Going or gone: defining 'Possibly Extinct' species to give a truer picture of recent extinctions

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The IUCN Red List is widely regarded as the most authoritative classification of species by their extinction risk (Lamoreux *et al*. 2003, Hambler 2004, Rodrigues *et al*. 2006), including those species known to have become extinct in recent times. Birds are the best-documented class of organisms on the Red List, and the fourth complete assessment of the status of the world's birds was recently published (BirdLife International 2004, IUCN 2004), and updated (at www.birdlife.org) for the 2005 IUCN Red List. As well as 1,208 threatened bird species in the categories of Critically Endangered, Endangered and Vulnerable (in order of decreasing risk of extinction), it lists 131 species as having become Extinct since 1500 (for which 'there is no reasonable doubt that the last individual has died': IUCN 2001), and an additional four species as Extinct in the Wild ('known only to survive in captivity': IUCN 2001).

However, extinction—the disappearance of the last individual of a species—is very difficult to detect (Diamond 1987). For a species to be listed as Extinct requires that exhaustive surveys have been undertaken in all known or likely habitat throughout its historic range, at appropriate times (diurnal, seasonal, annual) and over a timeframe appropriate to its life cycle and life form (IUCN 2001). Listing as Extinct has significant conservation implications, because conservation funding is, justifiably, not targeted at species believed extinct. Following a precautionary approach, conservationists are therefore reluctant to designate species as Extinct if there is any reasonable possibility that they may still be extant, in order to avoid the 'Romeo Error' (Collar 1998), where we might give up on a species before it is too late. This term was first applied to the case of Cebu Flowerpecker *Dicaeum quadricolor*, which was rediscovered in 1992 after 86 years without a record (Dutson *et al*. 1993), having been written off as extinct at least 40 years earlier on the presumption that no forest remained on the island of Cebu (Magsalay *et al*. 1995). This remarkable rediscovery is by no means unique. For example, Jerdon's Courser *Rhinoptilus bitorquatus* was rediscovered in 1986 also after 86 years without a record (Bhushan 1986). Caerulean Paradise-flycatcher *Eutrichomyias rowleyi* was known only from the 1878 type specimen and a belatedly published sight record in 1978, with fruitless searches in 1985–86 (Whitten *et al*. 1987) prior to its rediscovery in 1998 (Riley & Wardill 2001).

On the other hand, for some Critically Endangered species the chances of rediscovering a population must be extremely low, and in all probability they are already extinct. For example, Alaotra Grebe *Tachybaptus rufolavatus* underwent a well-documented decline owing to incidental mortality in monofilament gill-nets and predation by introduced carnivorous fish, compounded by hybridisation with Little Grebe *T. ruficollis*. The last confirmed records were in 1985, with individuals showing some characters of the species seen in 1986 and 1988 (Hawkins *et al*. 2000). The species was near-flightless and restricted to the Lake Alaotra area. There is a slim chance that individuals could survive at Lake Amparihinandriambavy, where unidentified grebes were seen in 2000, but this species is in all probability now extinct (BirdLife International 2004). Similarly, Nukupu'u *Hemignathus lucidus* is endemic to the Hawaiian Islands where it has not been recorded since 1995–96 despite extensive effort in a large proportion of the historic range (Pratt *et al*. 2001). It is in all likelihood extinct as a result of habitat loss and degradation combined with introduced diseases such as avian malaria spread by introduced mosquitoes.

A precautionary approach by IUCN to classifying extinctions is appropriate in order to encourage continuing conservation efforts until there is no reasonable doubt that the last individual of a species has died. It also minimises the danger of 'crying wolf' and reducing confidence in the accuracy of the label Extinct. However, this approach biases analyses of recent extinctions based only on those species officially classified Extinct or Extinct in the Wild. For example, the number of recent extinctions documented on the IUCN Red List is likely to be a significant underestimate, even for well-known taxa such as birds. In recognition of this, we develop a framework to examine relevant evidence and judge as objectively as possible which Critically Endangered species are likely to be already extinct. Using data on these species and on species evaluated as Extinct and Extinct in the Wild, we re-analyse recent extinctions to provide a more realistic assessment of their rate, taxonomic distribution, geography and causes.

Methods

Information on Extinct, Extinct in the Wild, and Critically Endangered species were taken from BirdLife International (2004), updated at www.birdlife.org. The accounts for Extinct species in BirdLife International (2004) were based largely on those in Brooks (2000). Dates were assigned to extinctions and possible extinctions based on the date of the last reliable or confirmed record. In cases for which extinction was estimated to have occurred during a particular period, the midpoint was taken. In theory, more sophisticated techniques for estimating extinction dates are available (Solow 1993), but these require knowledge of the dates of multiple records of a species prior to its extinction, which are rarely available for extinct birds. Recognising that it is difficult in most cases to precisely date extinctions, we analysed temporal patterns by pooling data into 25- or 50-year intervals. We analysed the taxonomy of recent extinctions at the family level, using binomial one-tailed tests to compare the significance of differences between the percentages of extinct species per family with the percentage for the class Aves. Causes of extinction and threats to extant threatened species were coded according to a standard classification of threats used to document all threatened species on the IUCN Red List (http://www.redlist.org/info/major_threats.html). For the purposes of the analyses here, threats deriving from alien invasive species impacting the habitat of a threatened or extinct species were pooled with other forms of threat by invasive species, rather than with other forms of habitat degradation. For the comparison of extinct and extant threatened species, we considered for the latter only high and medium-impact threats, i.e. those that affect the majority of the population and cause rapid declines (BirdLife International 2004).

Defining 'Possibly Extinct' species

We defined 'Possibly Extinct' species as those that are, on the balance of evidence, likely to be extinct, but for which there is a small chance that they may be extant and thus should not be listed as Extinct until adequate surveys have failed to find the species and local or unconfirmed reports have been discounted. 'Possibly Extinct in the Wild' correspondingly applies to such species known to survive in captivity.

For each species we considered five main types of evidence for extinction:

- For species with recent last records, the decline has been well documented.
- Severe threatening processes are known to have occurred (e.g. extensive habitat loss, the spread of alien invasive predators, intensive hunting, etc.).
- The species possesses attributes known to predispose taxa to extinction, e.g. natural rarity and/or tiny range (as evidenced by paucity of specimens relative to collecting effort), flightlessness, allospecies or congeners that may have become extinct through similar threatening processes, etc.
- Recent surveys have been apparently adequate given the species' ease of detection, but have failed to detect the species.

We considered four types of evidence against extinction:

- Recent field work has been inadequate (any surveys have been insufficiently intensive/extensive, or inappropriately timed; or the species' range is inaccessible, remote, unsafe or inadequately known).
- The species is difficult to detect (it is cryptic, inconspicuous, nocturnal, nomadic, silent or its vocalisations are unknown, identification is difficult, or the species occurs at low densities).
- There have been reasonably convincing recent local reports or unconfirmed sightings.
- Suitable habitat (free of introduced predators and pathogens if relevant) remains within the species' known range, and/or allospecies or congeners may survive despite similar threatening processes.

By explicitly laying out and classifying evidence for and against extinction under this framework, we then judged where to place each species on a continuum from high to low confidence of extinction, on a spectrum from Extinct to Critically Endangered (Possibly Extinct) to Critically Endangered. For any given balance of evidence, the position on this continuum was influenced by the time since the last confirmed record (see Fig. 1). For example, for species with recently confirmed records to be placed at the Extinct end of the spectrum, there had to be greater confidence in the extinction, i.e. greater confidence in the adequacy of surveys, the absence or inadequacy of local/unconfirmed records, greater severity of threatening processes, and better documentation of, and confidence in, observed population declines. In contrast, species that had not been recorded for many decades (e.g. more than 100 years) were judged to be more likely to have become extinct for a given balance of evidence for and against extinction, owing to the sheer length of time without records. Deciding the strength of evidence for and against extinction is necessarily subjective. However, this framework helped to make these judgements as objective as possible, by setting out the evidence, and weighing this against the time since the last confirmed record.

We tested this framework on 40 Critically Endangered bird species that we considered candidates for Possibly Extinct status. This included all species for which there was any reasonable possibility that they might be extinct, including any that had not been seen for >10 years (despite reasonable searches and/or for which there was a plausible threatening process), and any that had been last seen <10 years

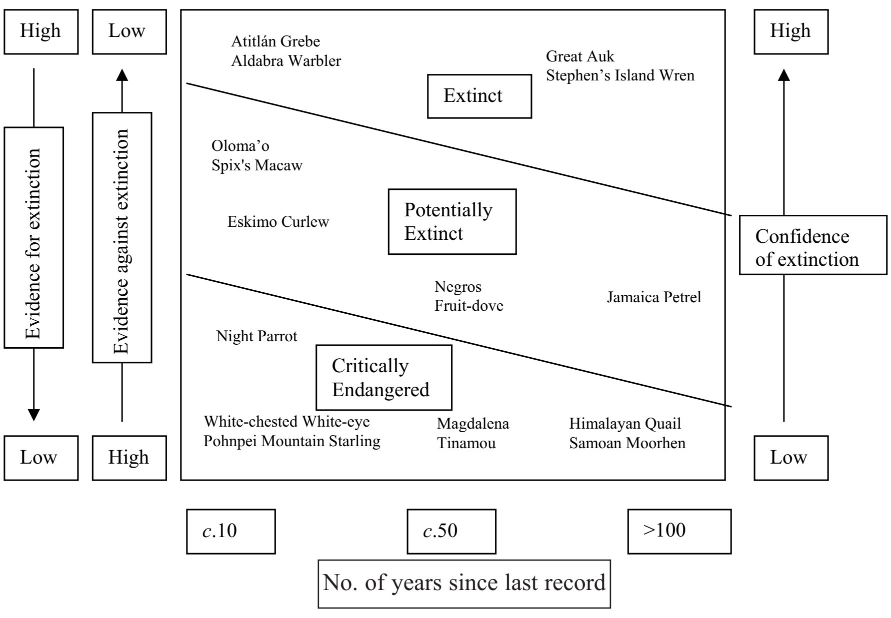

Figure 1. Schematic showing, with selected examples, how time since last record interacts with confidence of extinction to determine how species are classified as Critically Endangered, Possibly Extinct or Extinct. For species last recorded quite recently there needs to be greater confidence that the last individual has died in order for the species to be placed at the extinct end of the spectrum from Critically Endangered to Extinct.

ago for which there had been a well-documented decline of a tiny population. Of these, we identified 15 as Possibly Extinct (including one Possibly Extinct in the Wild species; Appendix 1) and 25 as Critically Endangered (Appendix 2).

One-third of the Possibly Extinct species have not been recorded for more than 50 years or so, and this significant duration since the last records is, of itself, strong evidence that these species may well be extinct. For example, Hooded Seedeater *Sporophila melanops* is known only from the type specimen collected over 180 years ago (BirdLife International 2004). Although habitat destruction in the region of the type locality has not been exceptionally severe, the sheer duration of time without records of a species that could be expected to be relatively easily identified and detected can be considered strong evidence that the species is now extinct. Similarly, Guadalupe Storm-petrel *Oceanodroma macrodactyla* has not been recorded since 1912 despite several searches, following a severe decline owing to predation by introduced cats and habitat degradation by introduced goats (BirdLife International 2004). Only the difficulty of detecting storm-petrels at their breeding colonies at night (when the birds are active) and the continued survival of other storm-petrels on the island point to the possibility that some individuals survive (and hence that classification as Extinct would be premature).

The remaining Possibly Extinct species have undergone well-documented declines, with the most recent records in the last 25 years or so. For example, the last known Spix's Macaws *Cyanopsitta spixii* were monitored until the last individual disappeared in 2000, following a severe decline owing to unsustainable and intensive exploitation for the cagebird trade (Juniper 2003). Searches have not led to the discovery of any other populations, although it is conceivable, if unlikely, that further individuals survive. Similarly, the last well-documented sighting of Oloma'o *Myadestes lanaiensis* was in 1980, with an unconfirmed report in 1988, and there have been no subsequent records despite further surveys in most of the historical range. It is likely to have been driven extinct by disease spread by introduced mosquitoes, and as a result of habitat destruction (Reynolds & Snetsinger 2001). However, the remote Oloku'i Plateau has not been surveyed recently and could still harbour some birds.

Three Vulnerable species have not been recorded for many years, but in each case the threats to them are less intense, and the lack of records clearly results from a lack of surveys, taxonomic uncertainties and/or identification difficulties, rather than because of possible extinction. They are classified as Vulnerable rather than Critically Endangered owing to their presumed small (rather than tiny) and declining populations. The species are: Nicobar Sparrowhawk *Accipiter butleri* (last definite record 1901; possible sightings in the 1990s, but identification uncertain owing to confusion with Besra *A. virgatus*); Manipur Bush-quail *Perdicula manipurensis* (last definite record 1932; possible record in 2004, and cessation of hunting, lack of field work and difficulty of detecting this species are likely to explain the lack of records); and Black-browed Babbler *Malacocincla perspicillata* (known only from a specimen collected in 1843–48, but the lack of subsequent records is most likely to have been a result of confusion over its taxonomic status). In addition, three Endangered species have also not been recorded recently, but are regarded as likely to be extant for similar reasons. They are classified as Endangered on the basis of their small known ranges and because their remaining populations are assumed to be too large to qualify as Critically Endangered. They are: Recurve-billed Bushbird *Clytoctantes alixii* (last recorded 1965 despite recent searches, but known from several sites in north Colombia and north-west Venezuela), Chestnut-bellied Flowerpiercer *Diglossa gloriosissima* (last recorded in 1965, but there has been a dearth of recent field work within its known range in Colombia), and Táchira Antpitta *Grallaria chthonia* (last recorded 1956 despite recent searches, but suitable habitat remains within the large national park in Venezuela from which the species is known).

We also examined a number of Data Deficient species that have not been recorded for many years. Data Deficient is a category on the IUCN Red List applied to species for which 'there is inadequate information to make a direct or indirect assessment of [the] risk of extinction' (IUCN 2001). For six species (Cayenne Nightjar *Caprimulgus maculosus*, Vaurie's Nightjar *C. centralasicus*, White-chested Tinkerbird *Pogoniulus makawai*, Red Sea Swallow *Hirundo perdita*, Sillem's Mountain-finch *Leucosticte sillemi* and Black-lored Waxbill *Estrilda nigriloris*) the available evidence suggests that they are unlikely to be threatened (and hence unlikely to be near extinction or potentially extinct), because no threatening factor is known or can be inferred, and there are convincing practical reasons for the lack of recent records (e.g. surveys have been inadequate, the species is difficult to detect and/or there is taxonomic uncertainty). In three cases (Sharpe's Rail *Gallirallus sharpei*, Coppery Thorntail *Popelairia letitiae* and Bogotá Sunangel *Heliangelus regalis*) knowledge of the original range is so poor that no further inferences can be made (e.g. Sharpe's Rail is known from an 1893 specimen of unknown provenance, possibly from the Greater Sundas).

The 15 species we identified as Possibly Extinct will be tagged as such on the IUCN Red List. The framework developed here is currently being tested on amphibians and mammals, prior to being considered, with potential modifications, for general adoption by the IUCN Red List.

Recent extinctions reanalysed

We combined data on Critically Endangered (Possibly Extinct), Extinct and Extinct in the Wild species from BirdLife International (2004; updated at www.birdlife.org) to undertake a realistic analysis of the pattern of recent extinctions.

Extinction rates

Combining totals for Extinct (131), Extinct in the Wild (four) and Critically Endangered (Possibly Extinct) species (15), exactly 150 bird species have gone or are likely to have become extinct since 1500. This represents a rate of 0.30 species per year. Since 1900, the total is 59 species: 0.56 species per year. While these data

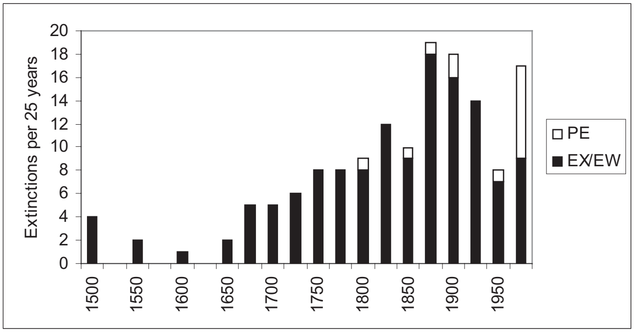

Figure 2. Number of avian extinctions per 25-year period showing totals for Critically Endangered (Possibly Extinct) species ('PE'; *n*=15), and Extinct ('EX'; *n*=131) plus Extinct in the Wild ('EW'; *n*=4) species.

may underestimate the extinction rate of 500 years ago, because some species may have become extinct without our knowledge (Balmford 1996), it appears that the extinction rate increased rapidly from the late 1600s, and peaked in the late 1800s and early 1900s at 0.72 species p.a. (in 1875–1925; Fig. 2). Very recent extinction rates remain high: 17 species were lost in the last quarter of the 20th century, and two species since 2000. The last known individual of Spix's Macaw *Cyanopsitta spixii* (Critically Endangered [Possibly Extinct in the Wild]) disappeared in Brazil in late 2000, and the last two known individuals of Hawaiian Crow *Corvus hawaiiensis* (Extinct in the Wild) disappeared in June 2002. Po'o-uli *Melamprosops phaeosoma*, also from the Hawaiian Islands, looks set to become the next addition to this list: one of the last three known individuals was taken into captivity in September 2004 but died two months later, and the other two individuals have not been seen for over a year (K. Swynnerton *in litt*. 2004). Fig. 2 shows clearly how important it is to consider Possibly Extinct species in assessing recent extinction rates: the total number of estimated extinctions in the last quarter of the 20th century almost doubles from nine to 17 when Possibly Extinct species are included.

How do these extinction rates compare to those derived from the fossil record? Comparisons of absolute rates are difficult given considerable uncertainty over the total number of species on the planet, so it is useful to compare relative extinction rates, expressed as extinctions per million species per year (E/MSY; Pimm *et al.* 1995). Mean fossil species lifetimes produce a background extinction rate of 0.1–1 E/MSY. The total number of bird extinctions since 1500 (150/9,906 species) therefore equates to 30–300 times the background rate. Taking the number of extinctions since 1900 (59/9,815 extant species in 1900) gives an extinction rate 57–570 times background extinction rates. These are still highly conservative estimates for the extinction rate across all taxa, because many taxonomic groups (e.g. amphibians, fish, plants, invertebrates) have on average much smaller ranges, and hence likely higher extinction rates in the face of human impact than do birds.

Estimates of extinction rates derived from measurement of a range of extinction drivers (e.g. habitat destruction, human energy consumption) yield E/MSY 1,000–11,000 higher than background rates (Pimm & Brooks 1999).

Geography of recent extinctions

Recent avian extinctions have occurred across the world, with particularly large numbers in Hawaii (27), Mauritius (18), New Zealand (14), Réunion (11) and St Helena (nine; Fig. 3). The majority (89.3%) has been on islands even though most bird species (>80%) live on continents (Johnson & Stattersfield 1990, Manne *et al*. 1999). However, continental species have been far from immune, and those subject to extinction often originally had extensive ranges. The wave of extinctions on islands may be slowing, perhaps because many of the potential introductions of alien species to predator-free islands have already occurred, and because so many susceptible island species are already extinct. By contrast, the rate of extinctions on continents appears to be sharply increasing (Fig. 4) owing to extensive and expanding habitat destruction (see below).

Taxonomy of recent extinctions

Recent extinctions have not been random with respect to taxonomy. Thirteen families were found to have suffered significantly more extinctions than expected by chance (Table 1). Among large families, Anatidae (ducks, geese and swans), Rallidae (rails), Psittacidae (parrots) and Sturnidae (starlings) have suffered a disproportionate number of extinctions. The Dromaiidae (emus), Raphidae (Dodo *Raphus cucullatus* and solitaires) and Acanthisittidae (New Zealand wrens) have all lost 50% or more of their species in the last 500 years. Conversely, some families

Figure 3. Global distribution of recent avian extinctions. Localities show last known records of Extinct (squares, *n*=131), Extinct in the Wild (circles, *n*=4), and Critically Endangered (Possibly Extinct) species (triangles, *n*=15).

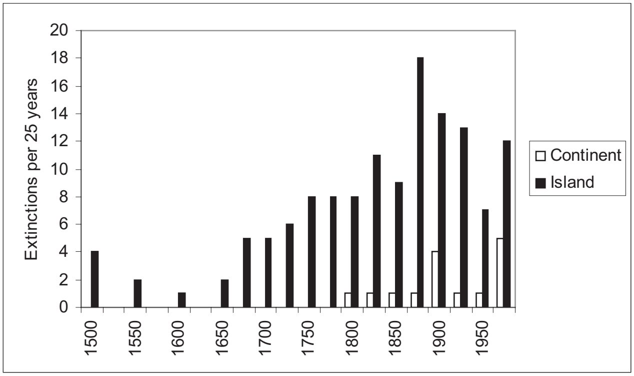

Figure 4. Number of avian extinctions per 25-year period on continents and islands. Totals include Extinct (*n*=131), Extinct in the Wild (*n*=4), and Critically Endangered (Possibly Extinct) species (*n*=15).

(or subfamilies) have suffered significantly fewer extinctions than expected by chance: Accipitridae (hawks and eagles, 0 extinctions/ 239 species), Formicariidae (antthrushes, 0/267), Furnariidae (ovenbirds, 0/242), Tyrannidae (tyrant-flycatchers, 0/409), Muscicapidae (thrushes, babblers, warblers and Old World flycatchers, 12/1,551), Emberizidae (buntings, 1/614; $P<0.02$ in each case). Passerines formed 19% of continental extinctions (3/16 species) and 34% of island extinctions (46/134 species), but this difference is not significant ($\chi^2= 1.58$, $P=0.21$).

TABLE 1
Families with significantly more recently extinct species (Extinct, Extinct in the Wild, and Possibly Extinct) than expected by chance.

Family	**No. species**	**No. extinct species**	**% extinct**	***P***
Raphidae (dodo, solitaires)	2	2	100	0.0002
Dromaiidae (emus)	3	2	66.7	0.0007
Acanthisittidae (New Zealand wrens)	4	2	50	0.0014
Drepanididae (honeycreepers)	34	16	47.1	<0.0001
Callaeidae (New Zealand wattlebirds)	3	1	33.3	0.0450
Upupidae (hoopoes)	3	1	33.3	0.0450
Rallidae (rails)	156	23	14.7	<0.0001
Podicipedidae (grebes)	22	3	13.6	0.0044
Ardeidae (herons)	67	4	6	0.0193
Psittacidae (parrots)	374	20	5.3	<0.0001
Sturnidae (starlings)	114	5	4.4	0.0308
Anatidae (ducks, geese, swans)	164	7	4.3	0.0039
Columbidae (pigeons)	318	13	4.1	0.0014

Causes of recent extinctions

Extinction is a natural phenomenon, being the final stage of the evolutionary trajectory that each species follows. However, recent extinctions appear to have been precipitated by human actions, either directly or indirectly. Here we analyse the broad mechanisms by which such extinctions have occurred, as classified on the IUCN Red List (BirdLife International 2004, IUCN 2004).

The impacts of habitat destruction and degradation, alien invasive species and over-exploitation by humans have been the major causes of recent avian extinctions (Fig. 5). Alien invasive species have been a cause of extinction or likely extinction for at least 77 species. Invasive species have impacts in different ways. Most important has been predation: introduced dogs, pigs, mongooses and, in particular, cats and rats have contributed to the extinction of at least 56 species. The most notorious example was the Stephen's Island Wren *Traversia lyalli*, whose entire world population was rapidly wiped out when cats became established on the island in 1894 (Tyrberg & Milberg 1991, Galbreath & Brown 2004). Diseases caused by introduced pathogens have contributed to the extinction of 20 species, 16 of them on Hawaii where introduced avian malaria and avian pox (transmitted by introduced mosquitoes) has had (and continues to have) devastating consequences (Scott *et al*. 1986, van Riper *et al*. 1986, Atkinson *et al*. 1995). Habitat destruction by sheep, rabbits and goats has been implicated in the extinctions of another ten species, and competitors have impacted six species. Gurevitch & Padilla (2004) argued that the evidence for invasive species having contributed to extinctions is poor, and noted that just 2% of 762 species listed as Extinct on the 2003 IUCN Red List were documented as having been impacted by invasive species. Their result contrasts with ours that

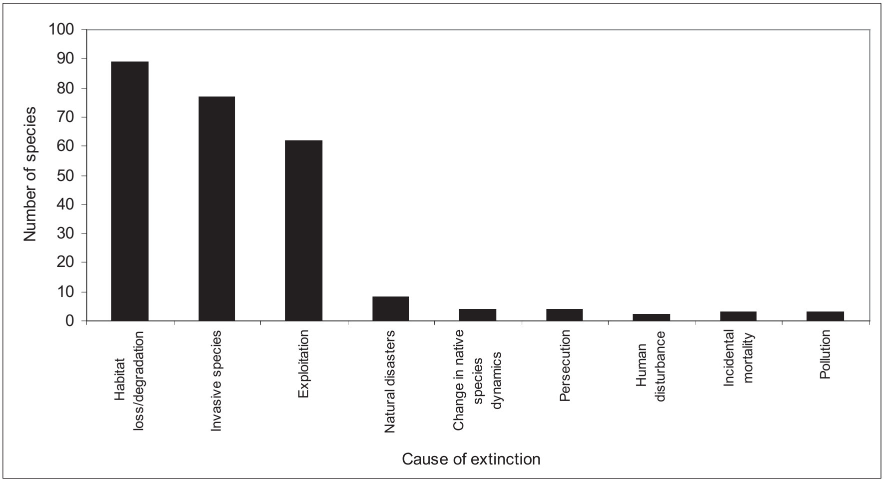

Figure 5. Causes of recent avian extinctions. Totals include Extinct (*n*=131), Extinct in the Wild (*n*=4), and Critically Endangered (Possibly Extinct) species (*n*=15).

invasive species were a major contributory factor to 51% of recent avian extinctions. Blackburn *et al.* (2004) and Clavero & Garcia-Berthou (2005) also provided strong evidence of the importance of invasive species in driving avian extinctions.

It is important to note that many species are impacted by combinations of threats: 48.7% of extinct species have multiple causes of extinction recorded, and this figure is likely to be an underestimate owing to lack of information on historical extinctions.

There are differences in the causes of extinctions of island versus continental species, with habitat loss and exploitation appearing to be more important causes of extinctions on continents than islands, although this result was marginally non-significant (habitat loss: 87.5% vs. 56.0% of species; exploitation: 62.5% vs. 38.1% of species; invasive species: 37.5% vs. 53.0% of species; χ^2= 4.13, P=0.076; Fig. 6). The apparent reduced importance of exploitation as an extinction driver on islands may be partly explained by the fact that passerines (which, being smaller, are less often targets for hunting) form a substantially lower proportion of island extinctions compared to continental extinctions (see above). It may also be a consequence of an extinction filter effect (Balmford 1996): non-passerine island species susceptible to exploitation through their size and naïveté may have already been driven extinct prior to 1500.

It is interesting to compare the threats to Extinct and Possibly Extinct species with those to extant threatened species (Fig. 7). Whilst habitat loss is the most important factor in both cases (impacting 59.3% of extinct species and 54.6% of threatened species), invasive species and exploitation were much more important as

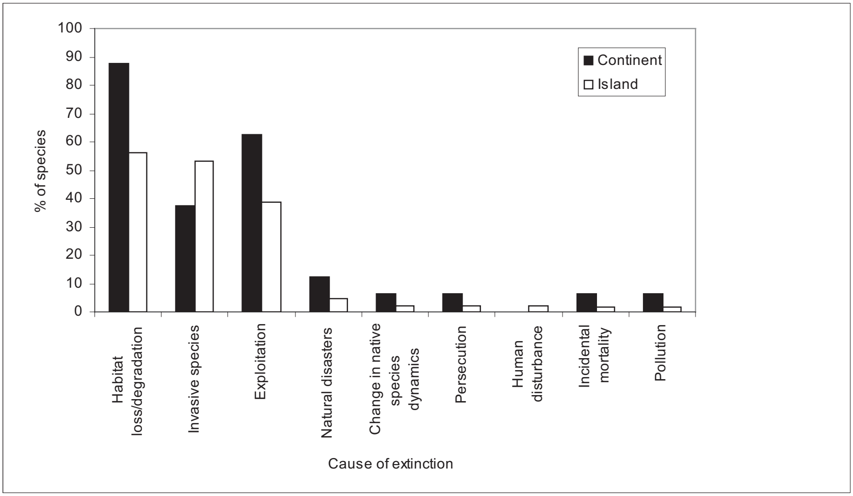

Figure 6. Causes of recent avian extinctions on continents (n=16 species) and islands (n=134 species). Totals include Extinct (n=131), Extinct in the Wild (n=4), and Critically Endangered (Possibly Extinct) species (n=15).

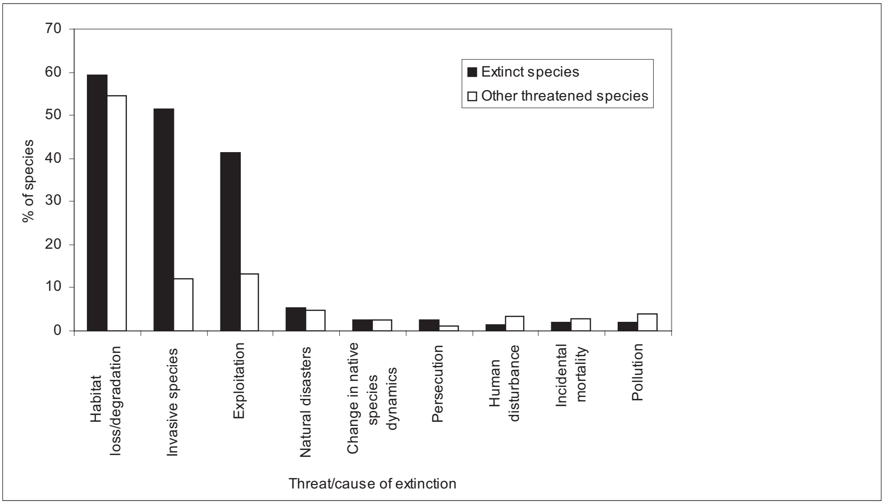

Figure 7. Causes of recent avian extinctions compared to threats to extant threatened birds. Extinct species include Extinct (*n*=131), Extinct in the Wild (*n*=4), and Critically Endangered (Possibly Extinct) species (*n*=15). Other threatened species include those classified as Critically Endangered (excluding Possibly Extinct), Endangered and Vulnerable (*n*=1,193).

causes of extinctions (implicated for 51.3% and 41.3% of species respectively) than as a threat to extant threatened species (12.1% and 13.1% of species respectively). However, as Blackburn *et al*. (2004) pointed out, invasive species (particularly predators) are still a potentially important driver for future extinctions. Most islands currently have few invasive predators: colonisation by additional predators is likely to lead to progressively more extinctions unless prompt intervention is achieved.

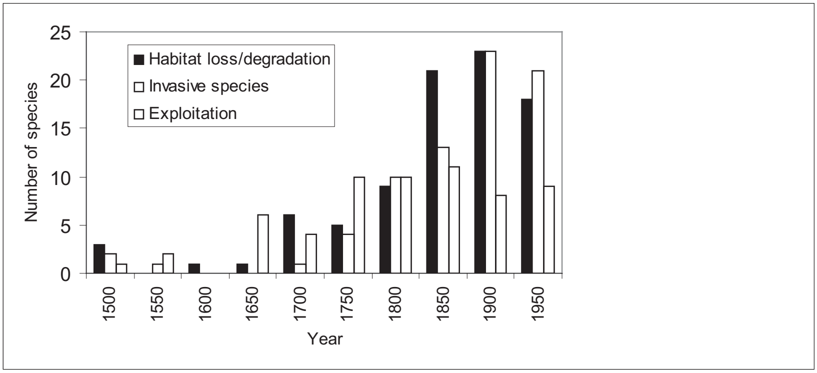

Figure 8. Causes of avian extinctions over time. Totals include Extinct (*n*=131), Extinct in the Wild (*n*=4), and Critically Endangered (Possibly Extinct) species (*n*=15).

Plotting the pattern of the number of extinctions over time caused by the three most important factors (habitat loss/degradation, invasive species and exploitation) shows that the importance of exploitation in driving extinctions has decreased through the 20th century whilst the importance of invasive species and habitat loss and degradation has increased (Fig. 8).

Conclusions

We developed and used the framework presented here to identify 15 Critically Endangered bird species as Possibly Extinct. Combining data on these species with data for 135 Extinct and Extinct in the Wild species shows that over the last century bird species have become extinct at a rate of one every 1.8 years. Habitat loss and degradation, invasive species and exploitation have been the main causes of extinction. Although the vast majority of documented extinctions thus far have been on islands, if we continue to degrade and destroy vast areas of natural habitats then it will be difficult to prevent even more extinctions from occurring imminently on continents.

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APPENDIX 1

Critically Endangered (Possibly Extinct) species, with evidence for and against extinction having occurred.

Species	Evidence for extinction					Evidence against extinction				
	Last confirmed record	Well-documented recent decline	Severe threatening processes	Predisposed to extinction?	Good recent surveys	Inadequate surveys	Low detectability	Unconfirmed reports	Habitat remains	**Notes**
Hooded Seedeater *Sporophila melanops*	1823					Near type locality.			x	Habitat destruction around type locality not severe.
Jamaican Pauraque *Siphonorhis americanus*	1860		Introduced predators; severe habitat loss.				x	x		Unidentified nightjar observations may refer to this species.
Jamaica Petrel *Pterodroma caribbaea*	1879		Introduced predators.				x			Searches in 1996–2000 failed.
Turquoise-throated Puffleg *Eriocnemis godini*	<1900		Habitat destroyed at only known locality.	x		Near type locality.			x	
Guadalupe Storm-petrel *Oceanodroma macrodactyla*	1912		Predation by feral cats; nesting habitat degraded by goats.			Wrong time of year.	x			Several searches have failed but Leach's Storm-petrel still survives on island.
Imperial Woodpecker *Campephilus imperialis*	1956		Habitat loss; hunting.		Conspicuous			1993		Some credible records in 1990s; recent discovery of suitable habitat (though surveys failed) indicates that other such areas may remain.
Eskimo Curlew *Numenius borealis*	1981	x	Habitat loss & hunting.			x		1990	?	Four apparently reliable reports in Canada in 1987 and unconfirmed reports in Argentina in 1990.
Oahu Alauahio *Paroreomyza maculata*	1985	x	Habitat loss; malaria, introduced predators.	Lowland		x			x	

Ou *Psittirostra psittacea*	1987	x	Habitat loss; malaria, introduced predators.					x		
Alaotra Grebe *Tachybaptus rufolavatus*	1988	x	Hybridisation; introduced fish; habitat loss.	Flightless?		x				
Oloma'o *Myadestes lanaiensis*	1988	x	Habitat loss; malaria, introduced predators.	Lowland		x			x	
Bachman's Warbler *Vermivora bachmanii*	1988	x	Habitat loss.			x		x		Recent unconfirmed sightings. Incomplete surveys of Congaree Swamp, South Carolina; partial habitat elsewhere.
Madagascar Pochard *Aythya innotata*	1991		Habitat loss; invasive species.			x	x			
Nukupu'u *Hemignathus lucidus*	1996	x	Habitat loss; malaria, introduced predators.		x			x		
Spix's Macaw *Cyanopsitta spixii*	2000	x	Trapping; habitat loss.		x	x				Captive populations survive.

APPENDIX 2

Selected Critically Endangered species not considered to be Possibly Extinct, with evidence for and against extinction having occurred.

Species	**Evidence for extinction**					**Evidence against extinction**				
	Last confirmed record	Well-documented recent decline	Severe threatening processes	Predisposed to extinction?	Good recent surveys	Inadequate surveys	Low detectability	Unconfirmed reports	Habitat remains	**Notes**
Siau Scops-owl *Otus siaoensis*	1866		Severe habitat loss.			Few searches.	x	1999	x	Probably nocturnal.
Samoan Moorhen *Gallinula pacifica*	1873		Introduced predators; hunting.	x		No thorough searches.	x	2003	x	Perhaps nocturnal.
Himalayan Quail *Ophrysia superciliosa*	1876		Habitat loss.			x		2003	x	

New Caledonian Rail *Porphyrio kukwiedei*	1890				Inaccessible, few surveys.	x	1998	x	
Sulu Bleeding-heart *Gallicolumba menagei*	1891	Habitat loss.			x		1995	x	
New Caledonian Lorikeet *Charmosyna diadema*	1913				x	x	x	x	Congeners very inconspicuous.
Rueck's Blue-flycatcher *Cyornis ruckii*	1918	Habitat destroyed at only known locality.	x		Limited survey work in Sumatran lowlands.	x	x	x	Presumably low density; inconspicuous.
Beck's Petrel *Pseudobulweria becki*	1929				x	x	x	x	Reports of *P. rostrata* in Bismarcks/Solomons may refer to this species.
Silvery Woodpigeon *Columba argentina*	1931	Habitat loss.				x	2002	x	Difficult to separate from *Ducula bicolor*.
Magdalena Tinamou *Crypturellus saltuarius*	1943	Habitat loss.			None in 1940–2000.		1990s	x	First surveys in 2002 failed, but some suitable habitat inaccessible.
Javan Lapwing *Vanellus macropterus*	1940	Severe habitat loss.		Conspicuous	x		2002	x	Searches planned in 2005–06
Pink-headed Duck *Rhodonessa caryophyllacea*	1949	Intensive hunting; habitat loss.	x	Conspicuous	Further surveys needed in Myanmar.		2004	x	Unconfirmed sighting in Kachin state, Myanmar, November 2004. Further searches planned.
Archer's Lark *Heteromirafra archeri*	1955	Habitat loss and degradation.		x	Most surveys restricted to type locality.	x	2003	x	Species is exceptionally reclusive.
Negros Fruit-dove *Ptilinopus arcanus*	1953	Severe habitat loss.	x	x	Needed on Panay.		2002	x	May be montane. Recent convincing local report.
Semper's Warbler *Lecuopeza semperi*	1961	Introduced predators.			No intensive searches.		2003	x	Some habitat remains; several possible sightings.
Glaucous Macaw *Anodorhynchus glaucus*	1962	Trapping; habitat loss.		x	Very large former range.		1990s	x	Persistent unconfirmed reports.
Crested Shelduck *Tadorna cristata*	1964	Habitat loss.		Conspicuous	Many areas poorly surveyed.		x	x	Original range poorly understood. Habitat loss insufficient.
Makira Moorhen *Gallinula silvestris*	1974	Introduced predators.	x			x	2002	x	Convincing recent local reports.

Bahia Tapaculo *Scytalopus psychopompus*	1983	Severe habitat loss.			x	x	1999	x	
Liberian Greenbul *Phyllastrephus leucolepis*	1985	Habitat loss.			Inaccessible owing to civil war.				Taxonomic status has also been questioned.
White-eyed River-martin *Eurychelidon sirintarae*	1986	Habitat loss.		Conspicuous	Rivers poorly surveyed in Myanmar.			x	Original range poorly understood.
Night Parrot *Geopsittacus occidentalis*	1990				Remote and large range.	x	x	x	Nocturnal, nomadic.
Bulo Burti Boubou *Laniarius liberatus*	1990				Inaccessible owing to security.			x	Not seen since described but no subsequent surveys. Taxonomic status has been questioned.
Pohnpei Mountain Starling *Aplonis pelzelni*	1995	Habitat loss, hunting, predation by invasive rats.					x	x	Drastic decline since 1930, only one record in last 50 years
White-chested White-eye *Zosterops albogularis*	2000	Predation by invasive rats.	x				x	x	In severe decline; formal surveys have failed to find any for 20 years.

NOTE ADDED IN PROOF.—Confirming their classification here as Critically Endangered, and not Possibly Extinct, Night Parrot was rediscovered at Mulga Downs, Australia, in 2005 (R. Davis *in litt.* 2006), populations of Bahia Tapaculo have been found at Ituberá and Una Biological Reserve, Bahia, Brazil (F. Olmos & P. C. Lima *in litt.* 2006), and White-chested White-eye was seen again as recently as 2004 (P. Olsen & R. Ward *in litt.* 2006). Two Endangered species discussed here have also been recently rediscovered: Recurve-billed Bushbird and Chestnut-bellied Flowerpiercer (O. Laverde, C. J. Sharpe & P. C. Pulgarín *in litt.* 2006).