongoing. Partner in collaborative recovery programme focusing on captive breeding and release, and training staff from national-level partners. Main local partner: University of Brasília; International Committee for the Conservation and Management of Lion Tamarins (ICCM)</td>
<td>CR EN</td>
<td>Cessing Durrell's captive breeding programme would not have had a significant impact on the wider ex-situ programme with the species held by many 10s of other zoological institutions by 1988. Training of staff from national-level partners would have ceased. However, we predicted the work of the many other national- and international-level partners would still have led to the recovery to EN. Criteria met: B1ab (iii)</td>
</tr>
</tbody>
</table>
of species in the wild. The genuine status changes given by Hoffmann et al. (2010) were updated using the latest information in BirdLife International (2013b) to account for any further category changes that occurred after 2010. Due to differences in the timing of Red List assessments for these three groups, we modelled an RLI for each taxonomic class separately with an aggregated RLI calculated as the arithmetic mean of the three modelled RLIs. The RLIs for each taxonomic group were interpolated linearly for years between data points and extrapolated linearly (with a slope equal to that between the two closest assessed points) back to 1988 (eight years before the first assessment for mammals, following Butchart et al., 2010) and forwards to 2012 for years for which estimates were not available (with a slope equal to that between the two closest assessed points), following the method of Butchart et al. (2010). Rather than extrapolating deterministically, this method incorporates extrapolation uncertainty by selecting the slope used for extrapolation from a normal distribution with a probability equal to the slope of the closest two assessed points, and standard deviation equal to 60% of this slope (i.e. the CV is 60%). Given that only one amphibian species was included in the Durrell RLI, and therefore only one species contributed to the RLI trend between 1980 and 1988 we set the starting point of the aggregated RLI at 1988, when all the birds were first assessed.

The ‘true’ RLI likely changes from year to year, whereas assessments are repeated only at multi-year intervals, meaning the precise value for any particular year is uncertain. To make this explicit, a final RLI value was assigned to each taxonomic group for each year from a 5 year moving window, centred on the focal year (with the window set as 3–4 years for the first two and last two years in the series). Each ‘run’ produced an RLI for the complete time period for each taxonomic group, incorporating extrapolation and temporal uncertainty. Following Butchart et al. (2010), ten thousand such runs were generated for each taxonomic group, and the mean was calculated. The aggregated RLI was calculated as the arithmetic mean of modelled RLIs for each taxa and the 2.5% estimate (lower) and 97.5% (upper) values were used to generate the 95% confidence interval displayed in Fig. 3.

The counterfactual RLI was calculated by predicting what Red List category each of the 17 species would have qualified at in 2012 if all Durrell-led or -supported conservation actions had ceased in 1988 and if threats at the time had continued unabated, following the logic of Butchart et al. (2006a) (see below). These 2012 counterfactual categories were used to calculate a counterfactual RLI value for 2012, and a line fitted back to the observed RLI value in 1988. For Critically Endangered bird species, we followed the criteria of Butchart et al. (2006a) to establish the likelihood of whether a species would not have survived as extant if conservation had been withdrawn in 1988. Butchart et al. (2006a) drew up a list of bird species that had a minimum population estimated to be fewer than 100 individuals in 1994 or had a current population that was estimated to be fewer than 200 individuals and estimated, inferred or suspected to be declining at a rate of more than 80% over 10 years or three generations (whichever was longer). They then determined whether each species was likely to have gone extinct during 1994–2004 if conservation action had ceased in 1994, using published and expert-based information on the population size, trends, severity of threats and intensity and effectiveness of conservation interventions. In their

Fig. 1. Locations of long-term species conservation programmes operated by Durrell and its national-level partners.
there was clear evidence that the species would have deteriorated further or still improved without this conservation.

Finally, for the species that were downlisted to a lower category of extinction risk during 1988–2012, we calculated the mean number of years between the start of the intervention and the date the species first qualified for downlisting (according to the data presented in Hoffmann et al., 2010). For all species, Durrell either instigated the conservation programmes or was involved from the time when significant conservation interventions were initiated. To account for species that may have recovered sufficiently to merit downlisting to a lower Red List category between the start of the intervention and 1988 (the year Red List categories were first assigned) we examined the population histories of each downlisted species prior to 1988. All qualified as Critically Endangered in 1988 except the Rodrigues fody which qualified as Endangered (see Table 1). At the start of the intervention for this species in 1982, its population was likely over 100 individuals and not declining and therefore probably would have still qualified as Endangered (under criterion D) at that date.

2.3. Threats and conservation actions

For each species in the RLI, we coded the threats operating during the intervention period and the conservation actions implemented (see Table A1). We used data available for birds (at www.birdlife.org/datazone/species) on the impact of threats, based on their timing, scope and severity, to exclude any of low or negligible impact. For mammals and amphibians, there is no data source on the impact scores for current or historical threats and therefore we made judgements based on the BirdLife International threat scoring system on their likely impact so as to only consider threats of a medium or high impact. We coded the threats following the ‘1st Level of Classification’ of the IUCN–CMP Unified Classification of Direct Threats Version 3.1 (2011; Salafskey et al. (2008)). Given the very broad definition of the Biological Resource Use and Natural System Modification categories and their prevalence among the species considered, for these threat types we used the 2nd Level of Classification sub-categories.

We coded the conservation actions following the ‘1st Level of Classification’ from the IUCN – CMP Unified Classification of Conservation Actions Needed Version 2.0 (Salafskey et al. 2008). Given the very broad definition of the Land/Water Management category, and its importance in Durrell’s conservation programmes, for this conservation action we used the 2nd Level of Classification sub-categories, which importantly allowed us to distinguish between 2.1. Site/Area Management (hereafter referred to as Land Management); 2.2. Invasive/Problematic Species Control (hereafter referred to as Invasive Species Control; and 2.3. Habitat and Natural Process Restoration (hereafter referred to as Habitat Restoration).

For each different threat or action type, we then calculated the number of species that were downlisted on the Red List or avoided uplisting compared with the counterfactual (hereafter referred to as species that ‘benefited from conservation’), and the number that remained unchanged compared with the counterfactual or were uplisted on the Red List (hereafter referred to as species that experienced ‘no detected benefit from conservation’, recognizing that some or many probably did benefit, but to a degree that did not affect their Red List categorization) (Fig. 2a and b). To investigate ability to mitigate different threats and the potential effectiveness of conservation actions we used a Fisher’s Exact Test (Fisher, 1922) on a series of 2 × 2 contingency tables to test for an unequal distribution of species between the benefit and the no benefit categories in the presence versus absence of each of the threats and conservation actions. All statistical analyses were conducted in R 2.11.1 (R Development Core Team, 2008).
3. Results

3.1. Red List Index

Across the 17 species included in the Durrell RLI, 12 ‘genuine category changes’ relating to nine species occurred between 1988 and 2012 (Table 1, some species moved categories in more than one time period between assessments), 11 of which were improvements (downlisting to lower Red List categories) in eight species and all were the result of conservation actions (Hoffmann et al., 2010). For example, the Mallorcan midwife toad *A. muletensis* was downlisted from Critically Endangered to Vulnerable under criterion D2 between 1996 and 2004 as a result of captive breeding and reintroduction combined with invasive species control. This led to the re-establishment of populations and the recovery of established populations (Table 1). The twelfth status change was the deterioration in the status of the Meller’s duck *A. melleri* during 1988–1994, driven mainly by the conversion of wetlands to rice production and hunting which is estimated to have caused the population size to fall below 2500 mature individuals, qualifying the species for uplisting from Vulnerable to Endangered under criterion B3a(iii) (Table 1). The 13th status change is the successful efforts in Mauritius since the late 1970s to conserve highly threatened birds. The downlisting of six of these bird species (Mauritius kestrel, echo parakeet, pink pigeon, Mauritius fody, Rodrigues fody and Rodrigues warbler) represents a globally significant species conservation success story. It has been brought about through intensive hands-on management of wild populations including captive breeding and release, clutch and brood manipulations, nest site enhancement and the provisioning of nest boxes, supplemental feeding, translocations as well as controlling invasive predators and restoring forest habitats through weeding and planting. The other downlistings resulting from genuine improvements in status related to golden lion tamarin *L. rosalia* (which was downlisted from Critically Endangered to Endangered in 2004 following a long-term programme of captive breeding, reintroduction, site management and habitat restoration) and Mallorcan midwife toad (which was downlisted from Critically Endangered to Vulnerable in 2004 after a long-term captive breeding and reintroduction programme).

The 17 species included in this study faced nine main threats with nine different main conservation actions implemented in response. Most notable was the difference in the ratio of the numbers of species benefitting versus not experiencing a detected benefit from conservation when the threat was present versus when it was absent (Fishers Exact Test, odds ratio = 11.1, P = 0.049). Of 11 species impacted by invasive species, eight experienced a benefit from conservation compared to three for which we did not detect any benefit.

Species management (15 species), land protection (13) and land management (13) were the top three most commonly implemented actions (Fig. 2b). Invasive alien control was the only conservation action for which there was a difference in the ratio of species that benefited and did not benefit from conservation (Fishers Exact Test, odds ratio = 18.8, P = 0.015). Of eight species for which invasive alien control was implemented as a conservation action, seven species benefited whereas only one species did not experience a detected benefit. This compared with a corresponding ratio of two and seven species when invasive species control was not implemented.

4. Discussion

In this study, we tested for the first time the practicality of the RLI for evaluating institutional-level conservation impacts. By contrasting an observed RLI with a counterfactual scenario we show it is possible to measure trends in the impact of an organization’s conservation efforts on the relative survival probability of a modestly sized set of bird, mammal and amphibian species. We also show that the length of time required for a detectable recovery in this group of globally threatened vertebrate species, as measured by an improvement in Red List category, is on average just over 16 years.

The main driver of the positive trend observed in the Durrell RLI is the successful efforts in Mauritius since the late 1970s to conserve highly threatened birds. The downlisting of six of these bird species (Mauritius kestrel, echo parakeet, pink pigeon, Mauritius fody, Rodrigues fody and Rodrigues warbler) represents a globally significant species conservation success story. It has been brought about through intensive hands-on management of wild populations including captive breeding and release, clutch and brood manipulations, nest site enhancement and the provisioning of nest boxes, supplemental feeding, translocations as well as controlling invasive predators and restoring forest habitats through weeding and planting. The other downlistings resulting from genuine improvements in status related to golden lion tamarin *L. rosalia* (which was downlisted from Critically Endangered to Endangered in 2004 following a long-term programme of captive breeding, reintroduction, site management and habitat restoration) and Mallorcan midwife toad (which was downlisted from Critically Endangered to Vulnerable in 2004 after a long-term captive breeding and reintroduction programme).

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the well-documented impacts of invasive mammalian species in particular on oceanic island faunas (see Crouchamp et al., 2003; Simberloff et al., 2013 for reviews). These analyses, however, are based on very small sample sizes and did not attempt to quantify the magnitude of the impact of the different threats types which is necessary to understand better the ability to mitigate different threats and the relative effectiveness of different conservation actions.

In order to evaluate fully the impacts of a conservation programme it is necessary to ask what would have happened if there had been no intervention, a process of making inferences about an unobserved counterfactual event that is rarely applied in conservation programme evaluation (Ferraro and Pattanayak, 2006). In the current study, we predicted what would have happened to the target species by 2012 if conservation had been withdrawn in 1988 (the start date of the RLI). We considered an alternative approach to evaluating the impact of conservation actions on the target species by contrasting them with a set of comparator species, matched for a range of biological traits but subject to no or much reduced conservation effort. However, the types of species targeted by Durrell essentially represent unique treatment units without obvious comparators, a common barrier to such quasi-experimental designs (Ferraro, 2009). Many of the target species in this study are from restricted island faunas with very few or no biologically similar species with comparable population histories but contrasting conservation efforts.

Predicting counterfactual Red List categories for the Mauritian birds was relatively straightforward, as the population histories, threats and conservation actions are well known, and several had been documented by a previous study examining the number of extinctions prevented by conservation interventions (Butchart et al., 2006a). In the 1980s, five of the Mauritian bird species were at extremely low population sizes (<100 individuals), with a strong likelihood of high-imact threats returning should conservation actions be withdrawn, and therefore a high likelihood that they would have gone extinct (Butchart et al., 2006a). Assessing ‘avoided category changes’ requires detailed information on population sizes and trends, and threats and effectiveness of conservation actions, which are often not available for taxa other than birds. For this reason, predicting counterfactual 2012 categories for amphibian and mammal species in the current study was not as straightforward. For the Malagasy giant jumping rat, the availability of a population viability model (Sommer et al., 2002) produced prior to a major forest conservation intervention enabled us to judge that conservation had led to an ‘avoided uplisting’ of this species. A set of standard criteria and levels of evidence for estimating counterfactual RLIs for a range of taxa would be needed to ensure consistency in impact measurement performed by different institutions and across different conservation programme structures.

Determining the counterfactual modern-day Red List categories for the target species was also challenging given all of the programmes are implemented as part of partnerships of national and international conservation organizations. As part of its operational strategy, Durrell works in close long-term partnerships with national-level organizations (or national-level programmes of international outfits) to deliver and build capacity for conservation actions. These partnerships are so intertwined that for the majority of species in this study we found it impossible to sensibly disaggregate the relative contributions of the institutions involved. We also did not consider the impact of any other agencies external to these partnerships that may have implemented actions benefiting the target species, mainly because these were extremely difficult to quantify and rare in occurrence. The conservation impacts reported here therefore are acknowledged as shared between Durrell and its national-level partners.

As it may require a substantial increase in population or geographic range size, or a major reduction in the rate of decline, for a globally threatened species to move into a lower Red List category of extinction risk, the RLI is best suited to tracking changes in the status of species over at least moderate time periods (4–5 years or more). While deteriorations in status, and hence uplistings on the Red List can happen very rapidly (e.g. Indian white-backed Gyps bengalensis and long-billed Gyps indicus vultures, Prakash et al., 2003; spoon-billed sandpiper Eryñorhynchus pygmeus, Zockler et al., 2010; and saiga antelope, Milner-Gulland et al., 2001), for the eight study species that improved in status it took on average 16.3 years from the start of the intervention to the year of the first downlisting, with a range of 11–25 years. The 16 year period reflects the time needed for actions to be implemented sufficiently to mitigate threats allowing population recovery of a magnitude to merit downlisting. It also reflects the periodicity of the assessment schedule, which at its most frequent takes place every 4 years (for birds). There is a clear mismatch between the average time to first downlisting shown here and the typical conservation funding time-frames of 2–4 years. For the many globally threatened species with longer generation lengths than species in this study Pacifici et al. (2013) and therefore often longer population recovery times, the time from initiation of conservation interventions to first downlisting is likely to be significantly longer than the 16 years reported here. This also emphasizes the challenge of meeting the CBD Aichi Target 12, under which the world’s governments have committed to improving the status of known threatened species by 2020 (CBD, 2010a).

5. Conclusion

As an indicator of institutional impact, the RLI is most practical for organizations with a relatively small set of target species that have restricted distributions (and therefore for which the institution’s interventions can impact a large proportion of the population of each species). For example, during 2008–2012, the BirdLife International Partnership undertook conservation action for 537 threatened bird species in over 140 countries worldwide (BirdLife International, 2013c). Determining the counterfactual status in the absence of conservation for each of these species would be a significant challenge, as would ascribing the impact of actions by BirdLife Partners or Species Guardians for species that span multiple countries (which is the case for 37% of threatened bird species: BirdLife International, 2013b) and which may receive conservation actions implemented by multiple organizations and agencies.

Using the RLI to track the impact of an institution has a further limitation. It relies on target species being periodically assessed for the IUCN Red List which in turn relies on the activities of IUCN Species Survival Commission Specialist Groups, IUCN Red List Partners and Red List Authorities, which often operate voluntarily. The number of species assessments in the Red List now exceeds over 70,000 species (IUCN, 2013a) but RLIs are only currently available for birds, mammals, amphibians and corals. Substantially greater funding and more efficient processes are required to scale up the taxonomic coverage and frequency of reassessments (Stuart et al., 2010; Rondinini et al., 2013).

The action-focused RLI indicator is well-suited for raising awareness for public and policy makers, auditing management actions and informing policy decisions (Jones et al., 2013). Like macroeconomic indicators, such as the FTSE 100 or Dow Jones Index, it is intuitively understandable to non-technical audiences despite its underlying technical complexity (Jones et al., 2013). Therefore, the RLI is a useful tool in demonstrating and
communicating medium to long-term conservation impacts of institutions and programmes to a range of non-technical but influential audiences such as trustees, supporters and donors. To conclude, by contrasting an observed with a counterfactual RLI this study provides scarce but vital quantitative evidence that, given time, intensive and sustained conservation efforts can significantly improve the status of threatened species. With widespread uncertainty about the effectiveness of conservation investments (Ferraro and Pattanayak, 2006), and the need to show progress towards CBD Aichi Target 12 at global, national and sub-national levels, this study suggests the RLI can make an important contribution to evaluating the performance of species-focused conservation institutions and programmes.

Acknowledgements

The authors would like to thank the many people whom have contributed to the IUCN Red List assessments upon which these analyses are based. We are also grateful to Nik Cole, Glyn Young, Lance Woolaver, Herizo Andrianandrasana, Matthew Morton and Dominic Wormell for their useful information and insights in the design and drafting of the manuscript. The research was funded by the institutions to which the authors are affiliated.

Appendix A

Supplementary Table A1.

Table A1

<table>
<thead>
<tr>
<th>Species</th>
<th>Threats to species</th>
<th>Species and site-based conservation actions implemented by Durrell and/or national-level partners</th>
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<tr>
<td>Mallorcan midwife toad <em>Alytes muletensis</em></td>
<td>Housing and urban areas&lt;br&gt;Commercial and industrial areas&lt;br&gt;Dams and water management/use&lt;br&gt;Invasive species&lt;br&gt;Droughts</td>
<td>Invasive species control&lt;br&gt;Species reintroduction/translocation&lt;br&gt;Captive breeding&lt;br&gt;Training</td>
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<td>Mauritius fody <em>Foudia rubra</em></td>
<td>Annual and perennial non-timber crops&lt;br&gt;Invasive species&lt;br&gt;Logging and wood harvesting</td>
<td>Site/area protection&lt;br&gt;Invasive species control&lt;br&gt;Habitat and natural process restoration&lt;br&gt;Species recovery&lt;br&gt;Species re-introduction/translocation&lt;br&gt;Captive breeding</td>
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<td>Mauritius kestrel <em>Falco punctatus</em></td>
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<td>Site/area protection&lt;br&gt;Invasive species control&lt;br&gt;Species recovery&lt;br&gt;Species reintroduction/translocation&lt;br&gt;Captive breeding&lt;br&gt;Training&lt;br&gt;Institutional and civil society development&lt;br&gt;Conservation finance</td>
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<td>Echo parakeet <em>Psittacula eques</em></td>
<td>Wood and pulp plantations&lt;br&gt;Logging and wood harvesting&lt;br&gt;Invasive species&lt;br&gt;Problematic native species</td>
<td>Site/area protection&lt;br&gt;Invasive species control&lt;br&gt;Habitat and natural process restoration&lt;br&gt;Nest protection&lt;br&gt;Species reintroduction/translocation&lt;br&gt;Captive breeding&lt;br&gt;Training&lt;br&gt;Institutional and civil society development&lt;br&gt;Conservation finance</td>
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<td>Site/area protection&lt;br&gt;Captive breeding&lt;br&gt;Training</td>
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<td>Meller’s duck <em>Anas melleri</em></td>
<td>Annual and perennial non-timber crops&lt;br&gt;Hunting and trapping terrestrial animals&lt;br&gt;Logging and wood harvesting&lt;br&gt;Invasive species&lt;br&gt;Agricultural and forestry effluents</td>
<td>Site/area protection&lt;br&gt;Captive breeding&lt;br&gt;Training</td>
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<td>Site/area protection&lt;br&gt;Invasive species control&lt;br&gt;Habitat and natural process restoration&lt;br&gt;Species recovery&lt;br&gt;Captive breeding</td>
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<td><strong>Annual and perennial non-timber crops</strong></td>
<td>Storms and flooding</td>
<td>Species recovery Captive breeding</td>
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<td>Policies and regulations</td>
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Black lion tamarin *Leontopithecus chrysopygus*

- Annual and perennial non-timber crops
- Wood and pulp plantations
- Livestock farming and ranching
- Logging and wood harvesting

Site/area protection

- Site/area management
- Habitat and natural process restoration
- Species re-introduction/translocation
- Captive breeding
- Awareness and communications
- Conservation finance

Golden lion tamarin *Leontopithecus rosalia*

- Housing and urban areas
- Annual and perennial non-timber crops
- Livestock farming and ranching
- Hunting and trapping terrestrial animals
- Logging and wood harvesting
- Fire and fire suppression

Site/area management

- Habitat and natural process restoration
- Species reintroduction/translocation
- Captive breeding

References


Leontopithecus


