The State of Australia's Birds 2010
Islands and Birds

Compiled by Julie Kirkwood and James O'Connor

Birds Australia

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Above: King Penguins and Elephant Seals share the beach on remote sub-Antarctic Macquarie Island. Photo by Glenn Ehmke.

Australia's islands: Biodiversity arks or rat-traps for future Dodos?

Table of contents

A note on the text Scientific and common names for birds in this report follow Christidis & Boles 2008. Scientific names are included the first time a species or subspecies is mentioned in the text of the report, and thenceforth only common names are used.

The State of Australia's Birds reports are overviews of the status of Australia's birds, the threats they face and the conservation actions taken. This eighth annual report focuses on the status of birds on Australia's islands.

This report features articles on a small number of Australia's precious islands, but it is only a snapshot of the situation, as more than 8,300 islands occur within Australia's jurisdiction. Indeed, only a small number of these islands are ever visited regularly by people who record biological data, and precious little is known about most of them. We are left to make inferences about what is happening on those unknown islands from what is happening on the few we have studied. Nevertheless, some distinct themes emerge from the articles in this report: a high level of endemism means islands represent a critical biodiversity ark; even small increments of climate change-induced sea-level rise will have grave consequences for low-lying islands; and invasive species have already caused widespread devastation of many islands' biological resources and ecological processes, and continue to do so at an alarming rate. We tend to know much more about islands inhabited by humans, of course, and the processes on inhabited islands are likely to be distinct. Patterns of invasion of islands by novel species, for example, are bound to be heavily influenced by human habitation: by contrast, climate change and sea-level rise will affect any island on the basis of its physical situation. Opportunities for mitigation, too, may depend on whether an island is inhabited. For instance, most examples of successful eradications and reintroductions have, so far, come from uninhabited islands, although there are some notable exceptions.

While we may know little about many of our islands, what we do know is that, by their nature, they constitute a unique and precious biological resource; and that, while they are extremely vulnerable to degradation and extinctions, they also represent unique opportunities for providing real and effective conservation measures for the protection of a large proportion of our natural heritage.

Introduction

The year 2010 marks the International Year of Biodiversity. At the 2002 World Summit on Sustainable Development, the world's nations agreed to pursue the objectives of the Convention on Biological Diversity (CBD) in order to achieve a significant reduction in the current rate of loss of biological diversity by 2010. However, the latest edition of *Global Biodiversity Outlook* (GBO3), which reports on progress towards the CBD targets, states baldly that the 2010 biodiversity target has not been met. It concludes that biodiversity continues to disappear at an unprecedented rate, up to 1,000 times the natural rate of extinction, and that the threatening processes that cause biodiversity loss are continuing unabated or, in many cases, intensifying.

Nowhere is the global extinction crisis more starkly demonstrated than on islands. Since 1500, more species have become extinct on small islands than on continental land masses, and 111 of 127 bird extinctions worldwide have been island endemics. Accordingly, island birds dominate the list of extinct taxa in Australasia. Of the 55 animal species or subspecies listed as extinct under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) in 2010, 23 are birds, and no fewer than 19 (eight species and 11 subspecies) of these are birds that were found only on islands (see Table 1).

The majority of these bird extinctions have occurred on Australia's oceanic island territories, and were caused primarily by invasive species, particularly mammals. Predation by introduced Feral Cats (*Felis catus*) and Black Rats (*Rattus rattus*) accounts for most of the losses of bird species from islands, although human predation for food, land clearing and other invasive animals such as foxes, pigs, goats, birds and insects such as ants have also been implicated, as have a variety of weeds.

The threats are by no means historical: three of the six Critically Endangered bird taxa listed in the EPBC Act are island birds: 21 of the 43 birds listed as Endangered; and 34 of the 60 birds listed as Vulnerable. Of Australia's threatened or extinct bird taxa, then, a grand total of 77 out of 132 (58%) are island birds.

Current pervasive threats to island birds include climate change, causing rising sea temperatures. This may affect pelagic food supplies and rising sea levels, which may endanger island breeding, roosting and feeding habitats, and a variety of invasive species. Several Australian island land and seabird populations are currently threatened by invasive species. Many seabirds

Table 1: EPBC Act list of extinct Australian bird taxa

Common name	Scientific names	Island taxon
Tasman Starling	*Aplornis fusca*	Y
White-throated Pigeon (Lord Howe Island)	*Columba vitiensis godmanae*	Y
Red-fronted Parakeet (Macquarie Island)	*Cyanoramphus novaezelandiae erythrotis*	Y
Tasman Parakeet (Lord Howe Island)	*Cyanoramphus cookii subflavescens*	Y
Rufous Bristlebird (western)	*Dasyornis broadbenti litoralis*	
King Island Emu	*Dromaius ater*	Y
Kangaroo Island Emu	*Dromaius baudinianus*	Y
Emu (Tasmanian)	*Dromaius novaehollandiae diemenensis*	Y
Roper River Scrub-robin	*Drymodes superciliaris colcloughi*	
Buff-banded Rail (Macquarie Island)	*Gallirallus philippensis macquariensis*	Y
Lord Howe Gerygone	*Gerygone insularis*	Y
New Zealand Pigeon (Norfolk Island)	*Hemiphaga novaeseelandiae spadicea*	Y
Long-tailed Triller (Norfolk Island)	*Lalage leucopyga leucopyga*	Y
Lewin's Rail (western)	*Lewinia pectoralis clelandi*	
Norfolk Island Kaka	*Nestor productus*	Y
Southern Boobook (Lord Howe Island)	*Ninox novaeseelandiae albaria*	Y
White Gallinule	*Porphyrio albus*	Y
Paradise Parrot	*Psephotus pulcherrimus*	
New Zealand Fantail (Lord Howe Island)	*Rhipidura fuliginosa cervina*	Y
Norfolk Island Thrush	*Turdus poliocephalus poliocephalus*	Y
Vinous-tinted Thrush	*Turdus poliocephalus vinitinctus*	Y
White-chested White-eye	*Zosterops albogularis*	Y
Robust White-eye	*Zosterops strenuus*	Y

breed only or predominantly on islands, being attracted by a range of factors, including proximity to oceanic food resources, strong winds and the absence of predators. In turn, seabirds play a key role in sustaining island soil, by excreting essential nutrients from their ocean diet via their guano. The loss of some seabird species on islands has led to a decline in this essential nutrient cycling, which affects other species and has the potential to cause ecosystem collapse.

Many of the articles in this report discuss the eradication of invasive species and subsequent recovery of threatened bird populations. Because of the high levels of endemism on islands, and because so many of our threatened birds reside on islands, these habitats represent a significant opportunity to meet our international obligations for tackling biodiversity decline. The conservation of a major part of the earth's terrestrial biodiversity can potentially be ensured by focusing conservation resources and actions within a relatively small total area.

This report highlights some of the key values of Australia's islands for birds and showcases a range of projects aimed at improving the conservation status of birds on islands. While there is a growing level of awareness regarding the values of and threats to Australia's islands, there is still significant scope to improve monitoring, research and conservation-management investment for Australia's vast island resources, and in the following pages we explore some of the issues and opportunities.

Overview of Australian islands

Most of Australia's islands, islets and rocks are inhabited by birds. Large, well-vegetated islands contain breeding or transient populations of landbirds; many smaller islands are used by seabirds for breeding; and islets, exposed rocks and intertidal and near-shore waters, beaches and headlands provide feeding and resting places for many seabirds and shorebirds.

Australia's islands range in size from Tasmania (64,519 km^2) and Melville Island (5,765 km^2) to islets of just a few square metres. Islands occur within all of Australia's jurisdictions, but predominate in Western Australia, Queensland and Tasmania (Table 2):

Table 2: Australian islands by jurisdiction (Does not include Australian Antarctic Territory).

Western Australia	3,747
Queensland	1,995
Tasmania	1,000
Northern Territory	887
South Australia	346
Victoria	184
Commonwealth (estimated)	109
New South Wales	102
Australian Capital Territory (at Jervis Bay)	1
Total	**8,371**

Islands fall into two major categories: oceanic islands and continental islands. Australia's oceanic islands, which arose from volcanic or tectonic action from deep oceans, are Christmas, Lord Howe, Norfolk, Macquarie, Heard and McDonald Islands. The Cocos (Keeling) Islands in the Indian Ocean are cays on two atolls, while the Ashmore Islands and Cartier Island in the Timor Sea are cays located on reefs. The plants and animals on oceanic islands arrived by random colonisation via sea or air from nearby continents. Small founder numbers may mean that there is low genetic diversity among populations of plants and animals, but, nevertheless, oceanic islands are often sites of high speciation. Each oceanic island has a unique set of ecosystems that are fragile and highly susceptible to disturbance, especially by invasive species.

Most continental islands were isolated by rising sea levels over the past 14,000–6,000 years. Such islands retain elements of their original biodiversity, modified through species loss due to changing climates, small size and changes in soil chemistry from wind-blown salt. Like oceanic islands, many large and some small continental islands have unique assemblages of plants and animals. Some have populations of species that are threatened with extinction on mainland Australia.

Cays are a specialised type of low-lying island that arise through the accumulation of sand or coral rock on reefs. Like oceanic islands, most of their plants and animals (apart from seabirds) arrived by random colonisation, but the plant and non-flying animals on cays that are close to the mainland are mainly similar to those of nearby shores. Cays are particularly important for seabird and sea turtle breeding. Coral cays within the Great Barrier Reef are discussed in more detail by Kees Hulsman and Carol Devney later in this publication.

Most islands have not suffered the same degree of disturbance as mainland Australia. However, as island biota have evolved in the absence of invasive species, they are particularly vulnerable to the impact of pests and weeds, especially on small islands. Oceanic islands have been hit particularly hard, and feature articles in this report on Lord Howe, Norfolk, Macquarie and Christmas Islands describe their past and current ecological imbalances.

Andrew A. Burbidge
Conservation Biologist, Perth

Monitoring birds on Australia's islands

James O'Connor
Birds Australia

There are 3,905 islands defined by the Geodata Coast 100K (1992) spatial layer, published by Geoscience Australia, which includes islands within coastal waters around Australia and excludes the oceanic islands. There has been some monitoring for the Birds Australia Atlas on only 219 (5.6%) of these islands. The number of islands that have been surveyed repeatedly is even smaller: only 71 islands (1.8%) have had more than five surveys. Nevertheless, this monitoring effort is not insignificant, comprising 7,391 Atlas surveys, including 2,317 two-hectare searches, and has turned up 552 species, including 352 species of landbirds. Although these islands cover a total of 3,202,606 hectares, which is only 0.4% of the total Australian land area of 769,202,400 hectares, this species tally represents 68% of the 811 bird species recorded by the Atlas in Australian territories.

This disproportionate representation of our avifauna can largely be accounted for by islands in northern Australia, many of which are likely to receive visits from vagrant species from further north, and in particular islands in the northern part of Torres Strait, which lie so close to New Guinea that their fauna is basically New Guinean. Boigu, Saibai and Dauan Islands lie just off the coast of the Papua New Guinean mainland and host a myriad of bird species, such as Gurney's Eagle (*Aquila gurneyi*), Collared Imperial-Pigeon (*Ducula mulleri*), Red-capped Flowerpecker (*Dicaeum geelvinkianum*) and Singing Starling (*Aplornis cantoroides*), which can be seen virtually nowhere else in Australia.

Getting to these islands takes time, work and money: visitors require permission from the islands' councils, and need to charter their own boat or light aircraft. It takes a determined birdwatcher to access places this remote and, overall, our islands receive much poorer survey coverage than the Australian mainland: despite the concentrations of endemic and rare species, the islands defined in this spatial layer have received an average of around 0.2 surveys per 100 hectares, compared with 0.6 per 100 hectares on the mainland.

Birds Australia Atlas data show the mean number of landbird species recorded per survey in island surveys (10.42 ± 0.8092 SE) is greater than that on the mainland (9.27 ± 0.0573 SE). Perhaps this is in part due to the high levels of endemism on islands. The data show a logarithmical relationship between species richness per survey and island area (Figure 1), which is consistent with the species–area relationship proposed by the theory of island biogeography (see the following article).

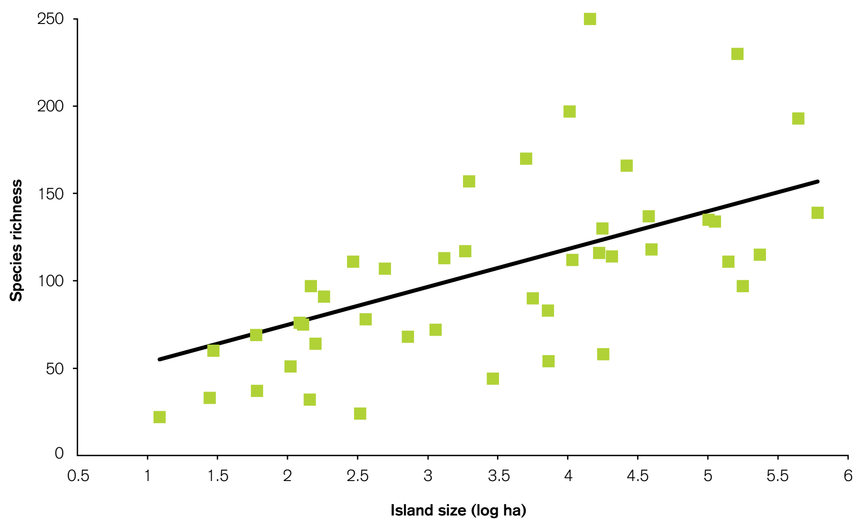

Figure 1: Landbird species richness on islands with >10 surveys (all survey types) in relation to island size, corrected for survey effort (Generalised Linear Mixed Model, p = 0.0034).

Above:
Bar-tailed Godwit flock on Mud Island.
Photo by Ashley Herrod

Island laboratories: Biogeography, speciation and extinction

James O'Connor

Islands have been well known as living laboratories for studying evolutionary processes for almost as long as the theory of evolution has been known. In 1837, John Gould identified Darwin's Galapagos collection as a series of unique new finch species—closely related to each other and occupying different subsets of islands in the archipelago—but beyond that, bearing similarities only to birds on the South American mainland. It wasn't long before Darwin had joined Alfred Russel Wallace as a subscriber to the theory of species transmutation, and by 1839 Darwin had started to develop the basics of his natural selection theory. Is it a coincidence that Wallace, who had been developing similar ideas about evolution during his travels throughout the Indonesian Archipelago, conceived of natural selection while lying in bed in a fever on a tropical island?

The concept developed by these fathers of evolution was one of colonisation by founder populations, followed by speciation to fill new niches in new environments; but it is not the only way to look at species patterns on islands. In the 1960s American biologist Edward Osborne Wilson developed his influential theory of island biogeography. The theory—which at its most basic level proposes that the number of species found on an undisturbed island is determined mostly by immigration, emigration and extinction—attempts to account for geographical patterns of species richness. Immigration and emigration are influenced by distance from source populations, while the rate of extinction (once a species makes it to an island) is influenced by the size of the island: the larger the island, the more likely it is that a species will persist, because large areas contain more potential habitat (for any given species), and are more likely to contain different types of habitat (increasing the likelihood of having suitable habitat for a greater number of species). Generally, more habitat also means bigger populations and, therefore, a reduced likelihood of extinction due to chance events (stochasticity).

Wilson tested his theory experimentally: he and his student Daniel Simberloff surveyed species richness on several mangrove islands in the Florida Keys. Then they fumigated the islands to clear them of arthropods, and monitored their recolonisation. Islands closer to the mainland were recolonised more quickly, and larger islands had more species at equilibrium, as predicted by the theory of island biogeography.

According to the theory, an undisturbed island will eventually reach some predictable equilibrium number of species based on this combination of factors. More recently, the idea of whether equilibrium is ever actually reached has been called into question, and the need to account for *in situ* speciation is part of this discussion. Given the correct degree of isolation, and a slightly different set of environmental parameters, adaptation and then speciation is likely to follow. So we are back to studying Darwin's finches to understand these patterns, although these days there are plenty of other models to look at, and one of them is in our own backyard.

Zosterops, islands and evolution

Are the *Zosterops* white-eyes one of the most prolific and threatened taxa in world avifauna? There are approximately 75 species of the genus *Zosterops*, a huge number for a single vertebrate genus, and no fewer than 24 are on the IUCN Red List, with statuses ranging from Near-threatened to Extinct. Without exception, these threatened species occur on islands, typically tiny islands with areas of well under 100 km^2. It's no surprise that one of the most diverse genera in the world is also one of the most threatened. The propensity of white-eyes for colonising islands has driven their speciation, and has also exposed them to a vulnerable environment, because islands constitute a paradoxical refuge: island endemics are protected by their isolation but, when that protection is breached by invasive species, they may suddenly have no place to hide from predation or ecological disruption, and no way of escaping. It may be that background extinction levels for these kinds of species (those with an ongoing pattern of dispersal, colonisation and extinction) are significantly higher than for less "intrepid" species.

A population of Silvereyes (*Zosterops lateralis*) on Heron Island, off the coast of Queensland, is a good example of how islands can act as living laboratories. The island's Silvereyes have been closely and comprehensively monitored since 1965, and researchers have been able to study population-wide evolutionary phenomena. The population is density-dependent; for example, survival of fledglings decreases with the number of breeding birds (McCallum *et al.* 2000). Population-viability models, including movement between Heron Island and neighbouring islands, have been tested; they suggest that the small neighbouring islands act as sink populations that could quickly become extinct (Brooke & Kikkawa 1998).

Another study found that the Heron Island population had undergone a significant increase in body size (equivalent to six standard deviations) since colonising the island about 4,000 years ago (Frentiu *et al.* 2007). In fact, all 11 island-forms of the Silvereye in the south-western Pacific have larger bodies than their mainland Australian ancestors. There are several theories that have been put forward to explain this pattern of change in island passerines: the traditional hypothesis proposes that in the absence of competitors, exploitation of a wider spectrum of resources is possible, and this is facilitated by a larger body—but it appears this theory has not been supported in the case of the Silvereyes. Another theory posits an advantage of large body size in cases of high-density island populations, which encourage increased intra-specific competition, entailing high levels of aggression and year-round territoriality. The Heron Island Silvereye population, at least, seems to fit this model, which has been termed the Dominance Hypothesis: researchers found that being large was associated with high fitness and dominant behaviour (Robinson-Wolrath & Owens 2003).

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Terrestrial islands

Dr David M. Watson
Associate Professor in Ecology
Institute for Land, Water and Society
Charles Sturt University, Albury

While the term "island" is generally used to describe landmasses surrounded by water, a range of other geographic features share similar ecological properties. Caves, mountain tops, lava fields, glacial moraines, lakes and rocky massifs are just some of the terrestrial features that represent discrete habitat patches that support distinctive communities of plants and animals, isolated from other patches by "seas" of inhospitable habitat. Biogeographers have noted that the structure and diversity of communities associated with these features are affected by the same forces sculpting island communities: primarily patch size, distance to nearest neighbour, age and habitat complexity. Worldwide, most of these land-locked islands are characterised by a suite of specialised bird species, from cave-nesting swiftlets and owls to alpine specialist sunbirds and finches. In Australia, two classes of terrestrial islands are of particular importance: lakes and mountain tops.

Our inland deserts contain a wealth of arid-adapted birds, but they also support a surprising diversity of waterbirds dependent on lakes. While a few inland lakes are permanent, most are ephemeral, filling after flooding rains associated with cyclonic systems in northern catchments. Just as with oceanic islands, these lakes represent patches of plenty, largely free of predators. Soon after filling, eggs of shrimps and other crustaceans lying dormant in the dry mud hatch, with Red-necked Avocets (*Recurvirostra novaehollandiae*), Banded (*Cladorhynchus leucocephalus*) and Black-winged Stilts (*Himantopus himantopus*), and Pink-eared Ducks (*Malacorhynchus membranaceus*) flying in (sometimes from coastal areas more than 1,000 km away) to capitalise on this short-lived resource. Bony Bream (*Nematalosa erebi*) and other fish move into these lakes from adjacent watercourses, building up in numbers and forming the foundation for another set of waterbirds—the herons, cormorants, grebes and other fish specialists. Rather than simply being opportunists moving from their usual coastal habitats, we understand that these birds depend on these inland lakes as core breeding habitat. While most apparent for Banded Stilts and Australian Pelicans (*Pelicanus conspicillatus*), most of our wetland birds are dependent on these desert oases; their short-lived productivity driving population growth in many groups.

The other class of terrestrial island that is of particular relevance to our avifauna is mountains. Often called "sky islands", some of these of altitudinally restricted habitats represent fragments of previously more continuous habitat types, exemplified by the Atherton Tablelands. Home to nine endemic bird species, these upland forests are the last surviving relict from the time when Australia and New Guinea were connected, and regional climates were cooler. As Australia moved northward, and Torres Strait formed; many of the plants and animals that lived throughout this region retreated to higher elevations, and are now restricted to the New Guinean highlands and the Atherton Tablelands. The latter are smaller and lower than their more northern counterparts, making their endemic species especially sensitive to further increases in temperature.

Thus, in addition to all of our offshore islands, Australia contains a range of other insular habitats, many of which are designated as Important Bird Areas (IBAs). Just as the processes that led to their distinctive communities are similar to those operating on oceanic islands, many of the same management principles and techniques also apply, and will be essential if their unique diversity is to be preserved.

Banded Stilts (left) and Australian Pelicans (above) are particularly dependent on our ephemeral freshwater oases. Photos by Glenn Ehmke.

What is Birds Australia doing on islands? **Peter Dann** Birds Australia

Birds Australia (BA) is involved with island bird conservation at both strategic and practical levels. "Island invasives" has been listed as one of the top three priorities for research and conservation in the organisation's strategic plan, and the need for review and priority setting for the future has stimulated the production of this report.

The Australian government's Action Plan for Australian Birds has identified a suite of island species that are threatened. Approximately one-third of the Important Bird Areas (IBAs) in Australia involve islands, and through the IBA project, Birds Australia hopes that greater recognition of the importance of these areas will be afforded, as well as giving an impetus to their appropriate protection and management (see p. 41). The Atlas of Australian Birds also provides a framework for determining the distribution and trends in abundance of island birds.

One of BA's strengths is our pool of skilled field people who can co-ordinate or contribute to surveys across the country. Two of Birds Australia's special interest groups (the Australasian Wader Studies Group (AWSG) and the Australasian Seabird Group (ASG)) both have considerable involvement with islands and their birds. Many wader roosts around the coast occur on islands and the extensive monitoring and banding activities of the AWSG and the Shorebirds 2020 program involve birds on a multitude of islands. The ASG also conducts survey work on islands in NSW (see the Birds Australia website for more details of special interest groups). Most regional groups also contribute to our knowledge of birds on islands in various ways. In the case of Birds Tasmania, island birds are their *raison d'etre*, and the group conducts projects on island endemics such as the Forty-spotted Pardalote (*Pardalotus quadragintus*) and indigenous honeyeaters, as well as surveys of beach-nesting shorebirds and small terns. The Western Australian regional group (BAWA) is involved with surveys on Rottnest and Faure islands. Islands feature prominently in Birds Australia's projects involving the Orange-bellied Parrot (*Neophema chrysogaster*) on King Island and the Hooded Plover (*Thinornis rubricollis*) in Tasmania, Kangaroo Island and Phillip Island.

The importance of islands for Australia's migratory and resident shorebirds is clear. Over 21% of the 2,000 areas surveyed as part of the Shorebirds 2020 program occur on islands. Further, more than 10% of all the shorebirds recorded in the national shorebird database come from islands. The relative importance of islands varies across the 43 shorebird species that occur in Australia: for example, nearly half of the Ruddy Turnstone (*Arenaria interpres*) and Australian Pied Oystercatcher (*Haematopus longirostris*) populations counted are on islands.

Birds Australia is involved in a range of projects on islands across Australia through the activities of its members and professional staff, but it does not have a plan for research and conservation that specifically targets island birds and their habitats. Whether the conservation of island birds requires a dedicated approach from Birds Australia remains to be determined.

Getting the good oil on island birds

In 2009 and 2010 Birds Australia's Southern Queensland Group conducted a series of bird surveys on Moreton and Bribie Islands to monitor the changes taking place as a result of the disastrous oil spill that occurred there in 2009. The islands flank Moreton Bay, an IBA containing 110,000 hectares of Ramsar-listed wetlands that hold in excess of 40,000 non-breeding waders during summer. The IBA also contains significant populations of the Endangered Australasian Bittern (*Botaurus poiciloptilus*), the Near-Threatened Bush Stone-curlew (*Burhinus grallarius*) and Beach Stone-curlew (*Esacus magnirostris*) and the endemic Mangrove Honeyeater (*Lichenostomus fasciogularis*), and more than 1% of the world's population of 10 other shorebird species (Black-winged Stilt, Red-necked Avocet, Red-capped Plover (*Charadrius ruficapillus*), Bar-tailed Godwit (*Limosa lapponica*), Eastern Curlew (*Numenius madagascariensis*), Grey-tailed Tattler (*Tringa brevipes*), Great Knot (*Calidris tenuirostris*), Red-necked Stint (*Calidris ruficollis*), Sharp-tailed Sandpiper (*Calidris acuminata*) and Australian Pied Oystercatcher). Shorebirds, terns, gulls and raptors were identified as being most at risk from an oil spill, and the welfare of Beach Stone-curlews, which nest on Bribie Island, is of particular interest. Surveys have indicated that sites affected by the spill contained 50% fewer species than unaffected sites. For more information on the Oil Spill Project, see www.birdsaustralia.com.au/the-organisation/oil-spill-project.html.

Top: More than half of the Ruddy Turnstone populations counted in Australia are on islands. Photo by Glenn Ehmke.

Status and conservation of the seabirds of Heard Island

Eric J. Woehler
School of Zoology, University of Tasmania

Heard Island and the associated McDonald Islands lie in the south-western Indian Ocean, equidistant between Australia and South Africa, and 1,500 km north of the Antarctic continent. The islands are administered by the Australian federal government, protected under the World Heritage and Ramsar conventions, and managed as IUCN 1A reserves (Strict Nature Reserve). There is no resident human population on the islands. A large marine reserve has been declared within the Heard Island and McDonald Islands Exclusive Economic Zone (HIMI EEZ). The limited human visitation to the islands has resulted in few species known to have been introduced to the reserve, and Heard Island is now the largest peri-Antarctic island free of introduced vertebrates, warranting the highest level of protection to ensure this exceptional conservation status continues.

The seabirds of Heard Island and the McDonald Islands have received less attention than the avifauna of most sub-Antarctic islands, due largely to the infrequency of visits by Australian National Antarctic Research Expeditions (ANARE), other scientific expeditions or private visits. A total of 19 species of seabirds breed on Heard Island and the McDonald Islands (Table 1), with another 28 species recorded as non-breeding visitors or from at-sea surveys within the HIMI EEZ.

Survey data on many aspects of the biology of the seabirds on Heard Island, collected between 1947 and 1955 by ANARE biologists and medical doctors, established valuable baselines for contemporary and future studies, in particular breeding localities and early estimates of breeding populations. Few data were collected during brief visits to Heard Island and the McDonald Islands by several private (non-ANARE) expeditions between 1955 and 1985. There have been no visits to the McDonald Islands since 1979–1980, and consequently there are no new census data available for the species breeding there. Volcanic activity in the last two decades has resulted in an approximate doubling of the surface area of the McDonald Islands, with a concomitant loss of areas previously used for nesting by seabirds. Few data are available to provide trends in breeding numbers of resident species due to the infrequent visits and poor weather that hampers surveys. However, anecdotal and semi-quantitative data are available for some species: at least two species are known to be increasing (King Penguin (*Aptenodytes patagonicus*) and Black-browed Albatross (*Thalassarche melanophris*)) and another two may be increasing (Light-mantled Sooty Albatross (*Phoebetria palpebrata*) and Southern Giant-Petrel (*Macronectes giganteus*)). Macaroni Penguins (*Eudyptes chrysolophus*) and Rockhopper Penguins (*Eudyptes chrysocome*) may be decreasing at Heard Island (Table 1).

Four penguin species breed on Heard Island (King, Macaroni, Rockhopper and Gentoo Penguins (*Pygoscelis papua*)), and the populations of King and Macaroni penguins are of international significance. The King Penguin population has increased rapidly since initial counts in the late 1940s, and the estimated minimum breeding population in 2003–2004 was 80,000 pairs. The extensive Macaroni Penguin colony on the McDonald Islands is believed to have been destroyed by volcanic activity some time in the last two decades. Two species of albatrosses breed on Heard Island (Black-browed and Light-mantled Sooty); there is a report of Wandering Albatrosses (*Diomedea exulans*) breeding. Numbers of breeding Black-browed Albatrosses have increased since the 1940s as climatic amelioration and glacier recession have allowed colonies to increase. The observed increases in the number of breeding Southern Giant-Petrels on Heard Island may be a result of breeding adults being displaced from the McDonald Islands by the recent volcanic activity there. Five species of burrowing petrels (Antarctic Prions (*Pachyptila desolata*) and Fulmar Prions (*Pachyptila crassirostris*), Common Diving-Petrels (*Pelecanoides urinatrix*) and South Georgian Diving-Petrels (*Pelecanoides georgicus*) and Wilson's Storm-Petrel (*Oceanites oceanicus)*) breed on Heard Island (Table 2). The island hosts breeding populations of one endemic sheathbill, Kelp Gull (*Larus dominicanus*) and Brown Skua (*Stercorarius antarcticus*), and a small population of Antarctic Terns (*Sterna vittata*) is present. The Heard Island Cormorant (*Leucocarbo atriceps nivalis*) is an endemic subspecies of the Imperial Shag found throughout the islands of the Southern Ocean.

Table 1. Breeding seabirds of Heard Island and the McDonald Islands, with current estimates of minimum breeding populations, current population trends where known, and IUCN status.

Species	Minimum breeding IUCN population (pairs) status	Population trend
Wilson's Storm-Petrel	B	no data
Wandering Albatross	1	May be attempting to
	Vulnerable	colonise
Black-browed Albatross	≥600	increasing
Light-mantled Sooty Albatross	~500	increasing?
Southern Giant-Petrel	~2500	increasing ?*
	Vulnerable	
Cape Petrel	1000–2500	no data
Antarctic Prion	≥100,000	no data
Fulmar Prion	≥10,000	no data
Common Diving-Petrel	1000–10,000	no data
South Georgian Diving-Petrel	10,000–100,000	no data
King Penguin	80,000	increasing
Gentoo Penguin	16,000	decreasing?
Rockhopper Penguin	10,000	decreasing?
	Vulnerable	
Macaroni Penguin	1,000,000	decreasing?
	Vulnerable	
Imperial Shag	1100	no data
	Vulnerable	
Black-faced Sheathbill (*Chionis minor*)	<1000	no data
Brown Skua	500	no data
Antarctic Tern	100–200	no data
Kelp Gull	~250	no data

* The breeding population of Southern Giant-Petrels on Heard Island may be increasing as a result of breeding birds displaced from McDonald Islands relocating to Heard Island.

? indicates a lack of confirmed increase or decrease in the population size.

B indicates breeding reported but no estimate of breeding population size is available.

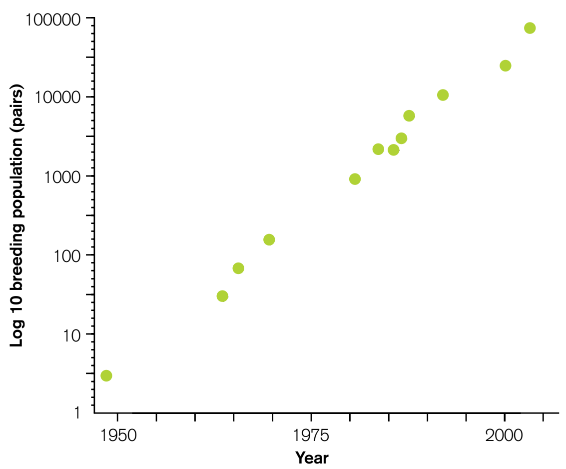

Figure 1: Log-normal plot of the total breeding population (pairs) of King Penguins on Heard Island, 1947–1948 to 2003–2004. The population has doubled every five years or so since the earliest surveys were conducted. There is no indication of a slowing in the current rate of increase.

Heard Island is the largest peri-Antarctic island free of human-introduced species. The relatively brief periods of sealers' occupation of Heard Island in the 19th and 20th centuries resulted in no permanent introductions to the island, in contrast to other peri-Antarctic islands. Any introductions that may have occurred from the presence of sealers and their support and resupply vessels on Heard Island in the 19th century apparently did not survive into the mid-20th century, since no mention is made of introduced species in early narratives, station logs or reports. A rat was killed after being observed running between two crates during the unloading operations associated with the sealer establishment in December 1947. The rat was believed to have been a recent arrival from the resupply vessel rather than a resident. The extensive use of baited traps has failed to detect any evidence of rats present on the island. Rats pose the greatest threat to breeding seabirds on Heard Island, since the rapid retreat of most glaciers has permitted coastal access to virtually all ice-free areas used by seabirds. Huskies were introduced in the late 1940s and were reported to eat prions. Sheep were introduced as a source of fresh meat and were present for just two years: 1950 and 1951. At least two of the areas used for grazing by the sheep support large colonies of burrowing petrels and it is unlikely that either trampling or grazing by the sheep had any impact on the burrows or their occupants. Expeditioners in the 1947–1954 period ate eggs of Gentoo Penguins and cormorants.

A recent study detected plastic ingestion by seabirds on Heard Island. Two Antarctic Prions had plastic chips inside their digestive systems, and two of 396 Brown Skua pellets contained small plastic chips. An earlier study found no plastic in 430 casts (regurgitated pellets of indigestible prey remains) of Imperial Shags. There have been no records of seabirds entangled in marine debris or fishing equipment. Three oiled seabirds were recorded during the 2000–2001 season—two diving-petrels and a Macaroni Penguin.

Rapid glacial retreat on Heard Island is predicted to increase suitable nesting habitat for seabirds, but increasing temperatures may hinder some population increases. The low frequency of scientific visits encumbers detailed population assessments, but protects nesting species from disturbance and potentially invasive species.

Table 2. Approximate breeding schedules for seabirds on Heard Island.
[YR] indicates some or all of the population is present on Heard Island throughout the year.

Species	Arrival	Onset of laying	Onset of hatching	Fledge/ departure
Wilson's Storm-Petrel	late Nov	early Jan	Feb	Mar–Apr
Wandering Albatross	Nov	mid Dec–Jan	mid Mar	mid Nov
Black-browed Albatross	mid Sep	mid Oct	mid–late Dec	Apr
Light-mantled Sooty Albatross	early Oct	late Oct	late Dec	May
Southern Giant-Petrel	Sept	late Oct	late Dec	May
Cape Petrel (*Daption capense*)	early Sep	late Nov	early Jan	Mar
Antarctic Prion	early Nov	late Dec	Jan	late Mar
Fulmar Prion	Sept	mid Nov	mid Jan	mid–late Feb
Common Diving-Petrel	late Aug	early Dec	mid Jan	Apr
South Georgia Diving-Petrel	late Oct	early Dec	late Jan–Feb	Apr
King Penguin [YR]		mid Nov	mid Jan	late Dec–Jan
Gentoo Penguin [YR]		mid–late Oct	mid–late Nov	late Feb–Mar
Rockhopper Penguin	early Nov	mid–late Dec	Jan	late Mar
Macaroni Penguin	late Oct–early Nov	mid Nov	Dec	Mar
Imperial Shag [YR]		mid–late Oct	early–mid Nov	Jan
Black-faced Sheathbill (*Chionis minor*) [YR]		late Dec	late Jan	late Mar
Brown Skua [YR]	early Sep	mid Nov	mid Dec	late Feb
Antarctic Tern	late Oct	mid Jan	Feb	Apr
Kelp Gull [YR]		mid Nov	early Dec	Feb

From top left:

The Heard Island Cormorant is an endemic sub-species of the Imperial Shag found throughout Southern Ocean islands. Photo by Eric J. Woehler.

Lauren's Peninsula, Heard Island. Photo by Eric J. Woehler.

King Penguins have increased rapidly since initial counts in the 1940s on Heard Island. Photo by Eric J. Woehler.

Shorebirds and seabirds of Flinders and King Islands

Eric J. Woehler
School of Zoology, University of Tasmania, and
Valeria Ruoppolo
International Fund for Animal Welfare (IFAW)

Tasmania and its offshore islands are the southernmost destinations in the East Asian–Australasian Flyway (EAAF) for migratory shorebirds in Australia. Many islands around Tasmania support high numbers of breeding seabirds, with large colonies of shearwaters, prions, penguins and petrels. King Island and the Furneaux Group (more than 70 islands, of which Flinders Island is the largest) lie in western and eastern Bass Strait respectively. With resident human populations of approximately 1,500 and 800 respectively, they are microcosms of the threats faced by seabirds and shorebirds elsewhere in Australia.

Flinders Island has high conservation value for resident shorebirds (Table 1) and seabirds. Flinders Island holds more than 2% of the Australian populations of Hooded Plovers and Australian Pied Oystercatchers, and at least 1% of the Sooty Oystercatcher population. Because little Sooty Oystercatcher habitat has been surveyed, it is likely that the total Sooty Oystercatcher population on Flinders Island will be considerably higher and, thus, its proportion of the estimated Australian population will also be higher. The beaches on the east coast of Flinders Island are of particular significance for resident shorebirds and small terns. This 75 km stretch of coast holds 84% of the Hooded Plovers, 55% of the Australian Pied Oystercatchers and 77% of the Red-capped Plovers recorded on the island. Given the numbers of resident shorebirds, and the potential nesting habitat for small terns, this area is of the highest conservation value to nesting shorebirds and small terns on Flinders Island.

Table 1. Estimates of breeding populations (pairs) of resident shorebirds on Flinders Island.

Species	Estimated total breeding population (pairs), Flinders Island	% Australian population on Flinders Island
Hooded Plover	100–105	>2%
Australian Pied Oystercatcher	130–140	>2%
Sooty Oystercatcher	No estimate available	≥1%
Red-capped Plover	50–55	No estimate available

Current estimates of seabird populations on the Furneaux Group include more than 250,000 pairs of Little Penguins (*Eudyptula minor*), more than 7.5 million pairs of Short-tailed Shearwaters (*Ardenna tenuirostris*), more than 60,000 pairs of White-faced Storm-Petrels (*Pelagodroma marina*) and 2,000 pairs of Crested Terns (*Thalasseus bergii*). These populations are significant at national and international levels, and many of the islands in the group have recently been designated as IBAs.

King Island is an important site for resident and migratory shorebirds, being recognised as internationally significant for Ruddy Turnstones and for Australian Pied and Sooty Oystercatchers, Hooded Plovers and Fairy Terns (*Sternula nereis*). King Island holds approximately 10% of Tasmania's Hooded Plover population and approximately 1% of the Australian population; and is thus significant at Tasmanian, Australian and international levels. It also supports approximately 7% of the Tasmanian population and approximately 2% of the Australian population of Australian Pied Oystercatchers. Based on current and incomplete data, at least 1% of the Australian Sooty Oystercatcher population are present on King Island, making the population significant at Australian and international levels (Table 2).

Table 2. Estimates of breeding populations (pairs) of resident shorebirds on King Island.

Species	Estimated total breeding population (pairs), King Island	% Australian population on King Island
Australian Pied Oystercatcher	110	~2%
Sooty Oystercatcher	>50	≥1%
Red-capped Plover	>40	<1%
Hooded Plover	60	~1%

Approximately 180 pairs of Fairy Terns are believed to have nested in Tasmania in the summers of 2007–2008 and 2008–2009, and approximately two-thirds of them bred on King Island, making it the most important breeding locality for this vulnerable species in Tasmania. There are large colonies of Little Penguins and more than 700,000 breeding pairs of Short-tailed Shearwaters on King Island and its surrounding islands. Almost 20 migratory shorebird species have been recorded on King Island (Table 3), but almost half of these have not been seen on the island for more than a decade and/or have been seen infrequently on the island since 1980. The cause(s) of the loss of these species are unclear, although the variable water levels in coastal lagoons are likely to be a contributing factor.

Table 3. Migratory shorebirds most frequently recorded on King Island. Not all species have been listed, because some species have not been seen for more than 10 years and/or have only been seen infrequently on the island since 1980.

Pacific Golden Plover (*Pluvialis fulva*)	Marsh Sandpiper (*Tringa stagnatilis*)
Grey Plover (*Pluvialis squatarola*)	Ruddy Turnstone
Double-banded Plover (*Charadrius bicinctus*)	Sanderling (*Calidris alba*)
Lesser Sand Plover (*Charadrius mongolus*)	Red-necked Stint
Bar-tailed Godwit	Sharp-tailed Sandpiper
Eastern Curlew	Curlew Sandpiper (*Calidris ferruginea*)
Common Greenshank (*Tringa nebularia*)	

Three migratory species occur on King Island in numbers that are nationally and internationally significant (Table 4). Double-banded Plovers are present during winter in numbers approaching 1% of the global population. An accurate assessment of the numbers present on King Island would require winter surveys (rather than the summer surveys for the other migratory species) because that is when they are there in greatest numbers. Recent counts of more than 1,200 Ruddy Turnstones indicate that a significant proportion of the global population of the species occurs on King Island.

King and Flinders islands have high shorebird and seabird values that are under significant and increasing threat. These values require urgent actions to conserve them into the future. The threats to the resident and migratory shorebirds, and small beach-nesting terns such as Fairy and Little Terns, are numerous, widespread and increasing in their intensity, frequency and distribution. A rapid increase in 4WD and quad-bike traffic on beaches during summer destroys nests and eggs and crushes chicks. Dogs walking off-leash prey upon eggs and chicks. An increasing human recreational presence on the beaches disturbs nesting and feeding shorebirds and terns. All disturbance of migratory shorebirds reduces their capacity to feed, and thus store energy for their migration, resulting in leaner birds with lower body masses, unlikely to migrate successfully. Large expanses of Sea Spurge (*Euphorbia paralias*) are present on most beaches on both islands, which, at many sites, are deemed to be beyond control by authorities due to the number and extent of the infestations. These infestations will pose additional threats to beach-nesting shorebirds and terns in the future because they prevent the birds from breeding.

Table 4. Significance of migratory shorebird numbers on King Island as proportions of their populations in the East Asian–Australasian Flyway (EAAF).

Species	Estimated number of individuals on King Island	%EAAF population
Double-banded Plover	250–500	0.5–1%
Ruddy Turnstone	1,200–1,500	3–5%
Red-necked Stint	500–800	0.1–0.5%

The islands are not unique with regard to these threats, which are common in most coastal areas close to human populations in Australia. Conservation efforts elsewhere should be used to provide best-practice principles and implement coastal management and conservation measures on the islands. Integrating coastal efforts with planning and all facets of community activities on the islands will maximise the potential benefits to the environment and the people who live there.

Efforts to reduce human impacts to shorebirds, small terns and seabirds will require innovative and concerted efforts in the face of community resistance to changes in lifestyle and perceived "traditional" coastal activities. Engagement with the local communities on both islands has been under way with mixed results. "Traditional" coastal activities such as 4WD driving will be difficult to stop, even in sensitive areas, because they are so ingrained in community lifestyles. Community recognition and acceptance of internationally and nationally significant values is critical to conservation efforts on the islands, otherwise the threats will continue to increase and the avian diversity and abundance will decrease in the short term. Lessons learned on King Island and the Furneaux Group could be used for similar efforts on islands elsewhere.

From far left, clockwise:
Vulnerable Hooded Plover eggs (left) are susceptible to crushing by vehicles and dogs (top left) on both King and Flinders Islands. Photos by Eric J. Woehler.

More than 1% of Australia's Hooded Plover population is found on King Island, and more than 2% are held on Flinders Island. Photo by Dean Ingwersen.

Small beach-nesting terns such as Fairy Terns are also threatened by vehicles and dogs. Photo by Dean Ingwersen.

Almost 1% of the global population of Double-banded Plovers are found on King Island. Photo by Chris Tzaros.



Bird conservation, tourism and the value of monitoring: The case of Rottnest Island

Denis A. Saunders
CSIRO Sustainable Ecosystems

Rottnest Island, 18 km off the coast, due west of Perth, differs from the 3747 islands off the coast of Western Australia for two reasons: one is environmental and the other social. Rottnest is the only island with extensive areas of deep, saline, inland waters, which constitute about 10% of the island's 1,900 hectares. The island is classified as a "Class A Reserve" managed for public recreation, and is managed as a tourist resort by the Rottnest Island Authority; a Western Australian government body. The island has up to half a million visitors per year, and during peak holiday periods in the summer there may be nearly 10,000 people present; equivalent to five people per hectare or 296 people per km of coastline. Protection of the important conservation values of Rottnest Island will require careful management to ensure that development does not impact on resident and visiting birds and their habitats.

Bird trends on the island

Denis Saunders and Perry de Rebeira conducted regular censuses of the birds on all of the salt lakes, swamps and coastal habitats between 1981 and 1987, and again in September 2007. They also kept lists of species in other habitats on the island. In summer 1998, Birds Australia volunteers commenced partial surveys of the salt lakes and have gradually expanded their surveys to include partial surveys of coastal and terrestrial habitats in summer and winter. Saunders and de Rebeira (2009) summarised all published material available on the avifauna of the island and discussed changes between 1905 and 2007.

Since 1905, 101 bird species have been recorded on the island and its coastal habitats, including its offshore islets and stacks. Forty-one of these species were vagrants. Twenty-two species that were formerly vagrants or had not been recorded on the island have established regular patterns of occurrence, while two species (Sharp-tailed Sandpiper and Pacific Golden Plover) have changed from regular patterns of occurrence to vagrants. Four species have increased in abundance and two species have been extirpated: Black Swans (*Cygnus atratus*) were present in small numbers in the 1980s, occasionally breeding, but were last seen on the island in 1989; the Rufous Whistler (*Pachycephala rufiventris*) was last recorded on the island in the early 1900s, and loss of habitat is believed to be responsible for its extirpation. Three species (Silver Gull (*Chroicocephalus novaehollandiae*), Rock Parrot (*Neophema petrophila*) and Australian Raven (*Corvus coronoides*)) have declined in abundance. Two non-native species were introduced as game (Common Pheasant (*Phasianus colchicus*)) or for ornamental reasons (Indian Peafowl (*Pavo cristatus*)). There have been no apparent changes in the status of 24 species.

Value of the island for birds

Rottnest Island is critically important for bird conservation for three reasons:

(1) Unique island populations

Rottnest Island is a particularly important conservation area for 22 of the 60 resident species. Three of these, Singing Honeyeater (*Lichenostomus virescens*), Red-capped Robin (*Petroica goodenovii)* and Western Gerygone (*Gerygone fusca*), are of special conservation importance because their populations on the island differ from those on the adjacent mainland. Singing Honeyeaters on Rottnest Island are nearly 25% heavier than those on the adjacent mainland—even their bones are larger—and they require a leg band one size larger than those occurring over the rest of their range. The island's Red-capped Robins and Western Gerygones have vocalisations that differ from those of mainland birds; this is so pronounced in Western Gerygones that its call could be mistaken for that of another species (Baker *et al.* 2003a, b). Islands around the south-western coast are particularly important conservation areas for Rock Parrots.

(2) Important breeding habitat for Fairy Terns

Rottnest Island is an important breeding area for 200–300 pairs of Fairy Terns and the island has been designated as an Important Bird Area for supporting globally significant numbers of this species. Over the past 60 years, numbers of this species breeding on the island have changed little. However, the species has declined markedly around the coast of the mainland and is now considered a threatened species because of a major decline in eastern Australia.

Table 1: Total numbers of 14 species of waders recorded in south-western Australia, between Kalbarri and Esperance, in mid-summer 2004 and proportion (%) of total recorded on Rottnest Island (RI). Data from Saunders and de Rebeira (2009).

Species	# recorded in SW of WA, 2004	% of these recorded on RI
Australian Pied Oystercatcher	207	3.9%
Banded Stilt	31,997	23.8%
Grey Plover	179	7.3%
Red-capped Plover	4,074	3.3%
Greater Sand Plover (*Charadrius leschenaultii*)	68	2.9%
Banded Lapwing (*Vanellus tricolor*)	37	100%
Bar-tailed Godwit	163	6.7%
Whimbrel (*Numenius phaeopus*)	13	7.7%
Common Sandpiper (*Actitis hypoleucos*)	26	38.5%
Grey-tailed Tattler	20	10.0%
Ruddy Turnstone	251	94.0%
Sanderling	379	25.9%
Red-necked Stint	13,284	7.4%
Curlew Sandpiper	368	12.5%

(3) Significance to trans-equatorial migrants

The island has significant conservation importance for 14 species of shorebirds (Table 1), some of which are trans-equatorial, non-breeding migrants. For example, in 1993 a nationwide survey by Birds Australia recorded 5,347 Ruddy Turnstones. In February of that year, 9% of that total was recorded on Rottnest Island. A Birds Australia survey of coasts and wetlands in south-western Australia (between Kalbarri and Esperance) conducted in mid-summer 2004 recorded 241 Ruddy Turnstones, of which 94% were found on the island.

Community bird monitoring

At present, avifauna monitoring on Rottnest Island is conducted on a voluntary basis and methods have changed over time. Standardised monitoring will be useful for informing environmental management on the island. Saunders and de Rebeira (1986) set out monitoring protocols that covered all salt lakes and swamps and all coastal habitats on Rottnest Island. However, various different practices have been used by volunteers and scientists, and therefore limited comparisons can be made. The protocol established previously would be useful for all to follow, since this would allow changes over time to be measured accurately and allow management to be adjusted accordingly.

Impacts of tourism and development

While, in terms of conservation, Rottnest Island is of regional, national and international importance, it is also a popular tourist destination. During summer, large numbers of boats moor around the island and most beaches are visited by people. This coincides with the period of peak numbers of shorebirds on the island. In the past, many tourist developments have impacted significantly on the avifauna. Two examples illustrate this point. The first was a major access road constructed around a salt lake that resulted in the loss of significant areas of foraging habitat for migratory waders, particularly Ruddy Turnstones. The second was a set of powerlines located at right angles to major flight paths of waders moving between the salt lakes, and many were killed in collisions with the lines. The 15-year delay in fitting warning devices after the threat was initially identified led to high levels of mortality. With consideration, the conservation values of Rottnest Island could be protected without compromising the island's tourist attractions. The island could be zoned in such a way that human access to high conservation areas could be restricted during critical seasons. For example, Fairy Tern breeding areas, which vary from year to year, could be fenced off during the breeding season. This would reduce the impact of people disturbing the terns and the subsequent predation of unprotected eggs and chicks by Silver Gulls and Australian Ravens.

In view of the high conservation value of the local habitat and the potential human impact of tourism, there is great potential for on-going standardised monitoring and adaptive management to reduce the impacts of development on Rottnest Island. The use of zoning is important to protect vulnerable species, especially during their breeding season.

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From top left:

The island's Red-capped Robins have vocalisations that differ from populations on the mainland. Photo by Chris Tzaros.

Rock Parrots have declined in abundance on Rottnest Island. Photo by Chris Tzaros.

Eastern end of Rottnest Island showing part of the extensive area of salt lakes, some of the remaining woodland and the settlement areas. Photo by Denis Saunders.




Birds Australia on Rottnest Island

Suzanne Mather
Birds Australia WA, Rottnest Island Surveys Co-ordinator

Birds Australia Western Australia (BAWA) volunteers are actively involved in both the regular monitoring of shorebirds and terrestrial birds on Rottnest Island and the island's education program. This involvement is a good example of a co-operative exercise between BAWA and another agency, the Rottnest Island Authority (RIA). While periodic records of migratory and resident wader numbers had been kept historically, regular counting of shorebirds began in 1998 and has continued bi-annually, with the addition in 2008 of seabird and waterbird species under the Shorebird 2020 survey protocols. From 2000, as part of the island's Woodland Restoration Program and at the request of the RIA, BAWA undertook annual bushbird surveys of revegetated sites; in 2009, the number of surveys was expanded to cover 24 sites, representing both revegetated and remnant bushland. As part of its commitment to regular monitoring of natural and rehabilitated areas, the RIA utilises the Golden Whistler (*Pachycephala pectoralis*) and Red-capped Robin as indicator species to establish the success or otherwise of revegetation initiatives on the island.

The regular monitoring of birds on Rottnest Island was recently formalised through a Memorandum of Understanding between BAWA and the RIA. This agreement identifies objectives to document the occurrence and relative abundance of shorebirds and terrestrial species and record evidence of breeding and any introduced pest bird species on the island. The agreement also specifies survey sites and methods, survey schedules, data analysis and management, reporting and the responsibilities of each agency.

BAWA's regular activities on Rottnest Island include annual shorebird surveys and biennial bushbird surveys that are scheduled into the regular BAWA Excursion program. Between 20 and 25 volunteers regularly attend the summer shorebird surveys, while four volunteers complete the annual shorebird surveys in winter. Survey results are collated and submitted to the Atlas of Australian Birds and Shorebird 2020 databases. As Rottnest Island is an Important Bird Area (IBA), designated for globally significant numbers of Banded Stilts and Fairy Terns, this on-going work also contributes to the IBA project.

During school holidays, BAWA volunteers deliver a presentation on the birds of the island followed by a walk to observe and identify birds. These sessions are always well attended, mainly by family groups.

Endemic Bird Areas on Australian islands

James O'Connor
Birds Australia

Perhaps the best-known extinction in human history is that of the Dodo (*Raphus cucullatus*), which was snuffed out forever in the 1660s after humans colonised its island home. It has since become a paradigm for human-induced extinction, spawning such common phrases as "dead as a Dodo". The Dodo is often popularly regarded as a relic that was somehow "inferior" due to its flightlessness and lack of fear of humans and other predators, but it could equally be remembered as a unique and remarkable species whose loss was a tragedy. The Dodo was an "endemic", inhabiting the island nation of Mauritius in the western Indian Ocean, which is now designated as one of the world's Endemic Bird Areas (EBAs).

More than a quarter of the world's 10,000 or so bird species are endemic, being restricted to a particularly small range—defined for the purposes of this exercise to be smaller than 50,000 km^2. BirdLife International has identified 218 regions worldwide where distributions of two or more such endemic bird species overlap. These regions of overlap are termed EBAs. More than half of the world's restricted-range bird species live on islands.

Australia has 17 EBAs, and of these four are islands. Apart from Tasmania, the other three islands are all outlying oceanic islands, and it will come as no surprise to Australian birdwatchers that these are Christmas, Lord Howe and Norfolk Islands. All of these islands and their precious cargoes of endemic birds are discussed in this report. These islands also meet the criteria for IBA status (see p. 41). Tasmania is particularly rich in endemic birds (with 12 species), and in contrast to many other islands, hosts a good number of species which do not appear on the various threatened fauna lists.

BirdLife International has determined that EBAs are among the most important places for habitat-based bird conservation. Together, the 218 EBAs contain nearly all of the world's restricted-range bird species—only 7% of these species do not overlap with other such species and therefore do not occur in EBAs. Half of these restricted-range species are globally threatened or near-threatened, and by dint of their limited range, all of them will always be vulnerable to the loss of habitat. Over 60 species with restricted ranges have gone extinct in the past 200 years—over 80% of all bird extinctions during this period.

Many EBAs also support more widespread bird species, and correlate highly with endemic species from other groups, especially with plants. Amounting to just 4.5% of the earth's land surface, EBAs are rightly regarded as high-priority areas for ecosystem and habitat conservation. The protection of a major part of the earth's terrestrial biodiversity can thus potentially be ensured by focusing conservation resources and actions within a relatively small total area.

On Mauritius the Dodo is gone, along with the Mauritius Blue-pigeon (*Alectroenas nitidissima*) in the 19th century, but the island still retains a host of threatened birds and other life-forms that are unique, found nowhere else on earth, and well worth protecting.

Above, left:
Rottnest Island is an important conservation area for 22 of the 60 resident bird species, including the Singing Honeyeater. Photo by Chris Tzaros.

Tasmania has 12 endemic birds, including the Yellow-throated Honeyeater (second from left), Tasmanian Thornbill (middle), and Green Rosella (right). Photos by Chris Tzaros.

Island arks for rare Western Australians

By Allan H. Burbidge and Sarah Comer
Department of Environment and Conservation, WA

How do you manage a bird that is endemic to just one island? This is the challenge for conservation of the Barrow Island Black-and-White Fairy-wren (*Malurus leucopterus edouardi*), a subspecies of the widespread White-winged Fairy-wren.

One answer is to translocate to another, predator free, island. In May 2010, we translocated 27 individuals from Barrow Island, the site of the massive Gorgon LNG Development on Australia's NW Shelf, to Hermite Island, 20 km NNE in the Montebello group of islands. Black-and-White Fairy-wrens were recorded in this island group in the early 1900s, but were subsequently lost. The presumed threats — Feral Cats and Black Rats — have been removed, and the other likely threat, nuclear testing, ceased there in the 1950s. Monitoring in August 2010 revealed the presence of at least 19 Fairy-wrens, some of which had moved beyond the release area. If further monitoring is encouraging, we plan to translocate more birds next year.

Another challenge for restricted-range species revolves around fire management. This has been the driving force behind a series of translocations for the Noisy Scrub-bird (*Atrichornis clamosus*). Once restricted to a small area on the mainland, a series of translocations has attempted to set up new populations to minimise the risk that a single bushfire might cause the extinction of the species. One of the most successful has been to Bald Island, just east of Albany, where eight males and three females were released in 1992-94. Numbers have increased well beyond expectations, with 99 territorial males heard on the island during the most recent monitoring, demonstrating the effectiveness of a very good firebreak (i.e. the Southern Ocean) and a lack of vertebrate predators. This translocation has been so successful that this year we used the island as the source of birds for a translocation to a new mainland site.

Above:
The Noisy Scrub-bird capture team of Saul Cowen, Cassidy Newland and Toby Deadman stand in front of the first cargo of birds to be translocated to the mainland from Bald Island. Photo by Sarah Comer.




Eradicating invasive species

Andrew A. Burbidge
Conservation Biologist, Perth

Invasive species, mainly mammals, have been by far the greatest cause of loss of species on Australian islands. While improved biosecurity can prevent or mitigate future losses (Burbidge, p.48 this publication), eradication of invasive animals is the only technique available that can allow rehabilitation or restoration, where possible, of island species where losses have been due to invasive species. On islands, unlike continental landmasses, eradication of invasive mammals is often achievable.

In parts of Australia, invasive species eradication on islands has been ongoing for some time. In Western Australia, six exotic mammals have been eradicated from more than 50 islands (Burbidge & Morris 2002), commencing in 1969 with the removal of European Rabbits (*Oryctolagus cuniculus*) from Carnac Island, a nature reserve with several breeding seabirds including the burrow-nesting Little Penguin. Although multiple conservation values were often protected, many of these eradications were specifically to protect breeding seabirds.

As is the case elsewhere in the world, Black Rats have been targeted most for eradication in Western Australia, since their invasive ability is extraordinary and their impact on birds—especially seabirds, including small ground-nesting species such as terns, and small burrow-nesters, such as storm-petrels—is significant. They have extirpated many breeding populations of seabirds on islands. Modern second-generation rodenticides are now readily available and can be laid by hand, in bait stations if necessary, or by a helicopter-borne spreader bucket. Non-target effects are minimal on most seabird breeding islands as there are usually no other mammals present, but non-target issues can complicate eradication planning if native mammals, especially rodents, are present. Toxin bio-accumulation can affect birds such as raptors. House Mice (*Mus musculus*) are eradicated by using similar technology, while European Rabbits have been eradicated using the compound 1080 in carrots, and Feral Cats are extirpated with meat baits developed by the Western Australian Department of Environment and Conservation.

In New South Wales, the only coastal islands known to have populations of exotic mammals—Brush Island, Montague Island and the Broughton Island Group—were cleared of Black Rats, House Mice and European Rabbits in operations between 2005 and 2009 (Priddell *et al.* in prep). Recent surveys on Brush Island have revealed increased numbers of frogs and crabs as well as the presence of the White-faced Storm-Petrel, a species not previously recorded there. It is expected that this species will also recolonise Broughton Island, as a large population once bred there but disappeared soon after rats arrived.

Elsewhere in Australia several projects are being planned. The largest of these is the eradication of European Rabbits, Black Rats and House Mice on Macquarie Island (Springer, p.22 this publication) and the eradication of Black Rats and House Mice on Lord Howe Island (Priddell & Hutton, p.28 this publication). Eradication of Black Rats on one or two of the islands on the southern atoll of the Cocos (Keeling) Islands is planned to allow the reintroduction of the Cocos Buff-banded Rail (*Gallirallus philippensis andrewsi*).

On Christmas Island (James & McAllan, p.36 this publication), Yellow Crazy Ants (*Anoplolepis gracilipes*) are being controlled where they form supercolonies, but eradication is not currently possible as the toxin used affects native species. Biocontrol of the mutualistic scale insects seems the only way of minimising the impact of the ants.

While invasive species eradication may be possible in many cases, it is not a universal panacea. Eradication is usually carried out with toxins and these can have undesirable environmental effects. Where invasive species become established on islands with complex ecosystems, such as Christmas Island, eradication either may be very expensive or not feasible. Conservation of island biota is a case where prevention is always better than the cure. Thus biosecurity planning and implementation is vital.

Weeds can be a major issue on seabird breeding islands. Invasive weeds such as African Boxthorn (*Lycium ferocissimum*), which has invaded several islands off the Western Australian coast, can cause entanglement and death of seabirds, while woody weeds such as European Tree-mallow (*Lavatera arborea*), which has become established on some seabird breeding islands near Perth, can render these islands unsuitable for seabird nesting (Rippey *et al.* 2002). The effect of many other weeds on island seabirds and land birds, e.g. Iceplant (*Mesembryanthemum crystallinum*), a prostate ground cover that is widespread on southern Australian islands, has not been quantified.

Major challenges for the future include: the minimising or eliminating of impacts of ants, cats and rats on Christmas Island; eradicating Black Rats and Feral Cats from Norfolk Island; and eradicating Feral Cats and Black Rats on Cocos (Keeling) Islands. Eradication of the European Red Fox (*Vulpes vulpes*), a recent arrival in Tasmania, may not be feasible with current technology.

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Climate change threat to islands
By Andrew A. Burbidge

While climate change is predicted to affect islands in similar ways to continental areas via increased temperatures and changed rainfall patterns, the major effects are likely to be increased sea levels and greater storm intensity and storm surges. Coral cays may keep pace with sea level rise so long as healthy coral grows, but increasing ocean acidity due to dissolved CO_2 may slow or stop coral growth.

Low-lying islands often provide important seabird nesting sites and sea turtle rookeries. An example is the Houtman Abrolhos, which comprises about 120 small, low-lying islands and which has the greatest species diversity and largest concentration of breeding seabirds in the eastern Indian Ocean, as well as an endemic subspecies of the Painted Button-quail (*Turnix varius scintillans*). The mixture of species is unique, because the breeding islands are shared by subtropical, coolwater and tropical species, and littoral and oceanic foragers. One listed threatened seabird, the Lesser Noddy (*Anous tenuirostris melanops*), breeds only in three small areas of White Mangroves (*Avicennia marina*) on three low islands in the Houtman Abrolhos. As discussed by Briggs in this publication (p.44), some coral cays, which provide key habitat for seabirds such as the Roseate Tern (*Sterna dougallii*), are expected to be lost as sea levels rise over the next century.

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Top – left to right:
Red-capped Plovers are one of many bird species that fall prey to feral cats. Photo by Chris Tzaros.

Rodenticide being laid on a grid using bait stations, Montebello Islands, Western Australia. Photo by Andrew A. Burbidge.

A helicopter-borne rodenticide spreader-bucket in use at the Montebello Islands, Western Australia. Photo by Andrew A. Burbidge.

Phillip Island Nature Park rangers removing infestations of African Boxthorn from shearwater colonies after the birds have migrated north.
Photo by Roger Kirkwood.

Top left:
The nesting Royal Albatross is striking against the Campbell Island landscape. Photo by Glenn Ehmke.

Middle:
Megaherbs on New Zealand's Campbell Island. Photo by Glenn Ehmke.

Top right:
With an explosion in rabbit numbers on Macquarie Island, Brown Skua numbers also increased due to the significant food source that rabbits provided. This, combined with removal of vegetation cover by rabbits, led to much greater skua predation on burrow-nesting seabirds. Photo by Glenn Ehmke.

Lessons from international island conservation successes

Glenn Ehmke
Birds Australia

Island conservation programs are clearly critical for biodiversity conservation, given the high diversity of endemic birds they host. However, islands can also be critical as refuges for non-endemic conservation-dependent species. In some countries, offshore islands form the cornerstones of bird conservation. A large number of species in New Zealand are heavily reliant on offshore island conservation, and some of these exist today exclusively because of such efforts. The South Island Saddleback (*Philesturnus carunculatus carunculatus*) and Kakapo (*Strigops habroptilus*), which were formerly widespread across the New Zealand mainland, are good examples. Both species' populations dipped to under 50 individuals, but thanks to dedicated island conservation programs, both are now increasing; the recovery of the South Island Saddleback, which now numbers more than 2,000, ranks among the world's most successful threatened species recoveries.

The main reason islands are critical "arks" for endangered species is because they can be purged of invasive species, the principal cause of animal extinctions on islands worldwide. Not surprisingly then, control or eradication of invasive species has been the main focus of international island conservation efforts. While eradication of invasive species is often considered unfeasible in continental scenarios, the isolation of islands makes the task more practicable, and the number of invasive species eradications from islands today is impressive—well over 200 successful eradications of 17 different alien mammal species from New Zealand islands (Clout & Russell 2006), seven species of introduced mammals eradicated from at least 24 islands in north-western Mexico (Tershy *et al.* 2002) and major eradications in the Galapagos Islands in Ecuador and in the Central Pacific Ocean (USA), to name just a few.

The number of bird species that have benefited from invasive-predator eradications worldwide is also substantial. In addition to the Saddleback and Kakapo, at least 27 other terrestrial birds and eight seabirds have recovered or recolonised islands (including many translocations) in New Zealand (Towns *et al.* 2009). In north-western Mexico, 27 seabirds and six landbirds have recovered after the eradication of introduced mammals (Tershy *et al.* 2002), and populations of numerous seabirds have recovered on islands in the Indian and Pacific oceans after similar operations. The biodiversity benefits of the eradication of invasive species on islands are highly significant and generally evident soon after effective eradication. However, while the isolation of many islands protects them from the severity of some major threats, all of the big problems that exist on the mainland (habitat loss, fragmentation and degradation, disturbance, etc.) can affect islands too. There are few islands on Earth, no matter how remote, that have been totally spared from human impact.

There are also a number of issues particular to islands, including their size: too big and pest eradication becomes problematic; too small and there might not be enough habitat to maintain viable populations of native species. Even when the habitat is right and there's enough of it, the genetic diversity of some island populations can be significantly lower than that of mainland populations (Jamieson 2009). The Kakapo is a prime example, with the vast majority of the wild population now consisting of island-bred birds with very low genetic diversity. Infertility and early dead embryos have been significant problems, and are suspected to be largely due to the low genetic diversity (and possibly old age of many of the birds). Only one bird from the mainland was saved (the now famous Richard Henry) and, fortunately, intensive recovery efforts, including the world's first successful wild bird artificial insemination have been used to increase the genetic representation in the remaining wild population.

Where the practicalities of eradication don't stack up—for example if the costs are not politically expedient—island conservation can still be highly successful. The 175,000-hectare Stewart Island, off New Zealand's South Island, is one such case. While plans have been mooted to undertake a rodent, cat and possum eradication program for this very large island, and the task appears technically feasible (Beaven 2007), in the interim the community has taken matters into its own hands. The Halfmoon Bay Habitat Restoration project involves intensive rat and possum trapping (removing up to 250 rats a month) by local residents in a dedicated area centred near the island's main town. The program has seen a more than 300% increase in forest bird counts across numerous species in the managed area (www.sircet.org.nz).

While islands are often isolated, they are not totally immune from recolonisation by pest species. In fact, no island is totally isolated from threats—vessels reach even the most remote places on Earth, potentially carrying rats and other invasive species. Many islands considered free of invasive species do not have an immigration rate of zero, it's just low enough so that a few limited control measures along with effective biosecurity are all that is needed to alleviate the threat. This is often the case on near-shore islands within swimming distance for invasive species.

This begs the question: how does the experience of island conservation translate to mainland bird conservation programs? In terms of invasive species, the critical demographic that distinguishes islands from mainland is recruitment of invasive species back into the system. An all-too-familiar experience in Australia is a significant decrease in exotic species abundance after management, only for the species to quickly increase again when control activities are not maintained.

Despite this, methods used in island eradications are being applied in mainland situations. Six "Mainland Island" projects are being undertaken by the Department of Conservation at sites on the North and South Islands of New Zealand. These areas are not surrounded by predator-proof fences (although such areas are also being expanded significantly in New Zealand); rather, they are areas of intensive management from which target control is conducted with a view to keeping pest densities low. The program has been running since 1996 years and there are tangible signs of success, with population recoveries noted in several species (e.g. Taylor *et al.* 2009).

Following the removal of invasive species, biosecurity is the principal ongoing concern for islands. While the days of sealers and explorers spreading rodents wherever they landed are over, an increasing number of vessels are reaching islands for a variety of other purposes, including tourism and research. Quarantine procedures are well established in some cases, for example on Antarctic and sub-Antarctic islands through national regulations and the co-operation of organisations such as the International Association of Antarctica Tour Operators (IAATO), but this is not the case everywhere. For islands with significant human populations,

Tipping the balance
Glenn Ehmke

One big lesson for island invasive species management is the importance of considering the unintended effects of removing keystone species (even introduced species) from island ecosystems. For example, selective removal of top-order predators such as Stoats (*Mustela erminea*) and cats on some New Zealand islands has resulted in increased numbers of rats, which then prey upon native birds at higher rates. In other cases, rat eradication has led to an increase in predation of birds by stoats (Murphy & Bradfield 1992; Tompkins & Veltman 2006; Rayner *et al.* 2007).

Perhaps the most pertinent example to Australia occurred in recent years on Macquarie Island. Following the successful eradication of cats (which had devastated bird populations for decades) in 2000, rabbit numbers exploded. (This was because of the reduced predation pressure from cats, combined with slightly 'warmer' winters caused by climate change, which allowed rabbits to breed successfully throughout the year, coinciding with the end to the effectiveness of myxomatosis.) This initiated a set of cascading, ecosystem-wide effects: a large increase in the number of Brown Skuas resulted because rabbits became a super-abundant food source for them; rabbit grazing wrought havoc on the island's vegetation; and burrow-nesting seabirds suffered increased predation from the skuas, partly as result of a lack of vegetation protecting their burrows (see Bergstrom *et al.* 2009 for a detailed account).

community involvement in quarantine is critical. Preventing reinvasions of rodents in particular is almost impossible on inhabited islands without comprehensive community awareness and support. This is a big challenge, but it is by no means impossible given the almost unparalleled unpopularity of rats and mice in human societies, and the economic damage they cause, for example, to agriculture and to eco-tourism underpinned by healthy bird communities.

Monitoring is the cornerstone of effective biosecurity. If invasive species make it to islands, action must be taken early to prevent their re-establishment, and critical actions must be taken to save at-risk native birds. The most heralded example of the importance of detecting invasions came in 1960s at Big South Cape Island in New Zealand's far south. The island was the last refuge for several birds, a bat and a number of invertebrates. Rats got onto the islands in 1964 from a visiting boat and ravaged the island's native fauna. They quickly drove three species—the Bush Wren (*Xenicus longipes*), New Zealand Snipe (*Coenocorypha aucklandica*) and Greater Short-tailed Bat (*Mystacina robusta*)—to extinction. However, the detection of the rats allowed for the quick capture and translocation of the last 36 South Island Saddlebacks, saving this species from certain extinction. South Island Saddlebacks now inhabit 11 islands and number around 2,000 in total—all from the 36 surviving birds from Big South Cape Island—making theirs one of the most successful threatened bird recoveries in the world today.

It is necessary to monitor whole island ecosystems when conducting conservation programs, to ensure ecosystem functions are not adversely affected. Monitoring is also critical in increasing our knowledge of the factors associated with successful invasive species management on islands. It is only through applying the lessons learnt over years of trial and error that has led to us being able to attempt the ambitious eradication programs underway today.

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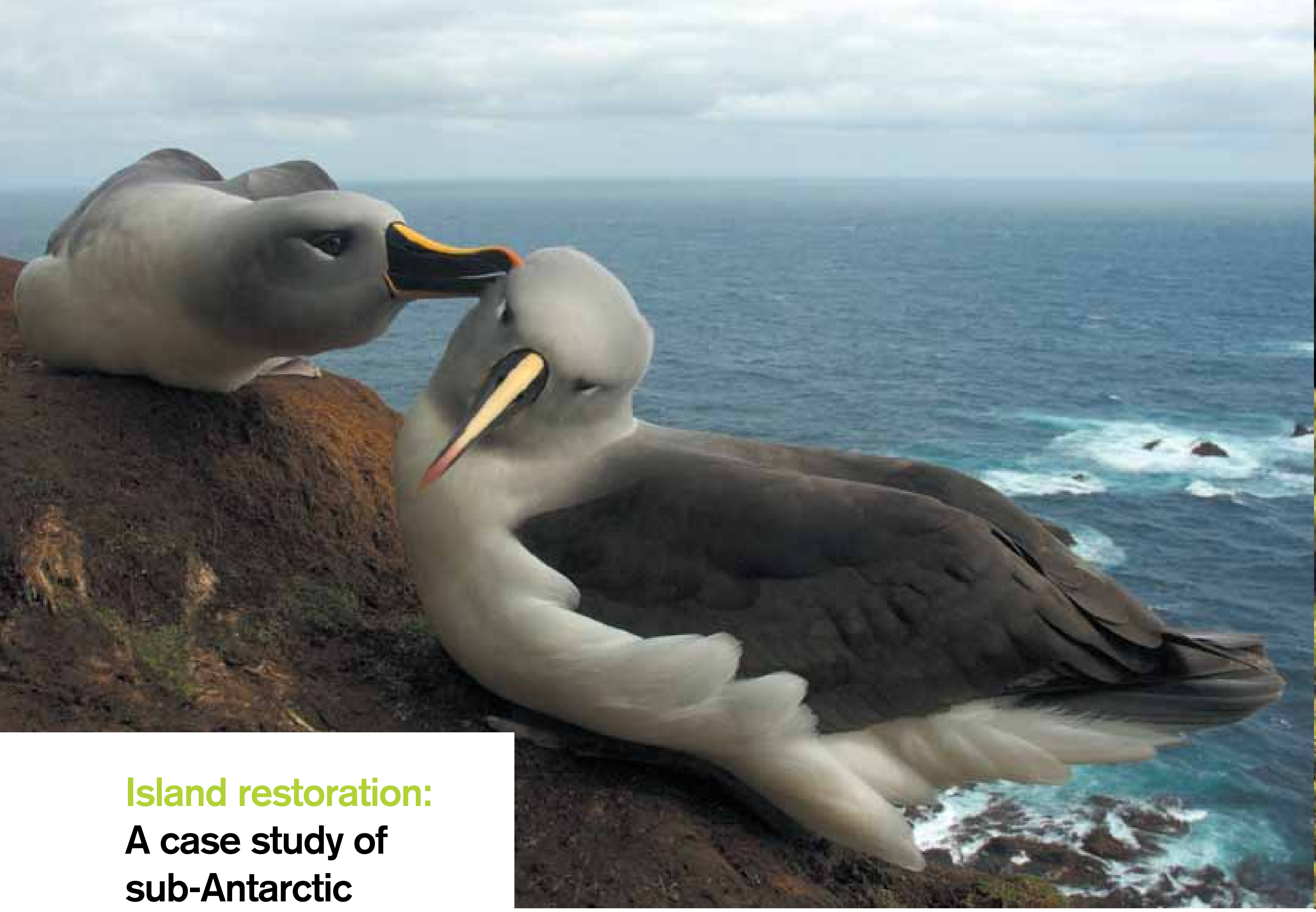
Left:
The megaherb *Pleurophyllum speciosum* on Campbell Island (foreground). The size of the leaves are said to be a response to the cloudy, humid and cold temperatures. An increase of up to 15 degrees has been recorded on the leaves of this plant on Campbell Island. Photo by Glenn Ehmke.

Top:
Grey-headed and Campbell (Black-browed) Albatross on Campbell Island's North Cape. Photo by Glenn Ehmke.



Island restoration: A case study of sub-Antarctic Macquarie Island

Keith Springer
Tasmania Parks and Wildlife Service

Above:
Rabbits threaten the stability of the steep slopes where Grey-headed Albatross nest on Macquarie Island. Photo by Aleks Terauds.

Opposite right:
Rabbit numbers are estimated to exceed 100,000 individuals. Photo by Glenn Ehmke.

Centre spread: King Penguins and Royal (Macaroni) Penguins on the beach at Macquarie Island. Photo by Glenn Ehmke.

Invasive animals are a major threat to island fauna globally, with introduced rodents one of the greatest causes of species extinctions. This has been well demonstrated on Australian islands, where at least 20 species or subspecies of Australian animals—mostly birds—have been driven to extinction due to the effects of invasive rodents. Cats are also major predators of island birds, while rabbits and goats can cause extreme habitat modification.

Islands now represent unique opportunities for conservation. Where invasive animals can be eradicated, native species can recover or be introduced. Techniques to eradicate invasive rodents from islands have been developed over the last 40 years, most notably in New Zealand. More recently, these techniques have been adapted and practiced in Australia, Alaska, the Mediterranean, the United Kingdom, the Pacific Islands and Mexico, among other locations. A number of islands in Western Australia (in the 1990s) and New South Wales (2000s) have been successfully cleared of rodents or rabbits or both.

Macquarie Island is a Tasmanian Nature Reserve and a World Heritage Site, located in the Southern Ocean about 1,500 km south-east of Hobart. Managed by Tasmania Parks and Wildlife Service, the island hosts an Australian Antarctic Division station focusing on supporting meteorological operations, biological and geological sciences and nuclear monitoring. With the adjoining New Zealand sub-Antarctic islands, Macquarie Island is a significant breeding site for Southern Ocean species, especially pinnipeds and birds.

Five alien species have established feral populations and caused significant impacts on native flora, fauna and landscapes—Black Rats, Cats, House Mice, European Rabbits and Weka (*Gallirallus australis scotti*). Dogs (*Canis lupus familiaris*) established a feral population early in the 19th century, but they had died out by about 1830. Weka were eradicated by 1989 and cats by 2001. Rabbits were introduced from New Zealand as a food source in about 1879 and have caused significant damage to the island. Myxoma virus was released annually from 1978 to control rabbits, and while highly effective at reducing rabbit numbers for about two decades, virus production ceased in 1999 after it began to lose its effectiveness.

Early records of the birdlife on Macquarie Island suggest dense populations of many species, especially burrow-nesting petrels. Research on many bird species has been conducted on Macquarie Island since the 1950s, including censuses, banding projects and more intensive studies to assess breeding success and diet. Albatrosses and petrels (giant-petrels and burrowing petrels) have been among the most researched species.

Decades of predation by rodents and cats have depleted bird populations significantly. Cats were implicated in the extinction of two endemic land birds by 1895, and the threatened status of six species of seabirds; by the early 1970s they were estimated to be killing about 60,000 seabirds per year on the island. Cat eradication resulted in the re-establishment of Grey Petrels (*Procellaria cinerea*), Cape Petrels and Soft-plumaged Petrels (*Pterodroma mollis*), and the increase in populations of Sooty Shearwaters (*Ardenna grisea*), White-headed Petrels (*Pterodroma lessonii*) and Antarctic Prions. Smaller petrels that are accessible to rats have continued to decline, with Blue Petrels (*Halobaena caerulea*) and some prions now breeding mostly on offshore rock stacks inaccessible to rodents.

In addition, removal of native vegetation due to overgrazing by rabbits has exposed the entrances of breeding burrows, changing environmental conditions and exposing newly fledged chicks to predation by skuas. Rabbit grazing has also denuded coastal slopes of vegetation, decreasing the stability of these slopes and increasing the risk of landslips. In the south-western corner of the island, this has increased the vulnerability of Grey-headed and Black-browed Albatrosses in their only breeding locations on Macquarie Island. The population of skuas has expanded, most probably due to the availability of abundant rabbits, with those affected by myxoma being easy to catch.

Tasmania Parks and Wildlife expressed its intent to eradicate rabbits and rodents in a simultaneous operation from 2003, with methods to be based on a successful eradication of Brown Rats (*Rattus norvegicus*) from Campbell Island, about 700 km to the north-east. Eighteen months of planning was undertaken on justification, regulatory and operational aspects before the project was funded in June 2007. The Australian and Tasmanian governments each contributed $12.3 million, with a further $100,000 being contributed by WWF Australia and Peregrine Adventures.

Project planning was based on a three-stage eradication operation: aerial baiting, ground hunting and monitoring. In the first stage, 305 tonnes of Pestoff 20R would be spread from helicopters with underslung buckets during the winter of 2010. Pestoff contains the anti-coagulant brodifacoum as the active ingredient, at a concentration of 20 parts per million. The toxin is used worldwide in a wide range of rodenticides and is also effective against rabbits. Eradication of Black Rats and House Mice is anticipated from the aerial baiting stage, but small numbers of rabbits are expected to survive because a small proportion will not eat the bait.

In the second stage, ground teams will hunt surviving rabbits using a combination of traps, burrow fumigants, firearms and nets. Eleven dogs have been trained to detect rabbits to assist hunters in locating survivors. Dog training took two years and focused not only on rabbit detection but also on avoidance of non-target species.

The third stage is a two-year monitoring period, which should provide field staff with the opportunity to thoroughly cover the island and detect any sign of rabbits or rodents that may have built up populations from very small and previously undetected nuclei. Total eradication will not be declared until two full years have passed without any sign of pest species. Following this, monitoring will be scaled down to field observations by island ranger staff.

In June 2010 the project team attempted the aerial baiting program on Macquarie Island. A small area at the northern end of the island was baited in early June, and this led to a total absence of rodent sign within two weeks, as well as greatly diminished rabbit numbers. An area of coastal slopes in the southern third of the island was also baited, and initial searches observed no live rabbits. However, flying was hampered by strong winds and low cloud, and after insufficient baiting progress in June and early July; the program

Top: Light-mantled Sooty Albatross (photo by Rowan Trebilco) and Black-browed Albatross (middle, photo by Aleks Terauds) are both threatened by rabbits on Macquarie Island's steep slopes.

Top right:
Rabbits have caused extensive damage on Macquarie Island. Photo by Keith Springer.

was abandoned in late July, because the suitable timeframe for baiting was coming to an end. July 2010 was the windiest July since records began in 1948. Subject to securing funding, the aerial baiting phase will now be undertaken in the winter of 2011. Winter was selected as the best time to achieve eradication because non-target impacts are fewer, pest species populations are at their lowest point in their annual cycle and are not breeding, and food supplies are less available, which increases the level of bait uptake.

While efforts were made to minimise non-target species mortality by baiting in winter when many native species are absent from the island, it was anticipated that there would be some mortality of Kelp Gulls and ducks from primary poisoning, and some mortality of skuas and giant-petrels from secondary poisoning (through eating carcasses of poisoned animals), and this occurred. Disturbance to King Penguin colonies was minimised by spreading bait at a higher altitudes than normal (informed by trials on this aspect in 2007 and 2008), while an observer was on hand to monitor the penguins' response to helicopters and relay that information to the pilots. To ensure that Wandering Albatross chicks did not inadvertently consume baits falling around their nests, an observer was on hand when bait was spread around them and all bait pellets within a five-metre radius of the nest were removed and placed into two bait stations within the perimeter of the five-metre radius.

If eradication is eventually successful, rapid ecological changes are anticipated. Recolonisation of the main island by burrow-nesting seabirds currently restricted to offshore stacks is likely in the first few seasons after rats are eradicated. Recovery of the vegetation, especially Poa tussocks and Macquarie Island Cabbage (*Stilbocarpa polaris*) is expected to be dramatic at lower altitudes after rabbits are eradicated, with the recovery rate diminishing with altitude and the degree of current modification. In the longer term, geoconservation values are expected to increase as vegetation cover improves the stability of the coastal slopes. Vegetation communities are expected to develop and stabilise, and this in turn will provide more cover and stability around burrow-nesting petrel colonies and albatross breeding areas. Little long-term change is expected in some bird species: terns, shags, gulls, ducks and possibly giant-petrels may not demonstrate significant population increases in the years after pest eradication, although this will depend on the extent to which rats currently prey upon eggs of these species, as well as other changes in environmental parameters. Similarly, the four species of penguins on the island are unlikely to be affected significantly, since they are largely independent of the impacts of rabbits or rodents. Skua numbers, however, are likely to decrease over time as their primary prey—rabbits—declines in number. Some degree of prey switching is expected, and recovering populations of burrowing petrels are likely to be impacted to a degree initially, but, over time, equilibrium can be anticipated as burrowing petrel populations stabilise and skua numbers come into balance with the altered environment on Macquarie Island.

Successful rabbit and rodent eradication on Macquarie Island would be one of the most significant conservation outcomes achieved in the Southern Ocean and in Australia, and it would be of incalculable value in restoring natural values to seabird populations. Further down the track, it may be possible to consider introducing species closely related to the two endemic land birds that had become extinct on Macquarie Island by 1893—the Macquarie Island Red-fronted Parakeet and the Macquarie Island Buff-banded Rail.

Successfully eradicating pests, however, is only sustainable if biosecurity measures are robust. The Australian Antarctic Division and tourist ships land cargo, staff and passengers on the island. Biosecurity measures for Macquarie Island have been reviewed, with a particular emphasis on prevention of rodent reinvasion of the island.

Keith Springer is managing the Macquarie Island Pest Eradication Project.

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Restoring balance on Lord Howe Island: A jewel in the Pacific

David Priddel Department of Environment, Climate Change and Water, New South Wales
and
Ian Hutton Lord Howe Island Nature Tours

An island paradise

Lord Howe Island (LHI) contains a remarkable array of flora and fauna; almost half of its native species are found nowhere else on earth. Fourteen species of seabirds breed there, making it one of Australia's most important seabird islands. Conservation action undertaken over the past 40 years has seen cats, pigs and goats eradicated, leading to a dramatic increase in birdlife, particularly seabirds. Black Rats and House Mice remain, but planning to remove these destructive pests is well advanced.

The LHI Group, located about 780 km north-east of Sydney, comprises the main island of Lord Howe (1,455 hectares) and a number of smaller islets and rocks. The central low-lying area of LHI contains the settlement and provides a marked topographical contrast to the northern hills and southern mountains. Fewer than 15% of the island has been cleared and 75% of it, along with all surrounding islets, is conservation reserve. The island's main industries are tourism and the export of the Kentia Palm (*Howea fosteriana*). There are about 350 permanent residents on the island and up to 400 tourists at any one time.

Degradation by introduced species

Lieutenant Henry Lidgbird Ball discovered LHI in 1788 while en route from Sydney to Norfolk Island. There is no evidence of any earlier human visitation. Although the island was not settled until 1834, introductions of exotic species began in the 1820s when mariners liberated pigs and goats to provide a source of food for those on passing ships. Settlement brought additional vertebrate species, many of which established wild populations (Table 1). Since the island was discovered, at least nine endemic land birds have become extinct (Table 2), accounting for 39% of all recent avifauna extinctions in Australia. Two species of plants and an unknown number of invertebrates have also been lost, and many more species are now threatened, due largely to rats. Two seabirds—the Kermadec Petrel (*Pterodroma neglecta*) and White-bellied Storm-Petrel (*Fregetta grallaria*)—were breeding on the main island when rats arrived, but soon disappeared and now breed locally only on rodent-free islets.

Conservation action

A palm seed industry, established in 1870, provided a reliable source of income for the island's residents and created impetus to preserve much of the local forest. In the late 1960s, the prospect of greatly increased tourism galvanised concern among residents, government and conservationists about the future of the island, and led to an increased appreciation of the island's biodiversity values. A subsequent government report made far-reaching recommendations for the conservation of the island's endemic wildlife, and drew attention to the plight of the Lord Howe Woodhen (*Gallirallus sylvestris*), of which only about 30 survived. The flightless woodhen was restricted to the mountain summits, which were inaccessible to pigs. A recovery program, involving the removal of pigs and feral cats, was initiated. Woodhen numbers quickly increased to around 300, and nowadays they are found in most parts of the island where habitat is suitable.

Pigs were hunted and eliminated by 1980. Feral cats were patchily distributed on the island and the removal of 84 individuals by local rangers in 1979–1980 eradicated the population. Domestic cats were banned in 1982, although existing pets could remain if desexed. By 2004 the island was free of cats.

In the early 1970s, hunters eradicated goats from the northern hills. This action precipitated regrowth of native vegetation along the ridgelines, and recolonisation of these areas by nesting seabirds such as the Sooty Tern (*Onychoprion fuscata*). Goats, however, continued to graze the rugged southern mountains. In 1999, an eradication operation using dogs and a helicopter destroyed 295 goats. A few female goats survived, but the species was eliminated as a breeding population. Many rare plants that previously were browsed heavily are now recovering.

Table 1. Introduced vertebrates that have established on Lord Howe Island.

Species	Date of arrival	Reason for introduction	Current status
House Mouse	*c.* 1860	Accidental arrival on ship	Widespread, but particularly common in the settlement
Black Rat	1918	Accidental arrival on ship	Widespread
Pig (*Sus scrofa*)	Early 1800s	Released to provide food for passing mariners	Eradicated by 1980
Goat (*Capra aegagrus*)	Early 1800s	Released to provide food for passing mariners	Eradicated by 2010
House Cat (*Felis catus*)	*c.* 1847	Pets	Feral cats eradicated by 1980, domestic cats not present after 2004
European Rabbit	Before 1869	Probably for food	Gone by 1887
Masked Owl (*Tyto novaehollandiae*)	1920s	To control rats	Widespread
Eastern Barn Owl (*Tyto javanica*)	1920s	To control rats	Thought to have died out but a few individuals may still survive
Magpie-lark (*Grallina cyanoleuca*)	1924	To increase avian diversity, but may have also arrived naturally	Widespread
Common Blackbird (*Turdus merula*)	1944	To control insect pests on palm flowers and vegetable crops	Widespread
Song Thrush (*Turdus philomelos*)	1944	To control insect pests on palm flowers and vegetable crops	Widespread
Eastern Snake-necked Turtle (*Chelodina longicollis*)	1960s	Pets	Occasionally observed; status unknown
Garden Skink (*Lampropholis delicata*)	*c.* 1995	Probably arrived with cargo	Widespread
Bleating Tree Frog (*Litoria dentata*)	*c.* 1995	Probably arrived with cargo	Widespread

Table 2. Birds that have gone extinct on Lord Howe Island since settlement

Species	Date of extinction	Cause
White Gallinule	1788–1844	Killed for food by mariners and whalers
White-throated Pigeon	1853–1870	Killed for food
Tasman Parakeet	1869–1870	Killed as agricultural pest by early settlers
Vinous-tinted Thrush	1919–1938	Rats, but declining before 1913
Robust White-eye	1919–1938	Rats
Tasman Starling	1919–1938	Rats
New Zealand Fantail	1924–1938	Rats
Lord Howe Gerygone	1928–1938	Rats
Southern Boobook	1950s	Rats, and competition from introduced Masked Owl

Benefits to seabird populations

The most dramatic result of eradicating exotic mammals has been the increase in seabird populations. Two species—Little Shearwater (*Puffinus assimilis*) and Black Noddy (*Anous minutus*)—have recently recommenced breeding on the main island. Numbers of Sooty Terns have increased, with birds now breeding in areas where they had not been recorded previously. Numbers of Red-tailed Tropicbirds (*Phaethon rubricauda*) and Black-winged Petrels (*Pterodroma nigripennis*) have also increased. Wedge-tailed Shearwaters (*Ardenna pacifica*) breed mainly on offshore islets, but now also breed on the main island, and numbers are increasing each year. Providence Petrels (*Pterodroma solandri*), once confined to the summits of the southern mountains, now breed at lower elevations, and have recolonised former breeding areas, identified from sub-fossil material, in the northern hills.

Rodent eradication

Rats and mice remain on LHI, and both species have significant adverse impacts on the biodiversity of the island. Rats also cause significant damage to Kentia Palms, resulting in economic losses to the local palm industry.

Since rats arrived on LHI, various attempts have been made to reduce their numbers. Current control is aimed primarily at reducing the loss of palm seeds, and consequently delivers few broader biodiversity benefits. Moreover, the continued use of rodenticide presents a major risk to wildlife, including the woodhens. The best option to mitigate the detrimental impacts of introduced rodents on LHI is to eradicate both rats and mice.

The LHI Board is responsible for maintaining the World Heritage values of LHI and is working closely with the community to eradicate rodents in a way that is safe for residents, wildlife and the environment. In October 2009, a draft Rodent Eradication Plan was completed and released for public comment. This plan builds on experience gained from more than 300 successful eradications from around the world over the last 20 years. Notwithstanding, LHI will be the largest permanently populated island on which the eradication of exotic rodents has been attempted. The presence of a large human population, a highly developed tourism industry, and the potential risk to endemic species all increase the complexity of the task.

The planned operation will involve the distribution of poison baits to all parts of the island. Within the settlement, the bait will be hand-broadcast; outside the settlement it will be dispersed aerially by helicopter. The entire operation will require approximately 42 tonnes of bait, containing 840 grams of brodifacoum, an anticoagulant poison that is toxic to most vertebrates. Bait will be dyed green to reduce its attractiveness to land birds, and will be distributed during the winter when natural food for rodents is most scarce.

The operation poses negligible risks to human health, soil, water and the marine environment, and to most non-target species. However, trials using non-toxic bait found that woodhens will ingest bait in amounts that could be fatal. Also, the local subspecies of Pied Currawong (*Strepera graculina crissalis*) is known to consume rodents and so potentially could be susceptible to secondary poisoning. To mitigate these risks, a substantial proportion of each population will be held in captivity on LHI until the baits have disintegrated and pose no further threat (approximately 100 days). Mortality of other non-target species is expected to be minimal, and all populations are likely to increase beyond current numbers once predation and competition from rodents have been removed.

The eradication of rodents on LHI will deliver a broad range of significant biodiversity benefits that could not be achieved through any control operation. For birds, these include marked increases in the abundance of many species and the re-establishment of nesting colonies of White-bellied Storm-Petrels and Kermadec Petrels on the main island. It will also allow for the safe reintroduction of species that have been extirpated from LHI but still survive elsewhere. The monitoring and enhanced biosecurity measures that will be put in place after the eradication to ensure rodents never return will also play a vital role in keeping other invasive species from establishing on the island.

From top left:

Little Shearwater and Black Noddy recolonised the main island within a decade of the removal of Feral Cats. Photos by Ian Hutton.

Lord Howe Island Woodhen numbers increased from 30 to 300 after cats and pigs were eradicated. Photo by Ian Hutton.

The island landscape is spectacular; the volcanic mountains of Mount Gower (875 metres) and Mount Lidgbird (777 metres) tower above the sea. Photo by Ian Hutton.

Stopping the fourth wave: Conservation and restoration of the Norfolk Island ecosystem

Richard N. Holdaway
School of Biological Sciences,
University of Canterbury,
Christchurch, New Zealand
and
Margaret Christian
Norfolk Island

Left to right:
Guano from a Tasman Booby; the first stage in the restoration of Phillip Island. Photo by Richard Holdaway.

Tasman Booby juvenile, Norfolk Island, showing pattern on breast and dark eye characteristic of these North Tasman birds. Photo by Richard Holdaway.

The Norfolk Island group exemplifies the history of human-induced changes to island biotas and the challenges of ecosystem conservation and restoration on islands with resident human populations. The two major islands of the group—Norfolk Island and Phillip Island—are both declared as Important Bird Areas. These islands lie at the junction of the Tasman Sea, the Coral Sea and the Pacific Ocean. Their biota reflects the group's geological age (approximately three million years) and relative isolation from source populations. There are closer biological associations with New Zealand and the Pacific Islands than with Australia. Norfolk Island's avifauna has experienced three waves of extinction over the past 1,000 years, resulting from a brief Polynesian settlement, successive European settlements (1788, 1825), ongoing permanent colonisation, and the effects of World War II.

The Polynesians' commensal Pacific Rat (*Rattus exulans*) initiated the first wave of extinction, eliminating several small birds and extirpating the only two lizard species from the main island. It would also have altered the species composition and structure of the vegetation, as it has on other islands (Campbell & Atkinson 2002).

When Europeans settled the island, the previously abundant Kermadec Petrel and Pycroft's Petrel (*Pterodroma pycrofti*) survived in small numbers but these, along with the Norfolk Island Ground-Dove (*Gallicolumba norfolciensis*), soon succumbed to the Europeans' Feral Pigs in a second wave of losses. These included the destruction of a major colony of Providence Petrels by starving colonists in the 1790s following the wreck of HMS *Sirius*; this completed the removal of burrow-nesting seabirds from the interior of Norfolk Island. The Norfolk Island Kaka, and Brown Goshawk (*Accipiter* cf. *fasciatus*) lingered a little longer, and the Norfolk Island subspecies of the New Zealand Pigeon survived until c. 1900.

The increasing human population left only remnants of the former vegetation concentrated on the Mount Bates–Mount Pitt massif, now the core of the Norfolk Island National Park. Losses continued with the third wave of extinction: the last record of the Norfolk Island subspecies of the Tasman Starling occurred in about 1923 and, following the arrival of Black Rats possibly during World War II, the Long-tailed Triller was last seen in 1976 and the Island Thrush (known locally as the Grey-headed Blackbird) (*Turdus poliocephalus poliocephalus*) in 1975.

Habitat loss and predation by rats, mice, and cats have depleted the avifauna both in terms of taxa and populations. In the remnant forest, a relict endemic avifauna remains. The surviving endemic taxa have global distributions of <15% of the island's 3,300 hectares (Figure 1, p.32), and include some of the rarest birds in the world. The population of the Norfolk Island subspecies of the Tasman Parakeet is likely to be less than that of New Zealand's hyper-managed Kakapo. The status of the world's largest *Zosterops*, Norfolk Island's endemic White-chested White-eye (*Zosterops albogularis*), is contentious: it is officially presumed to be extinct, but continuing occasional reliable reports give cause for hope. If it survives, it would rank as Australia's rarest bird. This third wave of extinction also included two bats, *Chalinolobus gouldii* and the endemic *Tadarida norfolkensis*, both last recorded in the late 1980s.

Comparison of the results of surveys in 1978 and 2005 indicates that the ranges of most other surviving endemics have contracted in the past 30 years (Figure 1, A–E). Most are now centred on the 460 hectares of the national park in the north-west of the island. Continued "urbanisation" has been accompanied by a loss of significant areas of habitat for endemic species including Pacific Robins (*Petroica multicolor*), Slender-billed White-eyes (*Zosterops tenuirostris*), Norfolk Island Gerygones (*Gerygone modesta*), and the endemic Norfolk Island subspecies of the Golden Whistlers (*Pachycephala pectoralis xanthoprocta*) outside the national park (Figure 1, A–D). The condition of the vegetation in the national park has been improved by replanting, removal of weeds and the exclusion of grazing.

Conversely, introduced and immigrant species continue to spread (Figure 1, F–H), and some pose significant threats to endemic species. The Red Junglefowl (*Gallus gallus*) has expanded its range dramatically in recent years, and is now common throughout the island. Its effects on the litter layer, seed and seedling survival and invertebrates are unstudied, but they must be considerable. Equally unstudied, and also damaging, is the effect of Purple Swamphens (*Porphyrio porphyrio*) on the breeding success of protected species on Phillip Island (Figure 1, G), where the swamphens are recent colonists. They prey upon the eggs, chicks, and adults of the resident birds, including Sooty Tern, Black Noddy, White-necked Petrels (*Pterodroma cervicalis*) and Kermadec Petrels, as well as on the threatened Norfolk Island Skink (*Oligosoma guentheri*) and Norfolk Island Gecko (*Christinus guentheri*), and invertebrates such as the endemic Phillip Island Centipede (*Cormocephalus coynei*); this predation could prove significant. There is ongoing debate about the implications of Purple Swamphens being allowed to prosper at the expense of endemic and threatened taxa.

Restoration of Phillip Island

The success of Phillip Island as a biotic lifeboat will depend on the rapid resolution of such problems. By the end of the 19th century, Phillip Island's terrestrial ecosystem had been almost obliterated, as vegetation and soil succumbed to overgrazing by rabbits and pigs. An epic eradication program saw the last rabbit killed in 1986. The recovery since then has been astounding: places that were bare rock 25 years ago now support regenerating forest on soil deep enough for

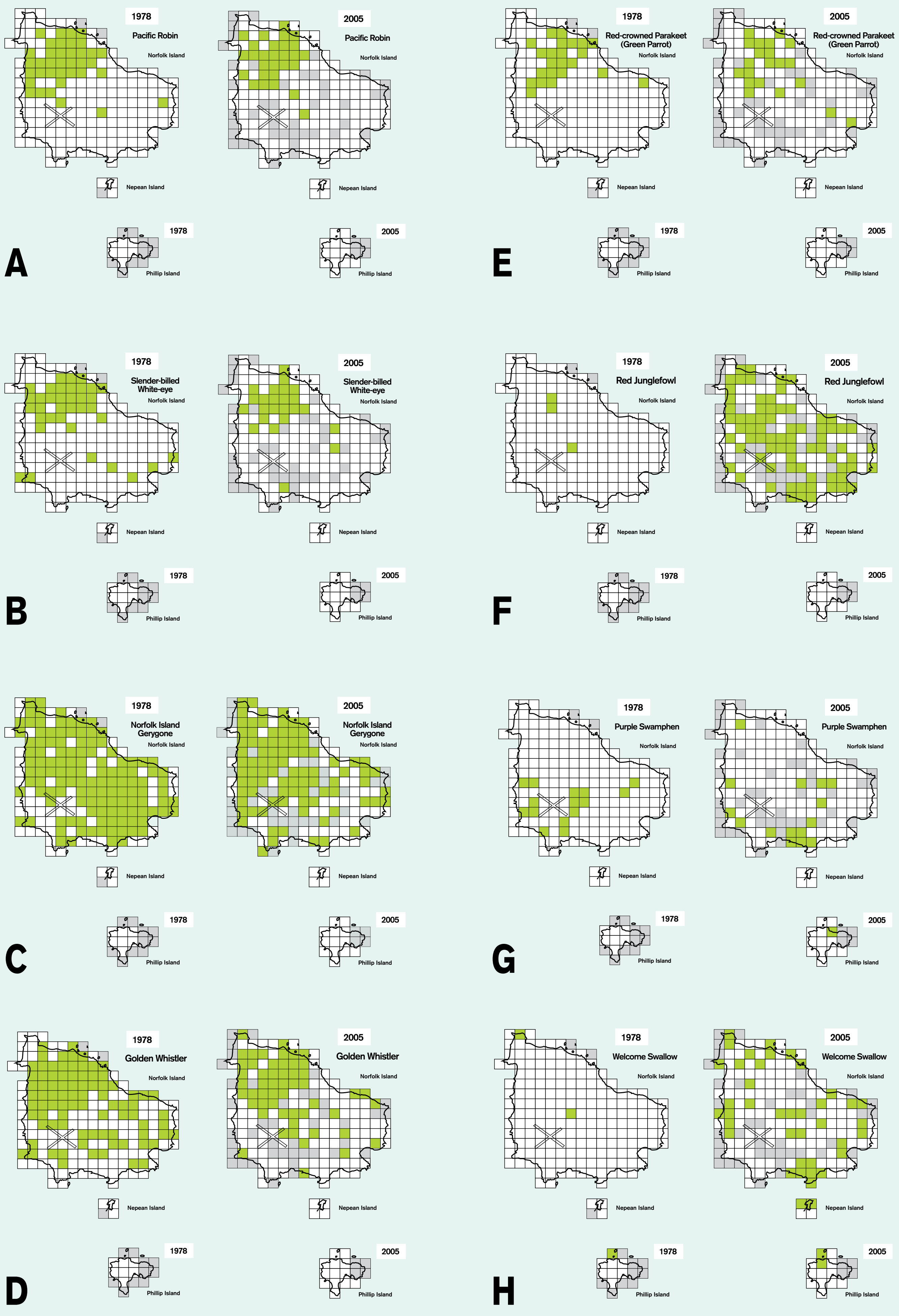

Figure 1 (left). Distributions of selected endemic and exotic birds on Norfolk Island during surveys in 1978 (left) and 2005 (right).

A–E: Five endemic terrestrial species showing similar patterns of contraction towards the national park (north-western corner).

F–H: One introduced (Red Junglefowl) and two self-introduced species. Purple Swamphens were recorded in similar numbers of squares in both years, but are now centred on Kingston Common on the southern coast, and they have vanished from the built-up area east of the airport; more significant are their recent presence as a breeding species on Phillip Island.

Maps from *A comparative atlas of bird distribution in the Norfolk Island group, 1978–2005*, Fauna & Flora Society of Norfolk Island, in press.

Key:

= present

= not recorded

= not surveyed in 2005.

Above:
The Norfolk Island Fantail is the only endemic passerine whose range has not contracted within the island over the past 30 years. Photo by Richard Holdaway.

petrels to burrow into. Even so, the revegetation of Phillip Island may not be rapid enough to provide a proposed refuge for Norfolk's forest birds before they decline to critically low levels, or even extinction.

The remarkable recovery of Phillip Island is driven at least in part by the supply of nutrients from the marine food chain via bird guano. In the forest of Norfolk Island itself, the marine nutrients were lost when the burrow-nesting petrels were slaughtered. The island's soils have low levels of nutrients and the weathered rock no longer releases phosphorus, which underpins the terrestrial ecosystem. The loss and continued absence of the petrels have serious implications for the longer-term viability of the island ecosystem. Many Norfolk Island Pines (*Araucaria heterophylla*) and other indigenous trees are now affected by the root-rotting fungus *Phellinus noxius*, a condition exacerbated by low levels of phosphorus.

Restoration of Norfolk Island

Re-establishing populations of burrow-nesting petrels in the forests of Norfolk Island is fundamental to the restoration of the ecosystem, which developed in the presence of copious supplies of their guano over the past two million years. However, any translocation of petrels is unlikely to succeed while rats and cats are still present. Extensive experience in New Zealand indicates that *Pterodroma* petrels and small shearwaters cannot survive long in the presence of introduced mammalian predators.

Top left:
Dedicated private landholders on Norfolk Island work hard to protect the Tasman Booby through local and intensive cat control. Photo by Julie Kirkwood.

Top right:
The Red-tailed Tropicbird is susceptible to predation by domestic and feral animals on Norfolk Island. Photo by Julie Kirkwood.

Predation by animals, including people, has been the major factor in the extinction of birds on Norfolk Island over the past 1,000 years. It persists as the most significant problem threatening the survival of the remaining species.

Current projects on Norfolk Island birds include ongoing monitoring of the hybrid Southern Boobook population (hybrids of the Norfolk Island subspecies *Ninox novaeseelandiae undulata* and the nominate New Zealand subspecies), Tasman Parakeet breeding, and study of the foraging strategies and population dynamics of the Tasman Booby (*Sula dactylatra tasmani*), which recent research has revealed is a threatened local race of the Masked Booby (*Sula dactylatra*). In addition, the authors are using geolocators to extend the long-term investigation of the movements of Wedge-tailed Shearwaters by Owen and Beryl Evans. Preliminary results of this program are being analysed, and marine nutrient contributions to the Norfolk Island terrestrial environment are being subjected to stable-isotopic analysis. The 1978 bird distribution survey was repeated in 2005, and a comparative Atlas is in preparation (Figure 1). Private efforts such as the survey and Atlas provide important background information for management, but there is a pressing need for more research on the population structures, habitat requirements, productivity, survivorship and other aspects of the ecology and behaviour of all birds on Norfolk Island.

The only way to prevent an imminent fourth wave of bird extinctions on Norfolk Island is to eliminate the introduced rodents and Feral Cats. Whether they are extirpated from the whole island, or just the mainland area of the national park within a predator-proof fence, will be primarily a social question: the technologies for both are available.

While the fourth wave of extinction can be averted, time is limited, and exotic taxa continue to arrive. The House Gecko (*Hemidactylus frenatus*) and other reptiles have recently arrived via the bulk importation of supplies. Local residents are attempting to eradicate the House Gecko population. The island's quarantine defences were breached again when Argentine Ant (*Linepithema humile*) arrived in about 2005. This ant threatens both the indigenous fauna and local horticultural production and is now the target of an intensive eradication program.

Brooke *et al.* (2007) rated Norfolk Island 11th in a worldwide cost–benefit analysis of islands, in terms of number of species saved versus cost of eradication program. No other Australian island was rated in the top 20. For about a quarter of the cost of eradicating rabbits from Macquarie Island, the future of the Norfolk Island avifauna—and much of its unique vegetation—could be assured. Provision of those funds is a political decision: making it could provide an example to the world.

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Above:
Numbers of the Christmas Island Hawk-Owl were estimated at 562±105 breeding pairs in the mid-1990s. Photo by Ian Montgomery.

The birds of Christmas Island face the invading hordes

David J. James
and
Ian A.W. McAllan

Rising from a deep abyssal plain, Christmas Island is an isolated oceanic island that is biogeographically unique, with many endemic species and some unique ecological processes. A total of 63% of the island is national park. Christmas Island is in the midst of a biodiversity crisis and several species are on the brink of extinction. The population status of most birds is inadequately known, and systems are not in place to identify and respond to species decline. A substantial rethink of conservation priorities on the island is needed to avert a pending avalanche of extinctions.

The landscape is a series of jagged limestone terraces separated by steep cliffs that are largely vegetated with tropical jungle. The coastlines are mostly sheer cliffs with a few small rubble beaches. The climate is equatorial with a wet season between December and April.

Christmas Island's biogeography is influenced by both the Indomalayan and Australasian biota, but it belongs to neither. The native vegetation consists of predominantly tall evergreen rainforests in the interior with semi-deciduous vine thickets on the coastal terraces. The forests are floristically depauperate but structurally complex. Approximately 25% of the island has been cleared, and comprises open rocky ground and phosphate mines, weed fields, secondary growth and urban areas.

There are at least 250 animals and plants (species and subspecies) endemic to Christmas Island (James & Milly 2006). Endemic animals, apart from birds, include five mammals, five reptiles, three marine fish and over 200 terrestrial, subterranean and marine invertebrates. It is one of the world's most spectacular breeding stations for tropical seabirds, and the diversity of its land crab fauna is unparalleled. The endemic Red Crab (*Gecarcoidea natalis*) plays a significant role in determining the floristics and structure of the forests and, no doubt, also the avifaunal composition.

A total of 16 species of birds bred on Christmas Island in 1888, and 23 species breed there now. Eleven birds are endemic at either the species or subspecies level; five endemics are recognised at the species level (Christidis & Boles 2008), but the Christmas Island Goshawk (*Accipiter hiogaster natalis*) and Glossy Swiftlet (*Collocalia linchi natalis*) are probably also endemic species. Five other species that were present at the time of settlement are wider ranging taxa. Four species have colonised the island unassisted and three introduced species have become established since settlement. In addition, 121 species of migrants and vagrants have been recorded (James & McAllan in prep).

In 2009 the Christmas Island Pipistrelle (*Pipistrellus murrayi*) became extinct, joining two endemic rats and a shrew, leaving a single surviving endemic mammal, a flying-fox that is also declining. Four of the island's five endemic reptiles are facing imminent extinction. About 100 endemic invertebrates have not been recorded for over 50 years, though appropriate surveys might lead to the rediscovery of many of these, and the discovery of new species.

So far, the birds have not been affected by the biodiversity crisis to the same extent, although six species are listed as nationally threatened. Predictions that the Yellow Crazy Ant would cause severe declines in the endemic land birds (Garnett & Crowley 2000; Davis *et al.* 2008) have not eventuated so far. Nevertheless, the status and trends of many species are inadequately known.

Based on nest surveys, the Christmas Island Frigatebird (*Fregata andrewsi*) declined by an estimated 7–16% between 1985 and 2003 (James 2003). More detailed nest survey data collected in 2004 and 2005 have not been analysed. Available historical data were used to extrapolate the species' population trend since 1888 (Figure 1). It was considered that threats in the marine range (such as fishing and marine pollution) were more likely to be responsible for present downward trends than factors in the breeding habitat.

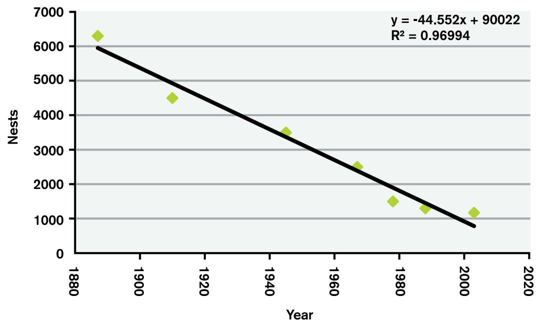

Figure 1. The extrapolated trend in the annual number of breeding pairs of Christmas Island Frigatebird since 1888.

A helicopter survey of Abbott's Booby (*Papasula abbotti*) nests in 2002 compared favourably with ground-based counts undertaken in 1992 (Olsen 2004). However, owing to a lack of ground-truthing and potential errors in the dataset, the findings should not be considered conclusive. The results of a second helicopter survey in 2009 are not yet available. While these figures are considerably lower than earlier estimates (see Stokes 1988), for the moment, the population size is assumed to be stable.

Studies of the Red-tailed Tropicbird in the mid-2000s indicated almost complete breeding failure. Figure 2 shows the rate of loss of eggs and chicks from a sub-colony of 150 nests between April and July 2006 (Ishii 2006). Camera traps revealed the cause to be predation from cats and Black Rats. There is no reason to assume that this process is not occurring across the entire island.

James & Retallick (2007) established baseline data on the relative abundance of eight species of land birds and a seabird by conducting presence–absence surveys that produced reporting rates (Figure 3). In 511 surveys, the Christmas Island White-eye (*Zosterops natalis*) and Christmas Island Imperial-Pigeon (*Ducula whartoni*) were reported at rates of more than 90%, while the Emerald Dove (*Chalcophaps indica natalis*), Glossy Swiftlet and Island Thrush were recorded at rates of 39%, 59% and 70% respectively. A repetition of this survey should provide accurate trend data for these species. In the meantime, the survey demonstrated that these species were still widespread and reasonably numerous.

The Christmas Island Goshawk was detected at a rate of only 1% (James & Retallick 2007). A colour banding study of this species initiated in 2005 led to a population estimate of about 250 individuals (James 2007). It would seem to be a naturally rare bird that could easily be pushed to extinction by a threat, and routine monitoring of this species is essential.

The population of the Christmas Island Hawk-Owl (*Ninox natalis*) was estimated to be 562±105 breeding pairs between 1994 and 1996 (Hill & Lill 1998). Although a monitoring method was established for determining the species' population trend, the required follow-up surveys have not been completed successfully to date.

Most conservation issues on the island stem from a combination of inadequate quarantine (leading to the establishment of invasive plants and animals) and inappropriate land management (e.g. land clearing, abandonment of mines, neglect of road verges, etc.), which allows invasive species to prosper. The most publicised threat comes from the Yellow Crazy Ant, which alters forest ecology significantly. There are also many other invasive species present, including numerous species of ants, centipedes, rats, cats, reptiles, bees and weeds. The threats faced by the wildlife are many and varied, complex and interactive, elusive to identify and difficult to ameliorate. In recent decades, the conservation effort has been focused on the widespread control of the Yellow Crazy Ant, rehabilitation of former mines and management of the Red Crab migration, but it has not focused on identifying and protecting the biodiversity assets that are most at risk. This approach has failed the Pipistrelle and the reptiles in the worst possible way. It is still failing the Red-tailed Tropicbird. If it continues, it will fail more species, possibly some of the endemic birds, in the near future.

Conservation management on Christmas Island needs an urgent, strategic and ongoing overhaul, with much wider input and accountability, and considerably greater funding. The first steps must involve gaining a better understanding of the complex threats and initiation of control measures for a wider range of the known threats, such as introduced cats, rats and centipedes. The task is enormously challenging, but the consequences of failure will be grave indeed.

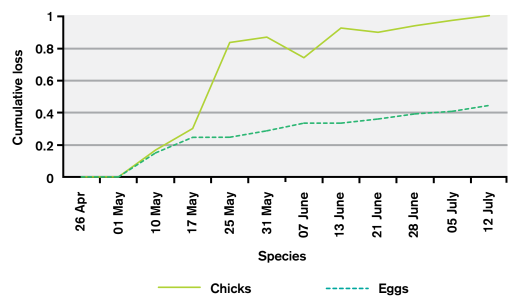

Figure 2. Observed loss of eggs and chicks in a colony 150 pairs of Red-tailed Tropicbirds in the 2006 breeding season.

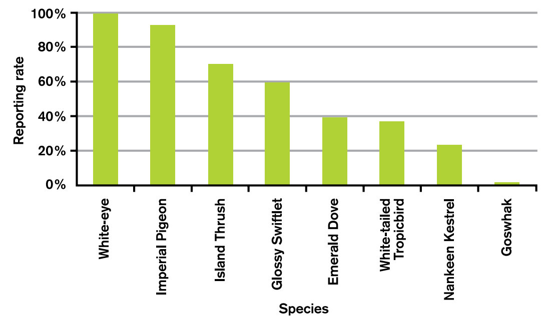

Figure 3. Reporting rates of forest birds (from most to least abundant) from 511 presence–absence surveys in 2005–2006.

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Potential impacts of changing sea-surface temperatures and sea level rise on seabirds breeding on the Great Barrier Reef

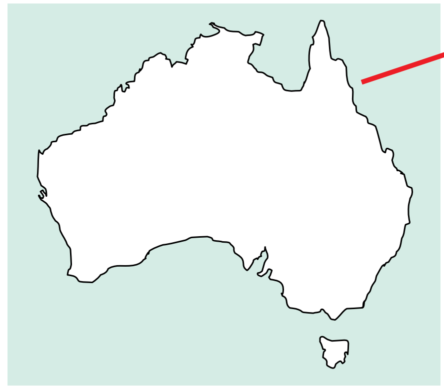
Kees Hulsman Environmental Futures Centre, School of Environment Griffith University, Nathan, Qld
and
Carol Devney James Cook University, Cairns

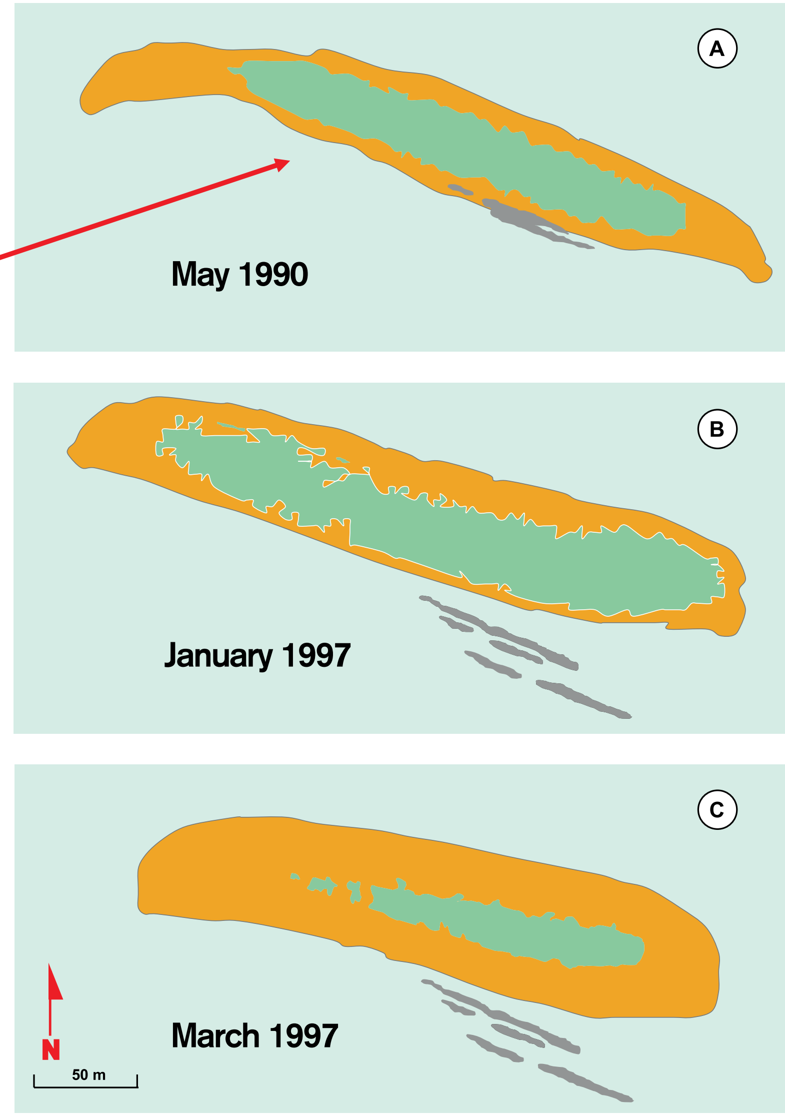
Above:
Black Noddies may take generations to adapt to climate change impacts on the Great Barrier Reef. Photo by Carol Devney.

As the globe warms, information on seabird population trends and whether or not species can adapt is critical. Unfortunately, it is unclear whether the substantial population declines observed for the many species of tropical seabirds breeding on the Great Barrier Reef (GBR) have continued. Recent and systematic data for most important seabird breeding colonies in the region are limited, but the latest research into potential coping strategies of seabirds on the GBR suggests that reproduction, and ultimately species survival, is under threat. Predicted global sea level rises and changes to cyclone dynamics threaten seabird populations around Australia, but particularly in tropical regions such as the GBR, where colonies are formed on low-lying coral cays and islands.

If sea level rises more quickly than coral can grow, then water depth over the live coral will increase, and a decrease in accessibility to prey will result. If climate change kills coral, there will be a change in the abundance and species composition of fish communities; decreased productivity of an area will lead to smaller populations of seabirds inhabiting it. For example, a significant decrease in the population of the Black Noddy in the Capricorn–Bunker Group resulted from the mass mortality of adults and chicks which coincided with coral bleaching over an extensive area during the El Niño Southern Oscillation in 1998.

Potential coping strategies for climatic variation include changes to timing of breeding, foraging behaviour, size and growth rates of offspring, and breeding location. However, when faced with wide variation in sea-surface temperature (SST), species may not have the plasticity to adapt to rapid climate change. Black Noddies, which forage offshore, are unable to modify their foraging behaviour (prey type, feeding frequency or meal size) or chick growth rates greatly. As sea-surface temperatures increase and food becomes limited, adult Black Noddies spend more time foraging but bring back less food. When food is super-abundant, feeding rates are





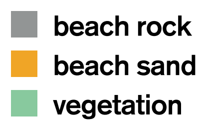


Figure 1. Michaelmas Cay, northern Great Barrier Reef. Green areas represent vegetated surface suitable for nesting in 1990 (A), in 1997 before Cyclone Justin (B) and in 1997 after Cyclone Justin (C) (from Devney et al., 2009) (http://www.publish.csiro.au/nid/144/paper/WR08142.htm).

Table 1. Distribution of biomass of breeding seabirds on the Great Barrier Reef in relation to location on the continental shelf.

Section of marine park	Inner	Middle	Outer	Biomass (tonnes)
Far Northern	8.3	4.6	67.6	80.5
Cairns	1.6	5.6	15.1	22.3
Townsville	3.8	0.02	0	3.82
Mackay/Capricorn	0.3	387.2	18.6	406.1
Total	14.0	397.42	101.3	512.72

Source: Hulsman 1997.

constrained by chick fullness and the chicks' inability to increase growth rates. These limitations suggest that responses of this species (and similar species) to climate change may take generations.

Another area of concern is the effect of climate change on the preferred habitat of breeding seabirds. On the GBR, the distribution and abundance of seabirds is correlated with the distribution and abundance of coral cays. The biomass of seabirds on the GBR is concentrated in the Far Northern and Capricornia sections of the GBR Marine Park (Table 1), where the majority of coral cays occur (Table 2). Seabird colonies there are threatened by a rise in sea level. In Australia, the sea level is predicted to rise by 80 centimetres by 2100. Most cays are less than three metres above the mean high-water mark. Low-lying coral cays, which are the preferred breeding sites of seabirds on the GBR, will be at risk of being flooded at high tide, while others will be inundated during storm surges from the increased number of intense tropical storms and cyclones.

Generally, cays gradually increase in size and elevation; however, a single storm can rapidly decrease a cay's size and elevation. Figure 1 shows changes in the vegetated area and position of Michaelmas Cay between 1990 and 1997. The vegetated area was relatively stable for at least seven years, but was then dramatically decreased by Cyclone Justin in 1997. Cays are known to migrate back and forth on the reef crest, as evidenced by changes in the cay's position relative to the beach rock (Figure 1).

Storm surges have been a major cause of mortality of eggs and chicks of species that nest just above the high water mark, e.g. Lesser Crested (*Thalasseus bengalensis*), Black-naped (*Sterna sumatrana*) and Roseate terns. However, with an anticipated sea level rise of almost a metre, combined with storm surges of several metres, species that nest on the interior of cays are also at risk. For example, parts of the nesting areas of Wedge-tailed Shearwaters at cays such as Heron and North West Islands would be inundated by storm surges and storm high tides of more than six metres. Cyclone Hamish in 2009 caused a four-metre high tide and surge, and water came up almost to the edge of the vegetation on the north-western side of Heron Island. Most of North West Island is lower than Heron Island. Loss of the Wedge-tailed Shearwater colony at North West Island would affect 80% of its breeding population on the east coast of Australia. Furthermore, flooding of vegetated areas by seawater would lead to the loss of habitat suitable for nesting. Changes in rainfall may also affect the vegetation; for example, decreased rainfall may dry out or kill the vegetation and increase the risk of fire.

The loss of cays would change the distribution of seabirds from the outer parts of the continental shelf to the inner and middle parts, where the continental islands occur. The majority of continental islands are in the MacKay–Capricorn section and the Townsville section of the GBR Marine Park (Table 2), though there are numerous continental

Table 2. Number of six different types of islands in the Great Barrier Reef Marine Park (source: D Hopley island database in Hulsman 1997)

Section of GBRMP	Type of island						Total
	High Continental	Low Wooded	Mangrove	Vegetated Sand Cay	Sand Cay	Vegetated Shingle Cay	
Far Northern	65	28	4	26	22	1	146
Cairns	23	11		7	7		48
Townsville	131	4			1		136
Mackay/Capricorn	227	10		16	7	2	262
Total	446	53	4	49	37	3	592

islands in the Far Northern section for seabirds to nest on provided they have suitable habitat.

Tropical cyclones that occur during the seabirds' breeding season increase mortality of eggs and chicks, and affect available nesting habitat. For example, chicks of Crested Terns, Sooty Terns, Common Noddies (*Anous stolidus*) and Black Noddies are reported to have died of starvation or exposure during tropical cyclones. The rough sea-surface conditions make it difficult for adult birds to detect prey, or they cannot return to the colony against the wind to feed their young. However, on Michaelmas Cay, although individual cyclones have had substantial impacts on reproduction and nesting space, there has been no noticeable impact on longer-term trends in breeding numbers. Predicted increases in the frequency or intensity of tropical cyclones as a result of climate change may have greater impacts to populations in future via increased adult mortality and reduced recovery periods.

The loss of coral cays suitable for breeding seabirds will affect their access to feeding areas. Inshore feeders, which breed in small colonies near their feeding grounds, will be affected differently from offshore and pelagic feeders, because they can readily switch their breeding sites between seasons. In contrast, even though offshore and pelagic feeders breed in a few large colonies and can travel large distances to their feeding grounds, they may skip breeding in a given season when problems arise. The loss of coral cays as breeding areas may increase competition between inshore species for nesting areas and access to feeding areas near the colony.

Climate change is likely to affect the viability of seabird colonies in two distinct ways: changes to the food supply and suitability of habitat for breeding. First, climate change will decrease the abundance of prey through the loss of corals which provide habitat and sources of food for many of the prey species of inshore feeders. Increased sea-surface temperatures decrease the productivity of plankton, in turn causing decreases in the abundance of pelagic fish stocks that are the major prey of the offshore and pelagic feeders. At least some species appear to have little ability to change their foraging behaviour and growth rates to compensate for a decreased food supply. Second, climate change will decrease availability of preferred habitats for breeding seabirds through changes in the mean high-water mark, which, when combined with the increased incidence of storm surges, will flood nesting areas or erode the size and elevation of cays. It seems that seabirds are unlikely to be able to adapt with sufficient rapidity to changes in their environment caused by climate change. That leaves us with the challenge of managing their populations to maximise their chances of survival.

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Important Bird Areas and Australian islands

Cheryl Gole
Birds Australia

Above:
Masked Booby and chick on Lord Howe Island IBA.
Photo by Ian Hutton.

Important Bird Areas (IBAs) are sites recognised as being internationally important for bird conservation and known to support populations of key bird species. The IBA program is an initiative of BirdLife International, developed to identify the most important places on earth for birds, to promote their significance for conservation and to assist the prioritisation of conservation efforts and resources. To qualify as an IBA, sites must satisfy at least one of a number of established, scientific criteria and must support one or more of the following:

- Globally threatened species listed in the IUCN Red List;
- Restricted-range species (vulnerable because they are not widely distributed);
- Congregatory species, or groups of similar species (such as seabirds, waterbirds or shorebirds, that are vulnerable because they occur at high densities in certain places).

For mobile species, IBAs include sites for all critical phases of the life cycle: breeding, non-breeding and migration, including migratory bottlenecks.

Birds Australia has identified IBAs in all Australian jurisdictions: these are generally concentrated in fragmented landscapes, coasts and islands. Of the 314 Australian IBAs, 95—almost one third—are wholly or partly islands. Most of the island IBAs are in Tasmania, Western Australia and Queensland (Dutson *et al.* 2009).

In Australia, the designation of island IBAs has been triggered by threshold numbers of globally threatened species, representative populations of restricted-range species and congregations of more than 1% of the global population of congregatory seabirds, waterbirds and resident and migratory shorebirds. Only two of Australia's 95 island IBAs have been designated for shorebirds only and two for terrestrial birds only; all other single-category island IBAs have been designated for seabirds (Table 1).

Many of Australia's small islands support large concentrations of nesting seabirds, especially in the Great Barrier Reef and around Tasmania. Most seabird colonies and island IBAs are small: 21 IBAs are 10 hectares or less. Island IBAs range from less than one hectare (for example, Shag Reef in Tasmania and Sudbury Reef in Queensland) to the 783,781-hectare Tiwi Islands IBA in

Table 1: Island Important Bird Areas that support threatened species. IBAs marked with an asterisk (*) also support more than 1% of the world's population of at least one congregatory seabird species.

IBA	Species	IUCN status
Cabbage Tree & Boondelbah Islands IBA	Gould's Petrel (*Pterodroma leucoptera*)	Vulnerable
Christmas Island IBA*	Christmas Island Frigatebird	Critically Endangered
	Abbott's Booby	Endangered
	Christmas Island Imperial-Pigeon	Vulnerable
	Christmas Island Hawk-Owl	Vulnerable
	Christmas Island White-eye	Vulnerable
Heard & McDonald Islands IBA*	Black-browed Albatross	Endangered
	Macaroni Penguin	Vulnerable
	(Southern) Rockhopper Penguin	Vulnerable
Lord Howe Island IBA*	Lord Howe Woodhen	Endangered
	Providence Petrel	Vulnerable
Macquarie Island IBA	Wandering Albatross	Endangered
	Black-browed Albatross	Endangered
	(Southern) Rockhopper Penguin	Vulnerable
	Royal Penguin	Vulnerable
	Grey-headed Albatross (*Thalassarche chrysostoma*)	Vulnerable
Norfolk Island IBA*	White-chested White-eye	Critically Endangered
	Tasman Parakeet (Norfolk Island subspecies)	Endangered
	Slender-billed White-eye	Endangered
	Norfolk Island Gerygone	Vulnerable
Phillip Island (off Norfolk Island) IBA*	Providence Petrel	Vulnerable
	White-necked Petrel	Vulnerable

the Northern Territory. Only two other IBAs are greater than 100,000 hectares: Fraser Island and Cooloola Coast (Qld) and Kangaroo Island (SA).

Australia's offshore island IBAs are extremely important for seabirds. Christmas Island, Ashmore Reef, North Keeling, Heard and McDonald islands, Macquarie Island, Lord Howe Island, Norfolk Island and Phillip Island (off Norfolk Island) IBAs support large numbers of threatened and widespread seabird species. A number of island IBAs also support threatened endemic seabirds and terrestrial species which are extremely vulnerable to loss or degradation of habitat and other threats.

Islands are also important for terrestrial species. While most island IBAs have been designated solely or primarily for seabirds, shorebirds and/or waterbirds, 26 island IBAs have been designated at least partly for terrestrial species. These include threatened island endemics such as the Slender-billed White-eye in the Norfolk Island IBA, but also other threatened terrestrial species such as the Orange-bellied Parrot (King Island and Hunter Island Group IBAs) and the Forty-spotted Pardalote (Bruny Island IBA).

Island IBAs can be an important focus for conservation efforts for globally significant populations of threatened and congregatory birds. By collecting and analysing data on the status of island IBAs, Birds Australia and BirdLife International are able to record changes in the status of bird populations and ecological characteristics that assist science-based decision making that affects these areas both at national and international levels. The identification of IBAs is an important first step in larger bird conservation initiatives, but island IBAs are currently among our most poorly known and monitored conservation sites. For example, in the states of Tasmania, Queensland and Western Australia, all 31 IBAs whose monitoring status are unknown are island IBAs. In Australia, the IBA project offers opportunities to engage volunteers in monitoring and conservation projects on island IBAs, promoting local stewardship and advocacy. Given issues regarding access and remoteness, this is a challenge for many island IBAs, but working with a range of stakeholders, including government agencies, the IBA program may be a starting point for site-based conservation efforts on islands.

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Above:
Heard Island IBA is important habitat for Macaroni Penguin.
Photo by Eric J. Woehler.

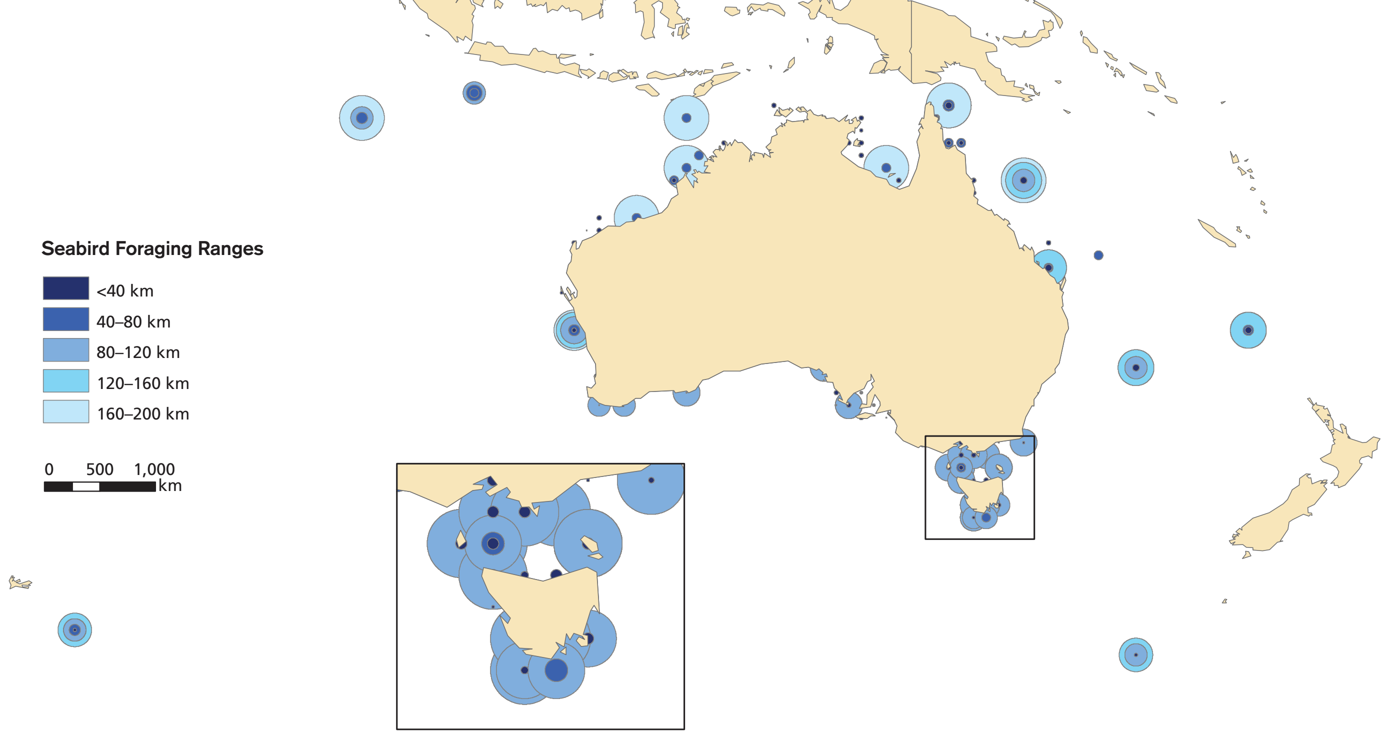

Figure 1: Foraging ranges of seabirds or groups of seabirds plotted as radii around island IBAs designated for breeding seabirds. 'Seabirds' include petrels and albatrosses, storm-petrels, gannets and boobies, penguins, tropicbirds and frigatebirds.

Marine Important Bird Areas

Ben Lascelles (BirdLife International) and Cheryl Gole (Birds Australia)

Marine foraging areas and breeding islands are both critical for seabird conservation. Following the successful implementation of the Important Bird Area (IBA) program around the world, a process that included setting priorities and focusing conservation action in terrestrial, freshwater, coastal and island habitats, BirdLife International has been working to extend the IBA program to include the marine environment. This work recognises the limitation of the existing program in identifying offshore areas that are critical for the conservation of predominantly marine species of birds, including pelagic species such as albatrosses. Challenges in identifying and designating marine IBAs include a lack of data, the difficulty of defining and delimiting sites in superficially featureless seascapes, and determining if and how terrestrial and marine IBAs might overlap where the requirements of pelagic species overlap the terrestrial–marine boundary.

In most cases, significant breeding colonies have already been identified as IBAs, but there are other ways in which the IBA process could be adapted and extended to capture other aspects of seabirds' life cycles that are amenable to site-based conservation. In addition to coastal congregations of birds and migratory bottlenecks, it will be possible to include sites for pelagic species where large numbers of birds might congregate while foraging. They might also include seaward extensions from breeding colonies. These extensions are used for feeding, maintenance behaviour and social interactions, and are limited by the foraging range, depth and habitat preferences of each species.

The distribution of seabirds at sea has been poorly known in the past. More recently, BirdLife International has utilised the results of tracking studies to estimate the foraging ranges of a number of species of seabirds. Foraging ranges of some species have been plotted as simple radii around island IBAs designated for breeding seabirds (Figure 1). This provides a preliminary indication of the contribution that a network of marine IBAs or marine protected areas would make to the conservation of seabirds on Australia's island IBAs. The foraging ranges were determined on the basis of data held in the BirdLife Seabird Foraging Range Database, which compiles information on foraging distances of species obtained from published and unpublished literature, as well as consultation with experts on the species. Since the database is not yet complete, for this mapping exercise the data for some species were grouped. Radii were added to sites where those species were IBA trigger species. Such mapping could be refined by utilising additional data (e.g. certain bathymetry contours, specific habitats, sub-surface predator distribution, upwellings) where they might be deemed by a literature review to be important to particular species.

Marine IBAs are now core business for BirdLife International's Global Seabirds Program, which sees the identification of marine IBAs as making a vital contribution to global initiatives to gain greater protection and sustainable management of the oceans, including towards the designation of Marine Protected Areas.

Swain Reefs: An island Important Bird Area for Roseate Terns

Allan Briggs
Birds Australia Capricornia

The coral cays of Swain Reefs provide a fragile roosting and breeding location for Roseate Terns and were declared an Important Bird Area because they support more than 1% of the world's population and over 50% of the Australian population of these birds. The cays are at risk from climate change and the birds are threatened by factors such as variations in numbers of pelagic fish. The future may not be so rosy for the Roseate Tern.

Swain Reefs is a group of coral cays and reefs that lies around 180 km north-east of Yeppoon, off the central coast of Queensland. There are myriad emerging coral reefs, many of which have formed into small coral cays. Six of these have been identified as breeding, feeding and roosting locations for the Roseate Tern. Each cay is composed of sand with small rocky beaches on the fringe of the cay—only Price and Frigate cays are vegetated, with low grasses and ground plants.

The Great Barrier Reef is vital for the survival of the Roseate Tern: 55% of Australia's population of the species is thought to breed there (Hulsman *et al.* 2007). Within the Great Barrier Reef, the most important site is Swain Reefs IBA, where up to 25,000 birds (mostly non-breeding) occur, which comprises 51% of the Australian population. Of these, 60% belong to a population of an Asian migrant subspecies (*Sterna dougallii bangsi*), while 38% are from an unknown breeding population (they are thought to breed on islands off Cape York) and the remainder is a small local breeding population (O'Neill *et al.* 2008).

Above:
The Roseate Tern is threatened by climate change on the Swain Reefs.
Photo by Andrew McDougall.

Threats to Swain Reefs IBA

There are four main threats to the Swain Reefs IBA that have the potential to seriously affect the viability of this system for Roseate Terns and, possibly, for the cays themselves.

(1) The loss or modification of habitat due to cyclonic weather activity. The violent action of cyclones can modify the habitat of a cay so that it becomes abandoned by the seabirds that it previously supported. For example, Thomas Cay was substantially modified by Tropical Cyclone Hamish in March 2009 and no Roseate Terns were recorded there in July 2009. With a forecast increase in the frequency of cyclonic activity in the future due to global warming, the importance of the Swain Reefs IBA may decline.

(2) The depletion and variation of pelagic fish stocks is a critical factor affecting the breeding success and population levels of Roseate Terns, and these factors will be influenced by both natural variation and climate change. Data suggest that pelagic fish populations around inshore islands in tropical Australia can support limited numbers of Roseate Terns during the breeding season (Milton *et al.* 2006), which increases the pressure on breeding success and makes this species especially susceptible to changes in the availability of their prey.

In the UK, the Roseate Tern has been placed under the protection of a national Biodiversity Action Plan because of the apparent influence that global warming has had in altering the vertical distribution of the fish it feeds on. It is not clear whether the same process is occurring around Swain Reefs, but coral bleaching events are being blamed on rising ocean temperatures, so it is a possible scenario.

Figure 1. The six cays that comprise the Swain Reefs IBA, showing the cays where Roseate Terns roost and breed. The distance from Bacchi Cay (in the north) to Gannet Cay (in the south) is 40 km. Each cay is small, ranging from 0.5 hectares (Bacchi Cay) up to two hectares (Price Cay).

(3) Low breeding success. Nisbit & Drury (1972) estimated that the breeding success of the Roseate Tern was 1.12 chicks per nest; this was strongly influenced by the food supply. Thus, if fish stocks were to decline around Swain Reefs, the number of Roseate Terns is likely to be affected.

(4) The sea level rise due to global warming. One of the criteria used by the Queensland Coastal Management Plan for development planning is a prediction of 0.8-metre rise in sea level by 2100. This is consistent with the Intergovernmental Panel on Climate Change (IPCC) predictions, but other factors suggest that the sea level may rise by as much as two metres. If that were the case, the small cays of the Swain Reefs IBA would become submerged, as it is unlikely they would build up at a rate consistent with the rise in sea level.

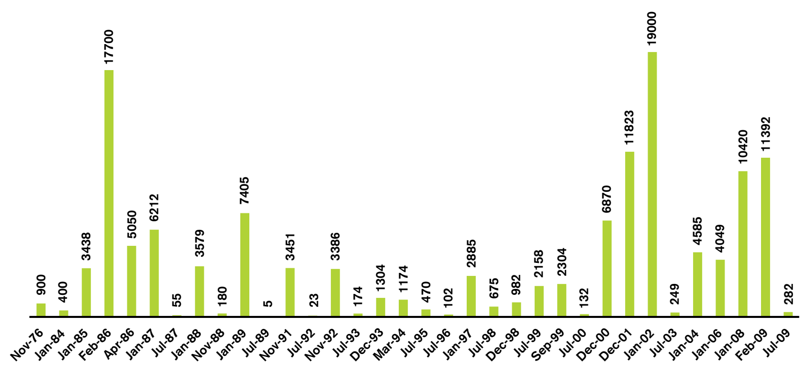

Figure 2. WildNet data for Swain Reefs on Roseate Terns 1976-2009.

Role of seabirds in the ecosystem

Seabirds play a vital role in nutrient cycling by concentrating organic matter as guano on islands. This enriches the soil to levels that allow the establishment of plants that would not otherwise be able to colonise the island. In addition, guano makes food scraps available, thus promoting a scavenger-based food chain of terrestrial animals. The cyclic nature of this interaction is evident: the Roseate Tern, along with other seabirds, helps to enrich the nutrient levels of the soil; this allows plants to colonise the cays; the plants then provide nesting and roosting sites, which makes the area more attractive for seabirds.

Variations in population

The WildNet is a computerised database with records of Queensland wildlife dating back to 1976. The chart below (Figure 2), a set of composite data for all of the cays in the Swain Reefs IBA, shows the fluctuations in the population of Roseate Terns.

All of the peaks in population have occurred between November and April, though there is considerable variation between years. Although there are no data to show the cause of this variation, in the future, researchers may be able to correlate particular environmental variables with peaks and troughs in the tern population. It is possible that a combination of factors, including cyclonic activity, global warming influences on fish stocks and the movement of birds affecting data collection accuracy might all play a part.

The future of Swain Reefs IBA

The vulnerable nature of coral cays, battered by cyclones and in danger of inundation from rising sea levels, makes them a precarious habitat for birds such as the Roseate Tern, which are themselves are at the mercy of variations in the pelagic fish they feed upon. Careful monitoring will help to record the fortunes of the species but there seems to be little we can do to assist their survival on these cays into the future. They provide an important example of a habitat and species that is particularly susceptible to the impacts of rising sea levels. It may be that this island IBA will cease to exist by as early as the middle of the century, and we will only have our maps, databases, photos and graphs to show our children how wonderful it once was. However, even if the cays disappear under the sea, the terns will hopefully move on and find other locations to breed and roost. Hence the ongoing monitoring of this species will be important in determining its response to rising sea levels.

Acknowledgement
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Tasmania and the fox

Julie Kirkwood Birds Australia,
Eric J. Woehler School of Zoology, University of Tasmania, and
Matthew Marrison Fox Eradication Branch, DPIPWE

Australia's largest island, Tasmania, demonstrates many of the ecological benefits of islands, such as biodiversity and endemism hot spots. The increased threat of Red Foxes becoming established in Tasmania is a significant concern for the conservation of the state's wildlife and biodiversity, and efforts are underway to locate and eradicate foxes on the island. However, due to its size, pest eradication and restoration of the island's flora and fauna is an onerous and particularly challenging task, as the Tasmanian Fox Eradication Program has discovered since work began in 2002.

Because it is isolated from the mainland, Tasmania is home to many endemic species of birds, such as the Forty-spotted Pardalote and Tasmanian Native-hen (*Tribonyx mortierii*). Tasmania provides critical breeding and feeding habitats for a range of shorebirds, many of which breed successfully on the undisturbed beaches in the lesser-visited areas of the state. Tasmania's coastline (including its associated islands) extends for almost 5,000 km, longer than the coastlines of Victoria and New South Wales combined. However, the island state also experiences many of the land-management issues that occur on mainland Australia. Many species are still decreasing—Wedge-tailed Eagles (*Aquila audax*), Swift Parrots (*Lathamus discolor*) and Forty-spotted Pardalotes are threatened by forestry activities, and many species considered to have relatively stable populations are now potentially threatened by an establishing fox population and the parallel decrease of the Tasmanian Devil population throughout much of the state.

Before the Tasmanian Devil population experienced severe decreases in abundance due to the facial tumour disease, it is thought that this species may have been a factor in preventing foxes from gaining a foothold in Tasmania. Foxes have been released in the state since 1864 but the Tasmanian Devil may have held any foxes in the Tasmanian environment in check by preying on fox cubs in the den (should fox breeding have occurred). However, this ecological control mechanism has now been thrown out of balance and the Fox Eradication Program and Tasmanian community are working together to locate and eradicate foxes before a permanent population becomes established in Tasmania. Initial estimates suggest that almost 50 species of birds in Tasmania will be potentially at risk from foxes—primarily those species that feed on the ground (such as rosellas and thornbills), nest on the ground (such as shorebirds) or nest close to the ground (such as fairy-wrens). Flightless species such as the Little Penguin and Tasmanian Native-hen would suffer considerable losses to their populations from fox predation, and raptors would also suffer from the decrease in the prey species on which they rely (as a consequence of foxes eating them).

Two questions must be considered regarding the fox eradication efforts: (a) is it too late for eradication of the fox from Tasmania; and (b) is eradication possible, given the size and terrain of Tasmania? Tasmania's landmass covers 6,852,000 hectares. The largest island where eradication of a large mammal (goat) has previously been achieved is Isabela Island in Ecuador (458,812 hectares). The eradication of the fox in Tasmania is therefore a great challenge, but one that would have significant benefits to Tasmania's diverse fauna, particularly its birdlife.

Top left:
The European Red Fox threatens to become established on Australia's largest island, Tasmania, also an identified Endemic Bird Area. Photo by Rohan Clarke.

Above, and top right:
Tasmania's endemic native-hen and Forty-Spotted Pardalote would be susceptible to predation from foxes if they establish in Tasmania. Photos by Chris Tzaros.

Does the size of islands matter?

Glenn Ehmke Birds Australia

How small is too small? There are certainly issues with population viability on small islands, but we should not be too quick to write off even tiny islands as viable long-term bird habitats. The entire world population of Campbell Island Teal (*Anas nesiotis*) and Campbell Island Snipe (*Coenocorypha sp.*) survived on single islets (both <30 hectares) of the New Zealand sub-Antarctic Campbell Island. Australasian Pipits (*Anthus novaeseelandiae*) were also stranded on tiny islets of this group, occupying less than 100 hectares. These three species were stranded on these tiny islets for more than 100 years until rats were eradicated from the main island in 2003. Since then, the teal have been re-introduced (from captive breeding) and snipe have recolonised; both are still endangered but are breeding on the main island, and pipits are in such abundance their numbers seem inestimable.

Can an island be too big?

Evidence is growing that island size may not be as much of a technical impediment for the eradication of some invasive species as previously thought. While some large islands are too big to feasibly consider pest eradication currently, the size of islands from which invasive mammals have been eradicated is increasing. Rodents are by far the most widespread invasive mammals on islands throughout the world and they are substantially more difficult to eradicate than ungulates (hoofed mammals) or cats. They are also among the most damaging invasive mammals for both seabirds and terrestrial species. There have been well over 250 rodent eradications on islands worldwide, but most of those have been small (<100 hectares); large islands have proven substantially more difficult. However, advances in technology and techniques have led to a substantial increase in the size of islands that have undergone successful rodent eradication. Campbell Island (at 11,000 hectares) is currently the largest island in the world to have had rodents successfully eradicated—Macquarie (which is slightly larger) will take that mantle if the current program outlined by Keith Springer (in this publication) is successful. Interestingly, these two islands are among the remotest places on earth, yet with increases in the efficacy of eradication methods, it is clear that eradication can be achieved even on large islands at the "ends of the earth".

Ridding weeds to help Little Penguins

Weeds can be a big threat to seabirds' survival, as discovered on Montague Island, off Narooma, in New South Wales. The highly invasive Kikuyu Grass (*Pennisetum clandestinum*) is a perennial grass that spreads by runners, and was introduced to Montague Island for control erosion. It has been found to have a significant impact on breeding Little Penguins by restricting their access into their nesting burrows: the birds become fatally entangled when they try to enter the burrow.

To combat this, a state government program has targeted the removal of Kikuyu from Montague Island by using intensively managed burns, and replacing it with native species. Scientific analysis has shown that the regular burning, which began in 2003, has saved an average of 380 Little Penguins each year.

Kikuyu also significantly restricts the number of Little Penguins, as well as Wedge-tailed Shearwaters and other burrow-nesting seabirds, which breed on five islands off Port Kembla; plans are underway to conduct a similar program on these islands.

Reference

Randall, R.P. (2002). *A Global Compendium of Weeds*. R.G. & F.J. Richardson, Melbourne.

Thanks to the Invasive Animals CRC and ABC news online.

Above:
Removal of Kikuyu grass has helped the survival of Little Penguins on Montague Island in New South Wales. Photo courtesy of Phillip Island Nature Reserve.

Biosecurity for island conservation

Andrew A. Burbidge
Conservation Biologist, Perth

Australia will continue to see the loss of island species and breeding populations as outlined in this report unless further invasions are prevented, or newly-arrived non-indigenous species are eradicated before they can cause major damage. Good biosecurity planning and implementation is the only way that the biota of islands can be protected from invasive species.

Biosecurity is based on an examination of infection, plus detection and eradication. Prevention of infection of pathways by which people, equipment, food and other goods are transported to islands is the key to stopping invasive species (or 'hitchhikers') from arriving on islands. Analysis of these pathways should result in quarantine barriers being developed to prevent infection, which in turn prevents arrival. Detection involves monitoring islands for invasive species, and early detection is often the key to developing effective eradication plans, as some eradication technologies, such as the use of toxins, can affect indigenous species.

Biosecurity must be everyone's responsibility, whether returning to Australia from an overseas trip, or visiting an island for recreation (including birdwatching). All commercial users of islands should be required to have biosecurity plans approved before the development occurs, as should scientific expeditions. The Quarantine Management System developed by Chevron Australia for the Gorgon Project on Barrow Island is currently the best example of a biosecurity system developed for a major project on an island. The New Zealand Department of Conservation and the Charles Darwin Foundation in the Galapagos Islands have both developed excellent island biosecurity systems, as has the Australian Antarctic Division to protect the sub-Antarctic islands it manages.

By and large, Australia does not have good island biosecurity systems in place. Many islands where developments are situated, attracting large numbers of visitors, have no quarantine at all. Thousands of island visitors are blissfully unaware that island quarantine is necessary to protect the values they wish to see; apart from increasing the risk of unwanted 'hitchhikers', this is a lost educational opportunity.

For the increasing numbers of people visiting islands by private boats, education and, in limited cases, legislation and permits are the best way to promote biosecurity.

Above:
Quarantine procedures for tourists on sub-Antarctic Campbell Island. Photo by Glenn Ehmke.

Important steps that can be taken by individuals are:

- **Keep your boat clean and check it before launching or leaving the mooring.** Don't allow soil, seeds and pests (or even native animals like geckoes and crickets) onto your boat. Maintain rat and mouse poison (wax blocks are best for damp places) in your boat and replace it every three months before it becomes unpalatable. (Ensure the baits are secured if small children board your boat.) Be alert for nests of ants, wasps, bees and termites on boats, and destroy them when they are found. The same rules apply if you are travelling by aircraft.
- **Check your clothing and footwear.** Before boarding a boat or an aircraft, check your clothes (including your trouser cuffs and socks) and footwear for soil and seeds, and remove any you may find. Backpacks and other similar equipment, particularly velcro, need special attention.
- **Check your food.** Ensure your food is free from pests and diseases and store it in insect-proof containers; avoid using cardboard boxes. Make sure that mice, cockroaches, crickets and spiders do not live in food containers. Separate bananas from bunches so that small animals cannot live in the nooks and crannies. Do not discard the seeds from fruit and vegetables on islands.
- **Store fishing and other equipment in pest-proof containers.** Spray containers with household insecticide just before the trip. Use residual (for example, permethrin-based) sprays in non-food areas, as they kill bugs that walk over treated surfaces for up to two months, depending on exposure to weather. Check that containers are free from soil and spider webs.
- **Bring your rubbish home.** Don't leave it on an island, don't bury it there and don't throw it into the ocean.
- **Use the sea for bodily wastes** where possible (salt water and sunlight quickly destroy harmful bacteria). Otherwise dig a deep hole (more than 30 centimetres deep) and cover it completely.
- **Don't take pets to islands.** Dogs and other pets can disturb or kill native animals. It is illegal to take dogs (other than guide dogs for the blind) into national parks and nature reserves.
- **Check** that your crew and guests are aware of these quarantine rules and follow them.

Too many birds, other animals and plants have been lost from islands due to invasive species. Australian policymakers and island managers are now in a good position to understand the cause of these losses and to prevent further losses, but action and vigilance are necessary if Australia is not to lose more of its island national heritage.

References and further reading

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Island biosecurity: Proposal for a national initiative

Mitigating the impact of invasive species is the key to the future of many of Australia's island ecosystems.

Between 70% and 95% of the world's terrestrial species extinctions have occurred on islands, and most of these were directly caused or facilitated by invasive species. However, these impacts can be prevented through quarantine or ameliorated through eradication or control. Island restoration after invasive species have been eliminated is possible, and history shows that successful actions on islands can provide the greatest benefits to biodiversity conservation with the least cost.

Island biodiversity is also under serious threat from another major driver of biodiversity loss—climate change—which will interact with biological invasions and other processes in complex ways. This effect has already been seen on Macquarie Island, where warmer winters were one of three contributing factors in the explosion of rabbit numbers. However, there is strong evidence that healthy ecosystems are resilient to the impacts of climate change. Management of invasive species, therefore, represents an effective way to help buffer resident communities from the impacts of climate change.

Recognising these important factors, a consortium, including Birds Australia, has prepared a proposal for a National Island Biosecurity Initiative. The initiative plans to build ecosystem health and resilience on Australia's islands through improved biosecurity.

Of the 8,300 offshore islands in Australia it is likely that most are directly subject to one or more Matters of National Environmental Significance under the EPBC Act. Thus the proposal encourages the Australian Government to take a leadership role in developing a nationally consistent approach and standards for the prevention of invasion, early detection and rapid eradication of organisms that threaten island ecosystems. The proposal has recently been presented to the Australian Government for consideration, and Birds Australia is advocating for investment. For an estimated cost of $1 million over three years, with matching resources from states and territories, the initiative could lay the foundations for an effective, national approach that would assist directly in the prevention of extinction of hundreds of threatened species and protection for globally significant populations of migratory species.

Taken from the proposal prepared by the Island Rescue Alliance. See: www.birdsaustralia.com.au/soab

Above:
Black Rats attack eggs and chicks, such as this blackbird nest in New Zealand. Photo courtesy of Nga manu Images.

The national context

Samantha Vine
Birds Australia

Top left and top right:
Macquarie Island is listed as critical habitat for the Grey-headed Albatross (photo by Aleks Terauds), and the Wandering Albatross (photo by Rowan Trebilco).

Middle:
The National Threat Abatement Plan for competition and land degradation by rabbits – 2008 contains actions relevant to bird conservation. Photo by Chris Tzaros.

There are many examples of species recovery on islands. In Birds Australia's *The State of Australia's Birds 2008*, the Gould's Petrel demonstrated that where species have been actively managed with well-implemented recovery plans, we are seeing great results. Recovery usually results from a combination of good science (to diagnose, address and adapt management to problems) and co-ordinated action by champions and the community. At the national level we have institutional frameworks in place that provide the foundation for this recovery, yet the bad news currently overwhelms the good. The following is a brief examination of the instruments, initiatives, and gaps in resources available to assist island bird recovery efforts.

Australian Government legislation, initiatives and developing policy

The EPBC Act

Australia's primary piece of National Environmental legislation, the *Environment Protection and Biodiversity Conservation Act* (EPBC Act) provides the policy framework for protecting matters of national significance, such as nationally listed threatened species and abatement of listed Key Threatening Processes. Large amounts of work have gone into developing a number of plans, but implementation has generally been limited, primarily due to a lack of resourcing.

Plans that may relate to birds on islands include:

- Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations—2006
- Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100,000 hectares—2009
- Threat abatement plan for competition and land degradation by unmanaged goats—2008
- Threat abatement plan for competition and land degradation by rabbits—2008
- Threat abatement plan for predation by feral cats—2008
- Threat abatement plan for the impacts of marine debris on vertebrate marine life
- Threat abatement plan to reduce the impacts of tramp ants on biodiversity in Australia and its territories—2006

The EPBC also provides for listing of habitat critical to the survival of threatened species, but to date the register has not been comprehensively developed. Currently three of the five listings are on islands:

EPBC Register of Critical Habitat

Diomedea exulans (Wandering Albatross)—Macquarie Island
Thalassarche cauta (Shy Albatross)—Albatross Island, The Mewstone, Pedra Branca
Thalassarche chrysostoma (Grey-headed Albatross)—Macquarie Island

A recent review of EPBC Act by Dr Allan Hawke has found that it needs substantial reform. Birds Australia is advocating for the government to adopt a package of recommendations to strengthen our environment laws and ensure that they are adequately funded and effectively implemented.

Caring for our Country

The 'Caring for our Country' program is the way the Australian Government funds environmental management of natural resources. It replaces the previous natural resource management initiatives and invests funds across six national priority areas. Business plans are produced annually and influence eligibility of potential projects.

No proposals were sought in 2010 for projects to address impacts of invasive species on small islands, as each new plan theoretically takes account of investment that has already occurred. Island biodiversity apparently received substantial investment through the 2009 business plan.

Although it is not inconceivable that an island bird project with on-ground works or community engagement component (or both) could not meet some of the other targets, Fraser Island and the Lord Howe Island group were the only islands specifically targeted by the Biodiversity and Natural Icons priority area in the 2010 business plan.

National Biodiversity Strategy

The Australian Government has recently been revising the National Biodiversity Strategy through the Natural Resource Management Ministerial Council. This strategy is due to be released once the ministerial council processes are complete. Birds Australia argues that the revised strategy will need to identify adequate resources to be properly implemented.

National Environmental Accounts

The *Assessment of Australia's Terrestrial Biodiversity 2008* stated that there are insufficient data to report on national trends in important aspects of Australia's biodiversity, including the conservation status of species. Accurate environmental information is needed to support decision-making. This year $18 million was committed to develop a National Plan for Environmental Information—a critical reform of Australia's environmental information base and a good first step towards a system of national environmental accounts. Birds Australia believes that the plan and ultimately the accounts need to include long-term bird data as indicators of environmental health.

National Environmental Research Program

In February 2010, Minister Garrett announced he would redirect current Australian Government environmental research funds into a biodiversity research grants program. This program is likely to fund three or four large groups to research emerging biodiversity issues across northern Australia, the Great Barrier Reef and Torres Strait.

NCCARF

The National Climate Change Adaptation Research Facility is a national interdisciplinary effort to generate the information needed by decision-makers and communities to manage climate change impacts. Thematic networks have developed National Adaptation Research Plans, which outline research priorities for the next seven years.

In addition, each state and territory has its own legislation that pertains to wildlife conservation, and has different funding streams that could be available to island bird conservation.

However, despite the efforts of many dedicated groups within the community, there are literally hundreds of projects left unfunded as national and state programs are over-subscribed—sometimes by over 10 times the available funds.

The take-home message is that substantially more resources need to be committed if we hope to recover island bird communities.

Cover photograph: Light-mantled Sooty Albatross adult on nest, Heard Island. Photo by Eric J. Woehler.

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Birds Australia

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