Tourism as a Threat to Critically Endangered and Endangered Birds: Global Patterns and Trends in Conservation Hotspots

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Abstract

More than 12% of bird species are threatened with extinction. Numerous anthropogenic activities and processes are considered responsible for such declines, including tourism related activities. These activities often occur in global biodiversity hotspots but few consider the potential risks associated with tourism. The relative importance of tourism as a threat to birds was quantified using a global analysis of the threats facing critically endangered and endangered birds in the hotspots. Sixty-three critically endangered and endangered bird species are reportedly threatened by tourism. Among those 63 species, marine, coastal and aquatic birds are threatened more by tourism than was expected. Hotspots with the most species threatened by tourism are Polynesia-Micronesia and the Mediterranean Basin. This study uses individual threatening processes in a new way to characterise hotspots for conservation action, advancing previous identification criteria. Analysing hotspots in terms of the relative presence of individual threatening processes may help to more effectively direct future research in these priority regions.

Keywords: birds, tourism, threatened species, impacts, red list

Introduction

Global bird populations face numerous anthropogenic threats, with 562 species listed as critically endangered (CR) or endangered (EN) on the IUCN Red List of Threatened Species (IUCN 2011a). Key threats to birds are similar to those for biodiversity in general and include: habitat loss and fragmentation, overexploitation, introduced species, and climate change (Brook et al. 2008; Hilton-Taylor et al. 2009; Butchart et al. 2010; Hoffmann et al. 2010). Furthermore, harvesting of wild birds for the illegal cage bird trade is a key threat for certain species (Strahl and Grajal 1991 Wright et al. 2001; González 2003 BirdLife International 2008; Butchart 2008). These threatening processes have impacted bird communities in most regions, but especially in the tropics and on islands (Simberloff 2000; Sodhi and Smith 2007; Hilton-Taylor et al. 2009).

Global patterns of conservation significance capturing taxonomic endemism and the extent of threats have previously been reported and refined within the 34 recognised biodiversity hotspots (Myers et al. 2000; Mittermeier et al. 2004). Other measures of biological importance (e.g. total species richness, threatened species richness and richness of endemic species) with particular reference to birds have also been used to define global hotspots (Orme et al. 2005). Both approaches have identified similarities among hotspots, largely arising from the number of threatened species in each (e.g. Tropical Andes and Indo-Burma). Despite these classifications the conservation crisis in these regions continues (Myers et al. 2000; Myers 2003; Mittermeier et al. 2004).

There is some congruence in the identification of areas critical for the maintenance of biodiversity through the use of threatened species distributions. However, there has been little investigation of individual threatening processes operating in each of these hotspots. Threats such as habitat loss and climate change are generally considered global in scale, with much

research directed to understanding their impacts on birds (Crick 2004; Pimm et al. 2006; Sodhi and Smith 2007). However, some less publicised threats (e.g. tourism) are also deserving of further investigation into their global extent as these may act synergistically with other key threats. Tourism comes in many forms (e.g. mass vs. ecotourism, developments vs. activities, motorised vs. non-motorised activities), and all have the potential to impact on birds in some way, even when labelled as ecotourism (Newsome et al. 2002). Some tourism activities are specifically focused on birds (e.g. birdwatching) and can also impact directly on birds (e.g. disturbance through the use of playback) (Şekercioğlu 2002).

Nature-based tourism and ecotourism are often purported to be mechanisms that enhance conservation of species and ecosystems (Tisdell and Wilson 2001; Brightsmith 2008; Brightsmith et al. 2008; Kuenzi and McNeely 2008), although empirical demonstrations of this are relatively few (Isaacs 2000; Buckley et al. 2012; Morrison et al. 2012). Furthermore, a burgeoning human population has resulted in an increased interest in nature and nature-based activities, placing more demand on the natural environment, especially in protected areas (PAs) (Chace and Walsh 2006). Such activities include tourism, sports and general leisure. Many of these activities have been shown to have both direct and indirect negative effects on the environment, including bird populations (Finney et al. 2005, Guillemain et al. 2007; Cardoni et al. 2008). Recent reviews report myriad responses by birds, including population declines, to both motorised and non-motorised recreational activities, particularly in PAs (Buckley 2004; Steven et al. 2011).

In addition to the impact by tourists themselves are those impacts associated with the delivery of the tourism product. Here tourism can have both direct and indirect impacts. For example; land clearing for tourism infrastructure (lodges, resorts etc.) (Green and Giese 2004), accidental introduction of exotic species of animals, parasites or plants, and pollution

produced from an increase in human activity, can all be damaging to bird populations in tourism development areas (Jay et al. 2003; McNeill et al. 2008). In some areas the tourism attractions themselves rely on birds which can impact upon native populations. For example, traditional dancing ceremonies, a popular tourist attraction in Papua New Guinea, make use of elaborate feather headdresses leading to increased hunting pressure on birds of paradise (Eaton 1991; Tolentino 2008).

At a local scale, tourism has been identified as a threat to birds in various isolated studies (Hesse and Duffield 2000; Karp and Root 2009; Anderson et al. 2010). However, the degree to which tourism threatens bird species more generally does not appear to have attracted much attention in the literature. Therefore, this study examines the importance of tourism as a threat to CR and EN birds on a global scale, relative to other threats. Regional trends in CR and EN bird species are examined using the existing global Conservation International hotspot regions (subsequently referred to as hotspots) as a case study. The conservation significance of the hotspots makes these areas a logical focus for analyses due to the high levels of endemism and threats in each. This study also advances previous hotspot analyses (Myers et al. 2000; Mittermeier et al. 2004; Orme et al. 2005) in two ways. First, we assessed the number of unique threats affecting CR and EN birds in global hotspots, similar to the approach used by Evans et al. (2011). Secondly we characterised the hotspots using specific threatening processes, rather than by the number of overall threatened species present.

Methods

Collection of data and analysis of threats

The most recent online version of the IUCN Red List of Threatened Species was used to compile a database containing pertinent information about CR and EN birds. The IUCN Red List is widely regarded as the most accepted and comprehensive source of information about species extinction risk and conservation status (Rodrigues et al. 2006; Hoffmann et al. 2010). As this study has used birds as a focal taxon, supplementary information was obtained from BirdLife International (BirdLife International 2011).

Data were collected between February 2011 and August 2011 by interrogating the IUCN Red List website (www.iucnredlist.org) using a hierarchical search tool enabling the selection of certain criteria to view data for specific organisms. Terms entered into this online search tool filtered the database records by taxonomy and assessment status as follows;

Taxonomy: Aves

Assessment: critically endangered (CR) and endangered (EN)

All other fields were left in the default setting and an option to display taxa to the sub-species and varieties level of classification was also not selected, thereby restricting results to the species level only. The Red List search tool returned results matching these criteria in the form of an alphabetical list of the birds' scientific names, with a hyperlink to profile pages for each species. These lists were downloaded as comma separated value files for further analyses. The study was largely restricted to CR and EN bird species for two reasons; firstly, these are the species considered to be most at risk, therefore most deserving of further examination. Secondly, transitions between threat categories of birds tends to result in species moving from lower to higher categories (Brooke et al. 2008), again highlighting the importance of CR and EN species.

Following the compilation of this list, the threats facing each CR and EN bird species were collated according to the coding system developed by Salafsky et al. (2008) and used by IUCN/BirdLife International. Each threatening process is allocated a numerical code, with subsidiary codes explaining such threats in more detail (Table 1). This study was particularly interested in the threats related to tourism (IUCN 2011b):

1.3 – (Tourism and recreation areas), including but not limited to; developments of resorts, golf courses, ski fields, campgrounds and coastal tourist resorts.

6.1 – (Recreational activities), including but not limited to; off road vehicles, motorboats, dive boats, birdwatchers, hikers, campers and rock-climbing.

We acknowledge that recreational activities are not necessarily restricted to tourism *per se*, but that birdwatching (i.e. avitourism) would certainly fall within this threat classification. All CR and EN species were categorised into their relevant orders to examine taxonomic relationships to threats. Data were examined as values (i.e. species richness) relative to the number of extant species for each order, thereby giving an indication of those orders most at risk from these threatening processes.

To make useful comparisons of the importance of tourism as a specific threat, species considered ‘at risk’ [Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR)] that are identified as being threatened by tourism were extracted from the IUCN Red List. These were compared to trends observed for CR and EN species.

More comprehensive information was recorded for CR and EN species, where available, including; species name, common name, taxonomic order of species, population trend, global species population size, sub-population size and locations of sub-populations. Bird species

distribution maps were obtained from BirdLife International for spatial analyses using ArcGIS.

Hotspots were used to analyse regional patterns in CR and EN birds as well as global threats due to these areas being of biological and conservation significance. Spatial data for the hotspot analyses were obtained as GIS shapefiles, from the Conservation International website (www.biodiversityhotspots.org/xp/hotspots/resources/Pages/maps.aspx).

Threatening processes

The frequencies of each unique threatening process (41 threats from table 1) were examined for CR and EN, species combined, and separately, to determine which threats are relatively more important among these birds. This enabled the identification of processes which are more of a threat to CR than EN and vice versa. Overlap among threatening processes between CR and EN birds was determined using simple Jaccard indices (Krebs 2009).

The prevalence of tourism (threats 1.3 and 6.1) as a threat was examined for at risk species as well as CR and EN species separately. Numbers of species within each order were tested using chi-square analysis, to determine whether more species are threatened by tourism than would be expected. Expected values were calculated based on the actual proportion of species taxonomically described within each order, as per the IUCN Red List. The magnitude of tourism threat was also recorded based on the three criteria used by BirdLife International to determine an overall impact or magnitude for each threatening process. The overall magnitude is determined by allocating a score to the timing (past, ongoing, future), scope (proportion of the population affected) and severity (rate of decline in species of interest) of the threat. The overall impact score may be between zero and nine (0-2 = no/negligible

impact, 3-5 = low impact, 6-7 = medium impact, 8-9 = high impact) (BirdLife International 2011).

Spatial examination of critically endangered and endangered birds and threatening processes

Threatened bird species distributions were analysed spatially using ArcGIS providing a visual representation of where the CR and EN species are concentrated among hotspots. Spatial analyses were completed by overlaying the distribution of all CR and EN bird species with hotspot boundaries to calculate the cumulative number of species in each hotspot.

Threatening processes associated with each CR and EN species in each hotspot were first summarised by bird order before being enumerated using pivot tables to determine the total number of unique threats affecting bird species in each hotspot. Pivot tables also summarised the number of bird species within each hotspot that were at risk from each of the 41 threats. Chi-square analysis was used to test for significant differences in the number of unique threats per hotspot based on the assumption that the expected number of threats was uniform among hotspot regions (i.e. 21 unique threats from a possible 41).

Results

Threatening processes affecting critically endangered and endangered birds

Thirty-eight out of a possible 41 unique threatening processes were recorded for the 562 CR and EN bird species (Table 1). Threat 2.1 (annual & perennial non-timber crops) was the most frequent threatening process with 374 of the 562 species affected (67%), followed by

logging and harvesting (threat 5.3, 49%), and invasive species (threat 8.1, 40%). Tourism threats (1.3 and 6.1) impacted on 24 (4%) and 42 (7%) species respectively.

There were some differences in the prevalence of some threatening processes when comparing CR and EN bird species. Threat 1.1 (housing & urban areas) threatens 15% of CR bird species and 26% of EN bird species. Similarly, threat 2.3 (livestock farming & ranching) represents a threat to 21% of CR bird species, but it is nearly double (40%) that for EN birds. Threat 5.3 (logging & wood harvesting) is also more of an issue for EN than CR bird species, with 55% and 38% species affected respectively (Table 1). Tourism and recreation areas appear to be more of a risk to CR species, while recreational activities threaten more EN species (Table 1).

Birds threatened by tourism

According to the IUCN Red List, 188 ‘at risk’ species are listed as threatened by tourism (NT=54, VU=71, EN=44, CR=19). Of these, 63 (34%) species are listed as either CR or EN (Table 2) belonging to 17 of 25 bird orders. There are species among the orders Cuculiformes, Phoenicopteriformes, Psittaciformes and Struthioniformes listed as being threatened by tourism, but none are CR or EN. Several orders (e.g. Caprimulgiformes, Ciconiiformes and Trogoniformes) have only one CR or EN species threatened by tourism.

Tourism threatens 10 orders of ‘at risk’ species, which is more than expected given their actual taxonomic representativeness ($\chi^2=426.25$, $p<0.005$, $df=24$). For example, based on the number of Charadriiformes species expected to be threatened by tourism ($n=7$), significantly more are listed as being threatened by tourism ($n=26$) (Table 2). In contrast,

Passeriformes are significantly less threatened by tourism with 72 species observed as opposed to the 109 species expected.

Despite the relatively low proportion of CR and EN species threatened by tourism, 11 of 17 orders of birds are more threatened by tourism than expected ($\chi^2=119.6$, $p<0.005$, $df=24$).

Species more threatened by tourism also tend to have aquatic or marine lifestyles (i.e.

Anseriformes (n=4), Charadriiformes (n=9), Gruiformes (n=5), Pelecaniformes (n=3),

Podicipediformes (n=1), Procellariiformes (n=4), and Sphenisciformes (n=2) have

approximately three times more species threatened by tourism than expected).

Magnitude of tourism threat

The magnitude of tourism threat is considered low for the majority of the 63 CR and EN species facing this threat (n=47) (Table 3). However, for all species threatened by tourism, the threat is considered to be ‘ongoing’ in nature. Additionally, for 20 of the 63 CR and EN species threatened by tourism, more than 50% of the global population is affected by this threat. At least 12 CR and EN species continue to, or will undergo rapid or very rapid declines as a result of tourism threats. Three species (*Antilophila bokermanni*, *Formicivora littoralis* and *Leptotila wellsi*) are highly threatened by tourism, with two of these found in South America, and the third in the Caribbean Islands. For both *A. bokermanni* and *F. littoralis* the development of tourism areas (threat 1.3) is the greatest threat to these species, over and above other threats. The developments affecting *A. bokermanni* include construction of recreational water parks, while *F. littoralis* is losing high value habitat to major resort developments, even within environmental protection areas.

Hotspots analysis

The distributional range of 91% of CR and EN species (n=512), overlaps with at least one hotspot [Figure 1 (a)]. Hotspots with the highest number of CR and EN bird species include the Tropical Andes (n=86), Polynesia-Micronesia (n=58) and the Atlantic Forest (n=47). Hotspots with the least number of CR and EN bird species include the Caucasus (n=4), the Mountains of Central Asia (n=2) and the Irano-Anatolian hotspots (n=5) [Figure 1 (a)]. Of the 50 species falling outside of the hotspots in this analysis, only seven are threatened by tourism; two in the United States, two in Saint Helena, and one each in Australia, Brazil and Canada.

Overall, CR and EN birds in 28 hotspots are threatened by tourism; 24 species by the development of tourism and recreation areas (threat 1.3) in 16 hotspots, and 42 by various recreational activities (threat 6.1) in 22 hotspots (Table 1). There is little overlap among these tourism threats in hotspots with only three species threatened by both (Jaccard Index = 0.285). Some hotspots appear to have more species affected by tourism than others, relative to the total CR and EN species richness of these hotspots. For example, despite lower CR and EN species richness, in the Caucasus, Irano-Anatolian, and Mountains of Central Asia hotspots, 40-50% of their CR and EN species are threatened by tourism. The Mediterranean Basin has 14 CR and EN species, 6 of which are threatened by tourism (43%) [Figure 1 (b)]. This hotspot stands out in terms of the proportion and number of species affected by tourism, both of which are high relative to the other hotspots.

Several hotspots have no CR or EN species threatened by tourism, including the Cape Floristic Region, Maputaland-Pondoland-Albany, Mountains of Southwest China, New Caledonia, Succulent Karoo and Wallacea [Figure 1 (b)].

Not all 38 unique threatening processes for CR and EN birds were recorded in every hotspot. Most hotspots have at least 20 unique threats affecting CR and EN birds (e.g. Atlantic Forest $n=24$, Himalaya $n=26$, New Zealand $n=27$). There is a significant difference between the number of unique threats present in each hotspot ($\chi^2=48.5$, $p<0.05$, $df=33$) when compared against an expected even distribution of threats among hotspots ($n=21$). For example, CR and EN birds in New Caledonia appear to face somewhat fewer unique threatening processes ($n=12$), while species in the Tropical Andes face significantly more ($n=31$) (Figure 2). The relative impact of different threats to CR and EN birds in each hotspot as represented by the number of species threatened in each case identified seven principal threats. Individually these threats impacted on more than 20% of CR and EN birds on average across all hotspots and included; annual and perennial non-timber crops (2.1), livestock farming and ranching (2.3), hunting and trapping terrestrial animals (5.1), logging and wood harvesting (5.3), fishing and harvesting aquatic resources (5.4), invasive non-native/alien species (8.1) and habitat shifting and alteration (11.1) (Supplementary Table 1).

Discussion

This study confirms that threats associated with habitat loss and degradation are driving the current patterns in CR and EN bird species, as they are for all threatened flora and fauna (Myers et al. 2000; Butchart et al. 2006; Hilton-Taylor et al. 2009; Hoffmann et al. 2010). Furthermore, these threats tend to be non-specific and widespread, especially among tropical hotspots (Brooks et al. 2002; Bradshaw et al. 2009). While habitat loss and degradation were less of a threat to pelagic and aquatic species, factors such as pollution still result in habitat degradation (Derraik 2002; Defeo et al. 2009). These threats affect many CR and EN species in island hotspots. More importantly, this study quantifies the nature and extent of tourism

threats to CR and EN birds that have to date received relatively little attention among the research community, despite being highlighted by IUCN and BirdLife International as valid, continuing and growing threats (Hilton-Taylor et al. 2009; Butchart et al. 2010; BirdLife International 2011).

Tourism threats to critically endangered and endangered birds

We acknowledge the potential that nature-based tourism and more specifically ecotourism presents as a means to both fund and raise awareness about conservation of threatened species and ecosystems. In some cases tourism has positive outcomes for conservation, particularly in well managed protected areas, and those generating their revenue via tourism (Brightsmith 2008; Brightsmith et al. 2008; Buckley et al. 2012; Morrison et al. 2012). For example, research investigating ecotourism with reference to sea turtles in Queensland, Australia and Komodo Dragon in Indonesia, found a positive shift in people's attitudes towards conservation (Tisdell and Wilson 2001; Walpole and Goodwin 2001). However, not all nature-based tourism can boast such outcomes, even among the ecotourism sector (Krüger 2005; Cunha 2012).

The patterns observed for tourism threats to CR and EN birds are similar to those identified in general reviews on the impacts of tourism on birds (Buckley 2004; Steven et al. 2011).

However, the present study has advanced our understanding of these patterns for: CR and EN birds, birds in hotspots, and taxonomic trends in birds threatened by tourism in general. This study found 188 'at risk' species (NT, VU, EN, and CR) listed as threatened by tourism, of which 34% are either CR or EN. Despite the relatively low incidence of tourism as a threat globally, this does not necessarily accurately capture the extent to which tourism is

threatening individual species or bird communities at the local scale. For example, some areas may have especially high tourism impacts, but due to the fact that a species is not threatened globally (i.e. there are many sub-populations) our estimates of tourism impacts may be under-estimated. In other words, localised impacts are not fully appreciated in a global analysis of tourism impacts.

Furthermore, of the 63 CR and EN species threatened by tourism, targeted studies on these impacts have only been published for three species (Yellow-eyed Penguin, New Zealand Dotterel and Egyptian Vulture), in five separate papers (Ratz and Thompson 1999; Lord et al. 2001; McClung et al. 2004; Ellenberg et al. 2007; Zuberogitia et al. 2008). It is possible that researchers avoid testing these impacts on CR and EN species for fear that they may contribute to the species decline (Şekercioğlu 2002), or that tourism is not seen as being as important as other threats. Studies assessing threats to related or similar species are relatively more common, with research focussed on the taxonomic orders that this study has identified as being more vulnerable to tourism activities than expected (e.g. Charadriiformes, Falconiformes, Gruiformes, Anseriformes, etc.) (Steven et al. 2011). It is therefore possible that studies conducted on these orders may be helpful in determining whether tourism is a threat to CR and EN species in the same orders by using a surrogate approach. However, some orders of birds still require further investigation, as much of their vulnerability to tourism remains unquantified.

Passerines, due to their sheer diversity have fewer than expected species listed as threatened by tourism. Furthermore, reviews of studies examining tourism impacts on these species has revealed that most investigated relatively common Passerines, and focused on the Northern Hemisphere regions of Spain (Mediterranean hotspot) and the continental United States (Buckley 2004; Steven et al. 2011). This is also where most species, not only Passerines,

threatened by tourism in hotspots are found. Contrastingly, many Passerines listed as CR and EN and threatened by tourism are in the Southern Hemisphere hotspots, especially Polynesia-Micronesia, New Zealand, and Madagascar and the Indian Ocean Islands, have not been examined in the published literature (Steven et al. 2011).

The Psittaciformes has the second highest number and proportion of CR and EN species, but none of these are reportedly threatened by tourism. Furthermore, of all species threatened by tourism identified in this study, parrots are one of the orders with fewer species threatened by tourism than expected. In fact, it is within this group of birds, that there are specific examples where tourism helps to fund the conservation of parrot species. For example, Macaw parrots (e.g. *Ara* spp.) are popular tourist attractions and projects dedicated to their management are funded largely by tourism (Brightsmith 2008; Brightsmith et al. 2008). However, despite clear cautioning in previous research (Brightsmith et al. 2008) the extent of negative impacts associated with avitourism is not frequently quantified. It is entirely possible that positive tourism effects (e.g. salvaging habitat using funds secured from tourism) may outweigh the negative (e.g. human disturbance associated with visiting tourists).

Tourism and its role in the 'extinction debt concept'

The 'extinction debt' concept conceived by Tilman et al. (1994) suggests a lag between habitat disturbance or removal, and the decline of affected species or populations of a species becoming apparent. This has been demonstrated by a number of authors (Brooks et al. 2002; Kuussaari et al. 2009; Triantis et al. 2010). For example, the relatively high proportion of CR and EN species reported for the Polynesia-Micronesia and New Zealand hotspots is likely to be a remnant impact of exotic species introductions and habitat clearance in these regions

from several hundreds of years ago, with many species having already gone extinct in these regions (Saunders and Norton 2001). This suggests that the current threatened species patterns in these areas reflect the extinction debt currently being paid in these hotspots. More recent studies are forecasting that payment of this debt will become increasingly apparent in Southeast Asia (Sundaland and Wallacea hotspots) and South America (Atlantic Forest and Tropical Andes hotspots) (Sodhi et al. 2006; Sodhi and Smith 2007), given the prevalence of CR and EN species and continued habitat removal in these regions.

While these studies identify the risks facing species and the future debt arising from ongoing habitat loss, invasive species and other threatening processes, few consider the potential debt risk from tourism activities. Conservation biologists, tourism managers (operators and PA managers) as well as relevant government authorities should consider potential extinction debt when planning to accommodate the growing nature-based tourism market. This industry has increased significantly in recent years (Balmford et al. 2009), and as the human population and its wealth continues to grow, it is expected nature-based tourism will grow accordingly (Burger 2000; Kuenzi and McNeely 2008). As tourism can have negative impacts on natural environments (Liddle 1997; Newsome et al. 2002), and birds (Buckley 2004; Steven et al. 2011), it may be appropriate to consider tourism as a potential source of accumulating extinction debt in many regions, particularly popular tourist destinations within hotspots (e.g. Mediterranean Basin, Japan, Irano-Anatolian, etc.). This study has shown that there are potentially 63 CR and EN species already at risk from such increased tourism, but that a further 147 species may be at risk in the future.

While highlighting the current trends among CR and EN birds, and their key threatening processes in the CI hotspots, this study provides a new way to look at the hotspots concept (c.f. Myers et al. 2000; Orme et al. 2005), by considering the cumulative number of unique

threatening processes facing birds in these areas. This approach has already been applied at a smaller scale by Evans et al. (2011) who highlighted the need for further research assessing the spatial distribution of threatening processes, and not simply threatened species. While our study reports on broad patterns in the number of CR and EN bird species threatened by unique threats in hotspots, further work is required to assess the relative magnitude of each threat for these birds, but also other taxonomic groups.

Using the best information available, tourism currently appears to be a relatively minor threat to CR and EN birds; however some taxonomic groups and regions appear to be more vulnerable than others. Furthermore, the full extent to which tourism is currently a threat to birds may not be fully appreciated for all birds and all regions. Additionally, while the approach taken here examined hotspots in a new way, there are opportunities to expand these efforts to specific threatening processes at finer spatial scales (e.g. the Important Bird Areas distributed across many countries). As nature-based tourism continues to grow as an industry, potential impacts need to be acknowledged and evaluated in the context of benefits gained to enable more effective management and mitigation wherever possible. Such management will be most effective if addressed at the appropriate scales.

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Table 1 Number of hotspots affected by each threatening process and number of critically endangered (CR) and endangered (EN) species

(separately and combined) affected by each threatening process. Values represent the number for each category and percentage of each category affected. Tourism related threats are indicated in shaded rows

Threat Level 1	Definition	Threat Level 2	Definition	No. of Hotspots	%	No. of CR&EN	%	No. of CR	%	No. of EN	%
1	Residential and commercial development	1.1	Housing and urban areas	26	76	123	22	28	15	95	26
		1.2	Commercial & industrial areas	23	68	50	9	17	9	33	9
		1.3	<i>Tourism & recreation areas</i>	16	47	24	4	11	6	13	3
2	Agriculture and aquaculture	2.1	Annual and perennial non-timber crops	32	94	374	67	115	61	259	70
		2.2	Wood and pulp plantations	21	62	49	9	10	5	39	10
		2.3	Livestock farming and ranching	28	82	188	33	39	21	149	40
		2.4	Marine and freshwater aquaculture	10	29	12	2	3	2	9	2
3	Energy production and mining	3.1	Oil and gas drilling	2	6	3	1	0	0	3	1
		3.2	Mining and quarrying	26	76	67	12	21	11	46	12
		3.3	Renewable energy	14	41	8	1	2	1	6	2
4	Transportation and service corridors	4.1	Roads and railroads	26	76	60	11	13	7	47	13
		4.2	Utility and service lines	17	50	13	2	3	2	10	3
		4.3	Shipping lanes	8	24	4	1	0	0	4	1
		4.4	Flight paths								
5	Biological resource use	5.1	Hunting and trapping terrestrial animals	34	100	219	39	74	39	145	39
		5.2	Gathering terrestrial plants	21	62	19	3	7	4	12	3
		5.3	Logging and wood harvesting	29	85	276	49	73	38	203	55
		5.4	Fishing and harvesting aquatic resources	27	79	37	7	10	5	27	7
6	Human intrusion and disturbance	6.1	<i>Recreational activities</i>	22	65	42	7	9	5	33	9
		6.2	War, civil unrest and military exercises	10	29	8	1	3	2	5	1
		6.3	Work and other activities	22	65	53	9	18	9	35	9

7	Natural system modifications	7.1	Fire and fire suppression	23	68	91	16	19	10	72	19
		7.2	Dams and water management/use	25	74	43	8	13	7	30	8
		7.3	Other ecosystem modifications	19	56	23	4	9	5	14	4
8	Invasive and other problematic species and genes	8.1	Invasive non-native/alien species	34	100	223	40	88	46	135	36
		8.2	Problematic native species	32	94	85	15	28	15	57	15
		8.3	Introduced genetic material								
9	Pollution	9.1	Domestic and urban waste water	5	15	3	1	1	1	2	1
		9.2	Industrial and military effluents	22	65	32	6	8	4	24	6
		9.3	Agricultural and forestry effluents	26	76	48	9	17	9	31	8
		9.4	Garbage and solid waste	1	3	1	0	0	0	1	0
		9.5	Air-borne pollutants	1	3	1	0	1	1	0	0
		9.6	Excess energy	11	32	6	1	0	0	6	2
10	Geological events	10.1	Volcanoes	18	53	14	2	5	3	9	2
		10.2	Earthquakes/tsunamis								
		10.3	Avalanches/landslides	2	6	2	0	0	0	2	1
11	Climate change and severe weather	11.1	Habitat shifting and alteration	33	97	174	31	71	37	103	28
		11.2	Droughts	19	56	21	4	9	5	12	3
		11.3	Temperature extremes	11	32	9	2	4	2	5	1
		11.4	Storms and flooding	22	65	58	10	28	15	30	8
		11.5	Other impacts	9	26	11	2	4	2	7	2

Source: Salafsky et al. 2008; IUCN 2011

Table 2 General comparison of taxonomic findings among critically endangered and endangered species; and Chi square analysis results for ‘at risk’ and critically endangered and endangered species threatened by tourism. Values are the number of species within each order

Order	Number CR and EN species	Percentage of each order listed as CR or EN	‘At risk’ birds threatened by tourism (NT, VU, EN, CR)			CR and EN birds threatened by tourism		
			Observed	Expected	χ^2 value	Observed	Expected	χ^2 value
Anseriformes	16	10%	8	3.16	7.41	4	1.06	8.17
Apodiformes	25	6%	5	8.30	1.31	2	2.78	0.22
Caprimulgiformes	5	4%	1	2.34	0.77	1	0.78	0.06
Charadriiformes	22	6%	26	6.66	56.19	9	2.23	20.53
Ciconiiformes	16	14%	1	2.24	0.69	1	0.75	0.08
Coliiformes	0	0	0	0.11	0.11	0	0.04	0.04
Columbiformes	24	8%	6	6.28	0.01	2	2.11	0.01
Coraciiformes	8	4%	0	4.11	4.11	0	1.38	1.38
Cuculiformes	5	3%	1	3.12	1.44	0	1.05	1.05
Falconiformes	18	6%	8	5.84	0.80	2	1.96	0.00

Galliformes	29	10%	6	5.42	0.06	3	1.82	0.77
Gaviiformes	0	0	0	0.09	0.09	0	0.03	0.03
Gruiformes	25	12%	11	4.23	10.85	5	1.42	9.07
Passeriformes	251	4%	72	111.19	13.81	21	37.26	7.10
Pelecaniformes	6	9%	12	1.23	93.89	3	0.41	16.17
Phoenicopteriformes	0	0	3	0.11	74.31	0	0.04	0.04
Piciformes	6	1%	1	7.65	5.78	1	2.56	0.95
Podicipediformes	3	16%	2	0.41	6.13	1	0.14	5.39
Procellariiformes	32	25%	8	2.45	12.57	4	0.82	12.31
Psittaciformes	48	14%	5	6.99	0.57	0	2.34	2.34
Sphenisciformes	5	28%	7	0.34	131.89	2	0.11	31.57
Strigiformes	16	8%	3	3.76	0.15	1	1.26	0.05
Struthioniformes	1	9%	1	0.24	2.36	0	0.08	0.08
Tinamiformes	0	0	0	0.88	0.88	0	0.29	0.29
Trogoniformes	1	2%	1	0.82	0.04	1	0.28	1.90
			188	df=24	426.25	63	df=24	119.60

Table 3 Critically endangered (CR) and endangered (EN) species threatened by tourism, the hotspot in which they occur and the magnitude of the tourism threat (numerical score and low, med, high), as per BirdLife International's threat assessment process (magnitude expressed as a minimum)

Scientific Name	Order	IUCN	Threat 1.3	Threat 6.1	Both	Magnitude of tourism threat	Hotspot
<i>Acrocephalus caffer</i>	Passeriformes	EN		1		5 - low	Polynesia/Micronesia
<i>Acrocephalus luscinius</i>	Passeriformes	CR	1			5 - low	Polynesia/Micronesia
<i>Amazilia boucardi</i>	Apodiformes	EN	1			5 - low	Mesoamerica
<i>Anas wyvilliana</i>	Anseriformes	EN		1		7 - med	Polynesia/Micronesia
<i>Antilophia bokermanni</i>	Passeriformes	CR	1			9 - high	NA
<i>Apalharpactes reinwardtii</i>	Trogoniformes	EN	1			5 - low	Sundaland
<i>Brachyramphus brevirostris</i>	Charadriiformes	CR		1		5 - low	NA
<i>Branta ruficollis</i>	Anseriformes	EN		1		5 - low	Caucasus, Irano-Anatolian, Mediterranean Basin
<i>Caprimulgaus noctitherus</i>	Caprimulgiformes	CR		1		5 - low	Caribbean Islands

<i>Centrocerus minimus</i>	Galliformes	EN	1	4 - low	NA
<i>Charadrius obscurus</i>	Charadriiformes	EN	1	5 - low	New Zealand
<i>Charadrius sanctaehelenae</i>	Charadriiformes	CR	1	5 - low	NA
<i>Circus maillardi</i>	Falconiformes	EN	1	4 - low	Madagascar and the Indian Ocean Islands
<i>Cistothorus apolinari</i>	Passeriformes	EN	1	4 - low	Tropical Andes
<i>Collocalia bartschi</i>	Apodiformes	EN	1	4 - low	Polynesia/Micronesia
<i>Columba junoniae</i>	Columbiformes	EN	1	5 - low	Mediterranean Basin
<i>Coracina newtoni</i>	Passeriformes	CR	1	5 - low	Madagascar and the Indian Ocean Islands
<i>Corvus kubaryi</i>	Passeriformes	CR	1	6 - med	Polynesia/Micronesia
<i>Dasyornis brachypterus</i>	Passeriformes	EN	1	4 - low	NA
<i>Dendrocopos noguchii</i>	Piciformes	CR	1	5 - low	Japan
<i>Eudyptes moseleyi</i>	Sphenisciformes	EN	1	5 - low	NA
<i>Formicivora erythronotos</i>	Passeriformes	EN	1	7 - med	Atlantic Forest
<i>Formicivora littoralis</i>	Passeriformes	CR	1	8 - high	Atlantic Forest
<i>Gallirallus okinawae</i>	Gruiformes	EN	1	5 - low	Japan

<i>Garrulax courtoisi</i>	Passeriformes	CR	1	5 - low	NA
<i>Geothlypis beldingi</i>	Passeriformes	CR	1	6 - med	Madrean Pine-Oak Woodlands
<i>Geronticus eremita</i>	Pelecaniformes	CR	1	3 - low	Eastern Afromontane, Horn of Africa, Mediterranean Basin
<i>Gorsachius goisagi</i>	Ciconiiformes	EN	1	5 - low	Japan, Philippines
<i>Grus americana</i>	Gruiformes	EN	1	5 - low	NA
<i>Himantopus novaezelandiae</i>	Charadriiformes	CR	1	5 - low	New Zealand
<i>Hymenolaimus malacorhynchos</i>	Anseriformes	EN	1	5 - low	New Zealand
<i>Larus bulleri</i>	Charadriiformes	EN	1	5 - low	New Zealand
<i>Laterallus levraudi</i>	Gruiformes	EN	1	5 - low	Tropical Andes
<i>Leptotila wellsi</i>	Columbiformes	CR	1	8 - high	Caribbean Islands
<i>Loxioides bailleui</i>	Passeriformes	CR	1	4 - low	Polynesia/Micronesia
<i>Megapodius laperouse</i>	Galliformes	EN	1	6 - med	Polynesia/Micronesia
<i>Mergus octosetaceus</i>	Anseriformes	CR	1	6 - med	Atlantic Forest, Cerrado

<i>Myophonus blighi</i>	Passeriformes	EN	1	4 - low	Western Ghats and Sri Lanka
<i>Neophron percnopterus</i>	Falconiformes	EN	1	6 - med	Mediterranean Basin, plus nine more hotspots
<i>Oceanodroma homochroa</i>	Procellariiformes	EN	1	6 - med	California Floristic Province
<i>Otus insularis</i>	Strigiformes	EN	1	4 - low	Madagascar and the Indian Ocean Islands
<i>Pelecanoides garnotii</i>	Procellariiformes	EN	1	4 - low	Chilean Winter Rainfall-Valdivian Forests
<i>Phalacrocorax harrisi</i>	Pelecaniformes	EN	1	4 - low	Tumbes-Choco-Magdalena
<i>Phalacrocorax onslowi</i>	Pelecaniformes	CR	1	5 - low	New Zealand
<i>Pitta gurneyi</i>	Passeriformes	EN	1	4 - low	Indo-Burma
<i>Ploceus nicolli</i>	Passeriformes	EN	1	5 - low	Coastal Forests of Eastern Africa, Eastern Afromontane
<i>Prosobonia cancellata</i>	Charadriiformes	EN	1	7 - med	Polynesia/Micronesia
<i>Pterodroma baraui</i>	Procellariiformes	EN	1	4 - low	Madagascar and the Indian Ocean Islands, Southwest Australia, Sundaland

<i>Pterodroma madeira</i>	Procellariiformes	EN		1	4 - low	Mediterranean Basin
<i>Rallus semiplumbeus</i>	Gruiformes	EN	1		5 - low	Tropical Andes
<i>Rallus wetmorei</i>	Gruiformes	EN	1		7 - med	Tropical Andes
<i>Ramphocinclus brachyurus</i>	Passeriformes	EN	1		7 - med	Caribbean Islands
<i>Rollandia microptera</i>	Podicipediformes	EN		1	4 - low	Tropical Andes
<i>Saxicola dacotiae</i>	Passeriformes	EN		1	5 - low	Mediterranean Basin
<i>Spheniscus mendiculus</i>	Sphenisciformes	EN		1	5 - low	Tumbes-Choco-Magdalena
<i>Sterna albobriata</i>	Charadriiformes	EN		1	5 - low	New Zealand
<i>Sterna lorata</i>	Charadriiformes	EN		1	6 - med	Tumbes-Choco-Magdalena
<i>Stymphalornis acutirostris</i>	Passeriformes	EN		1	5 - low	Atlantic Forest
<i>Terpsiphone corvina</i>	Passeriformes	CR	1		6 - med	Madagascar and the Indian Ocean Islands
<i>Torreornis inexpectata</i>	Passeriformes	EN		1	5 - low	Caribbean Islands
<i>Toxostoma guttatum</i>	Passeriformes	CR	1		4 - low	Mesoamerica
<i>Tringa guttifer</i>	Charadriiformes	EN		1	5 - low	Indo-Burma, Sundaland
<i>Xenoperdix udzungwensis</i>	Galliformes	EN		1	4 - low	Coastal Forests of Eastern Africa, Eastern

Note: FSAL=French Southern and Antarctic Lands, MIOI=Madagascar and the Indian Ocean Islands, CWRVF=Chilean Winter Rainfall-Valdivian Forests. See Table 1 for threat descriptions.

(a)

(b)

Fig. 1 Distribution of critically endangered and endangered bird species (a), and percentage of critically endangered and endangered species threatened by tourism (b) in each CI hotspot

Fig. 2 Number of unique threatening processes for critically endangered and endangered bird species identified in each CI hotspot