The State of Australia's Birds 2006

Invasive Species

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CONSERVATION THROUGH KNOWLEDGE

Invasive species: a species which, as a result of human activities, has established beyond its normal distribution or abundance and consequently may damage valued environmental, agricultural or personal resources

The State of Australia's Birds series presents an overview of the status of Australia's birds, the major threats they face and the conservation actions needed. This fourth annual report focuses on invasive species. Australia has hundreds of invasive plants and animals, both native and introduced. Some have been brought purposely, others hitchhiked. The majority simply took the many opportunities offered by human alteration of the landscape. Invasive species are considered to be the greatest threat to biodiversity after habitat loss; they also exact a massive toll on agricultural production. Some of the most abundant invaders compete with or prey upon native birds, or alter their habitat. Introduced predators, plants and competitors are conservatively estimated to contribute to the threatened status of some 95, 12 and 16 bird taxa (species and subspecies), respectively. Yet, invasive plants and animals may provide food and habitat for native birds in already degraded natural systems, and some native birds themselves become invasive.

In situations where threatened native birds require protection, strategies such as direct control or eradication and protection from the invader are useful on a small scale, such as on islands or at nest sites. However, the issues are often complex and require long-term, integrated management for effective, broad-scale environmental outcomes. The true environmental impact of invaders, their interaction with other threatening processes, the effectiveness of control of widespread pests and the level of control needed are poorly understood.

Often pest problems are the result of a general ecological malaise brought by human destruction of natural habitats and the systems that regulate them. In many cases, restoration and management of habitats offers the greatest hope of limiting the damage caused by invasive species. Biological control, and better targeted and more sustained control of invaders for environmental outcomes offer some hope. Importantly, it is the responsibility of all Australians to prevent further introductions, including more careful screening of plants for farm and garden, and to react quickly to quell new incursions.

Greater cooperation and uniformity in legislation and policy will be necessary before real progress in addressing pest problems can be made, for the social, economic and environmental benefit of the nation. Beyond that, it is inevitable that many of today's invasive species are likely to be dominant components of future landscapes: opportunistic species that prosper in a human-dominated environment with a pest and weed ecology.

Water Hyacinth provides a nesting platform for the eggs of an incubating Comb-crested Jacana, one of the few species to benefit from the highly invasive aquatic weed from South America, which is choking the life from this waterhole. Photo by **Graeme Chapman**

Key Points

Invasive species bring mixed news for Australia's birds. Our continent has an abundance of invasive species, some of which are harmful, some benign and many whose impacts are unknown.

Favourable news

- The Australian Government has identified a number of Key Threatening Processes, including a range of invasive species that impact on native birds, and is taking action to address them.
- There are a number of cases where invasive species and their impacts have been effectively managed to protect threatened birds, and there have been some eradications of invasive species from islands.
- Quarantine measures are in place at our borders and specifically for some important islands, and efforts have been made to prevent the spread of certain invasive species.
- Some new infestations of invasive species have been identified and eliminated.
- Some invasive plants provide food and habitat for native birds, and some invasive animals provide food for predatory native birds.
- Targeted control measures can be effective against some invasive species in situations where reinvasion is limited or environmental assets can be protected, provided surveillance and some measure of ongoing effort is maintained.
- Every Australian can help by being vigilant for new invasive threats and alerting authorities, making their yards invasive unfriendly, controlling their pets and becoming involved in threatened bird recovery efforts.

Unfavourable news

- Invasive species are recognised as a national problem, often requiring a cooperative response to their management and the management of a whole suite of interrelated environmental problems.
- For most invasive species, eradication is not currently feasible, and these species are likely to remain in Australia. Thus, any management will have to continue long-term and may ultimately be ineffective.
- According to *The Action Plan for Australian Birds 2000*, introduced predators threaten some 95 bird taxa. About one-quarter of birds listed as threatened nationally under the *Environment Protection and Biodiversity Conservation Act* are considered to be under threat, or potentially under threat, from predation or habitat alteration by just six invasive animal species.
- There is a need for risk assessments to be conducted on already imported exotic pasture grasses, not yet classified as 'weeds', and where necessary control imposed on their sowing and spread.
- Introduced pasture grasses are invading northern grasslands and woodlands, increasing fire extent and intensity, modifying and destroying native habitats.
- Applications to import potentially damaging invasive species continue to be made and accidental arrivals are an ongoing threat.
- Improvements could be made with respect to surveillance and early intervention to eliminate newly established infestations of invasive species.
- The Red Fox, recently introduced to formerly fox-free Tasmania, is apparently building in numbers in that State, posing a massive threat to the environment and agriculture. Efforts to eradicate it are proving difficult, but must not be abandoned; greater funding for eradication is essential.
- Rabbits are destroying Macquarie Island's fragile vegetation, causing erosion and exposure, which threatens its seabirds. Plans to control rabbits are stalled by funding disputes.
- Common Starlings have broken containment lines and have established populations in Western Australia; efforts are underway to eliminate them, but the task is daunting.
- Barbary Doves, potentially a highly invasive species, have become established in the wild since 1980—the first feral bird to establish in the Northern Territory—and no effort is being made to eliminate them.
- Habitat change will continue to favour some native invasive species.
- Some current pest control activities may ultimately be exacerbating pest problems.
- Some current control efforts are poorly targeted and have little or no environmental benefit.

Uncertain news

- The true environmental and economic impacts of invasive plants and animals, and their interactions with each other and other changes to the land, are poorly known and require further study.
- The effectiveness of many control efforts is unknown; assessment of effectiveness, including cost-effectiveness, should be a component of any control program.
- Not all of the 225 exotic bird species held in captivity have been assessed for their capacity to establish in the wild, and the security of high-risk birds seems inadequate.
- The impacts of climate change on the spread of currently and potentially invasive species are difficult to predict.
- Retention and restoration of a greater area of natural habitat is likely to eventually help to curb the self-spread of native invaders, but commitment to this goal is uncertain.

Introduction

SINCE 2003 BIRDS AUSTRALIA has produced an annual *State of Australia's Birds* (SOAB) report. The reports collate and disseminate information on trends in bird populations to inform Australians of the status of their birds and help bring about improved understanding and better management of the land for birds and other biota. They also provide feedback to the dedicated thousands who volunteer their time and skills to monitor birds. The first SOAB (2003) was an overview of the state of the nation's birds and the intention is to revisit those findings in 2008 to assess change. The interim reports address themes of national conservation importance to birds.

SOAB 2005 dealt with possibly the most severe challenge to Australia's birds—habitat loss and fragmentation—which is threatening a suite of woodland birds, predicted to face increased rates of population decline as remaining habitat patches age and erode. The report was launched at the Australasian Ornithological Conference in New Zealand and has been widely distributed and well received. Since then there has been a little good news. In the eastern States, clearing reforms are in place and the challenge will be to ensure that they bring about effective restoration and retention of remaining woodlands. In the north, grazing and fire management are priorities for woodland sustainability; these are linked to the spread of exotic pasture grasses, an issue also addressed in this report on invasive species.

Much of Australia's agricultural country continues to experience the cumulative effects of several years of below average rainfall. Ground cover, in particular, has suffered but lowered stocking rates have eased the situation somewhat. If rainfall improves there is the promise of improved conditions for birds, but also for invasive species, which are often the earliest to respond.

An invasive species is one that occurs and thrives outside its normal geographical distribution as a result of human activities. It may or may not be a pest, that is, cause damage to valued environmental, agricultural or personal resources. Invasive species include feral animals (including invertebrates), weeds, and introduced diseases and parasites (see p. 5 and lower box at right on p. 6). Not only can native birds suffer significant damage from invasive species, but they can themselves become invasive (see top, p. 6). There are hundreds of invasive introduced and native species, and they continue to increase, but only a few present a significant threat to the environment. Nevertheless, when they do have an impact, it can be devastating to the environment and the economy, and all but impossible to control.

Here we present examples of just a few of the issues and opinions concerning invasive species in Australia, particularly as they relate to birds. The problems are complex and the management options limited. Invasive species are widely regarded as second only to habitat loss as the greatest threat to birds. Yet, only rarely is the real impact of invasive species known. Further, the effectiveness of control actions against invasives is seldom measured in terms of the reduction in the environmental or economic damage caused; instead numbers of operations or animals or acres removed or treated are tallied, which may be unrelated to the degree of damage. Control can sometimes be well targeted, for example, where invasive plants or animals endanger rare birds, but a suite of interrelated threats may all require management action; dealing with one threat alone may simply exacerbate another.

A number of major invaders, such as foxes, cats, rabbits (see maps opposite), pigs and bees are so widespread that their eradication is not feasible, except from islands. Nor, in many cases, is their management likely to be fully effective in the long-term, except in very circumscribed areas where it can be sustained.

Threats to native birds are the primary focus of this report, but the agricultural impacts of invasive native birds and their management can also have environmental and ethical implications. And what of the dilemma presented by exotic birds in cities and urban centres, where they may do no significant damage to the natural environment—are they acceptable?

Not least, many of the ill-effects of invasive species are the direct consequence of human alteration of the land—the creation of artificial environments and loss, fragmentation and degradation of natural habitats—which facilitates the establishment and spread of the invaders. In the rangelands and more populated areas there is a trend towards loss of native habitat specialists, and their replacement (in abundance but not diversity) by native and introduced generalists favoured by human modification of the landscape. In such situations, attempts to control invaders are ultimately limited in their success, if not doomed to failure, unless natural habitats can be restored.

White-backed Woodswallow nests dug out by foxes; the light sandy loam makes digging easy. Unless the swallows find banks 1.5 m or so high they are at risk. Photos by **Graeme Chapman**

Introduced animals and plants

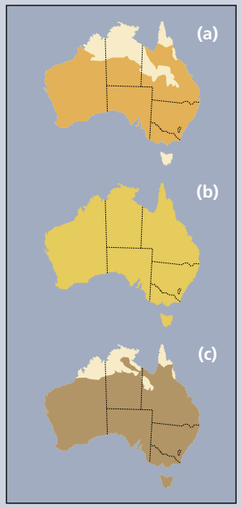
At least 80 introduced vertebrates (and many invertebrates) have established wild populations on mainland Australia. Some have become environmental pests that adversely affect bird populations by predation or competition; some also have potential to spread disease to wild birds. Few offer any benefits to native birds, the exceptions being fish that may replace depleted native fishes and several birds, rodents, rabbits, and similar feral animals consumed by raptors and other predatory birds.

There are over 3,000 weed species in Australia. Weed management is coordinated through the National Weeds Strategy under which a list of Weeds of National Significance (WONS) has been developed. These are 20 or so weed species such as Lantana, Bitou Bush, Blackberry, Salvinia and Mimosa, identified as already causing significant environmental damage; all of those currently listed have potential to spread further. The list does not include introduced pasture grasses such as Gamba, Para, Buffel, Mission and Grader Grasses, which are amongst the worst environmental threats. Some weeds have an adverse effect on birds, others enhance habitat for certain birds or provide surrogates for lost native vegetation in degraded areas. Many weeds go unrecognised for their environmental impact because by altering habitats their impact is often long-term and subtle. A Gamba-grassed plain looks infinitely more benign than a cat, but its impact on wildlife is often greater.

According to *The Action Plan for Australian Birds 2000* introduced predators threaten some 95 bird taxa; introduced competitors threaten the survival of another 12 species; and introduced plants threaten at least 16 species (almost certainly an underestimate given the insidious nature of the impact some invasive plants on wildlife).

About one-quarter of birds listed as threatened nationally under the *Environmental Protection and Biodiversity Conservation Act* are considered to be under threat from predation or habitat alteration by just six invasive animals (see graph)—all listed as Key Threatening Processes (see p. 28)—amongst other challenges to their survival. A few of these invasive, introduced mammals occur almost Australia-wide (see fox/rabbit/cat maps at right).

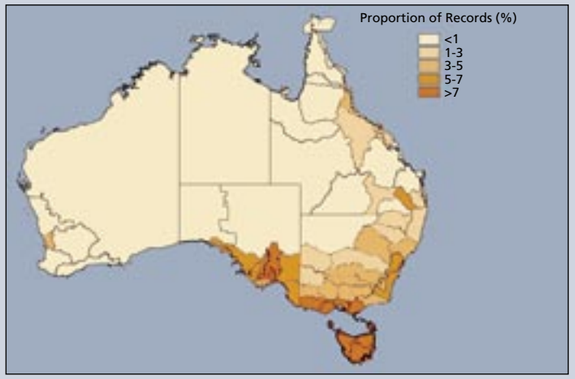
Introduced birds are most prevalent in more temperate parts of Australia, particularly around major centres of human population (see map below); many are commensal (i.e. dependent on humans and human habitats).



The main areas of invasion by the three greatest vertebrate threats to the environment: (a) fox; (b) feral cat; (c) feral rabbit, the populations of which are to some extent interdependent. Source: **Robley et al. (2004),** see p. 10.

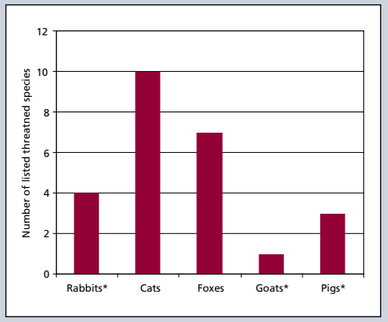
Introduced (non-native) vertebrate species that have established widespread populations on mainland Australia; the total number of established species is given in brackets. Additional species have established localised populations on the mainland or on islands. Based on Bomford and Hart (2002).

Mammals (25)	Birds (20)	Amphibians (1)
Feral Cat	Common Starling	Cane Toad
European Red Fox	Common Myna	
European Rabbit	Mallard	**Freshwater fishes (23)**
Black Rat	Rock Dove (Feral Pigeon)	European Carp
Brown Rat	Spotted Turtle-Dove	Mosquitofish
Feral Goat	Senegal Turtle-Dove	Mozambique Tilapia
Feral Pig	Common Blackbird	Weather Loach
Dingo/Feral Dog	House Sparrow	Tench
House Mouse	Skylark	Redfin Perch
Feral Horse	Eurasian Tree-Sparrow	Rainbow Trout
Feral Donkey	Nutmeg Mannikin	Brown Trout
Feral Buffalo	European Goldfinch	Goldfish
Feral Camel	European Greenfinch	Guppy
Feral Cattle		
European Brown Hare		



The proportion of records after 1997 in the Atlas of Australian Birds that were of introduced (exotic) birds such as the Starling, Common Myna and House Sparrow. These are averages across Natural Resource Management (NRM) regions—the Australian Government's units for regional investment in management of biodiversity and other natural resources. Greatest concentrations are near long-settled centres of human population and farming lands. Western Australia has managed to remain relatively free of introduced birds, but that is changing (see lower box pp. 18–19).

Australian White Ibis thrive in rubbish dumps and city parks; they have invaded cities and expanded their range into the south-west Western Australia and Tasmania. Photo by **Graeme Chapman**



The number of threatened bird taxa under confirmed or perceived threat from six widespread invasive animals, out of a total of 107 extant birds listed under the *Environment Protection and Biodiversity Conservation Act* (also see Table p. 28). *These species primarily threaten birds through the habitat damage they cause.

Two invaders: a native invasive species, the Crested Pigeon, has spread widely into farmlands, but is perceived as a benign invader. Here it finds a safe nesting place in an introduced invader, the spiny Boxthorn. Photo by **Graeme Chapman**

Water, clearing and pastoralism encourage a general increase and expansion in distribution of commensal species, such as Australian Magpie, Galah and Crested Pigeon, which replace woodland species across the landscape. The Crested Pigeon was originally a species of semi-arid and arid Australia that has spread to occupy much of the mainland; it is still spreading southwards in Victoria and south-east New South Wales. The map shows Crested Pigeon records in the Atlas of Australian Birds 1977–1981 (purple circles) and after 1997 (red circles).

Records after 1997 in the Atlas of Australian Birds showing the natural (purple) and introduced (red) distributions of the Superb Lyrebird. There are concerns that 'earthworks' by this seemingly benign Australian icon may alter Tasmanian forests.

Translocated and self-spreading native birds

Native species can become invasive when they increase their natural range or abundance because of human alteration of the landscape, or when they have been deliberately introduced to places where they do not naturally occur and establish wild populations. Examples of 'successful' deliberate introductions include: Crimson Rosellas to Norfolk Island; Laughing Kookaburra, Red-browed Finch, Long-billed Corella and Rainbow Lorikeet to Western Australia; Gang-gang Cockatoo to Kangaroo Island and Australian Brush-turkey to South Australia; Scaly-breasted Lorikeet to Victoria; Laughing Kookaburra and Superb Lyrebird (see map at lower left) to Tasmania; and Masked Owl to Lord Howe Island. The greatest numbers of translocated species occur in Tasmania and the south-west of Western Australia—both are centres of human population isolated by natural barriers from the rest of Australia.

At least two of these translocated species have become serious threats to local birds: Masked Owls introduced to Lord Howe Island to control rats prey on the endangered woodhen, and Crimson Rosellas exclude endangered Green Parrots (aka Red-crowned Parrakeet) from nest holes on Norfolk Island. Other species have become serious economic pests of forestry and agriculture and compete with local species for scarce tree hollows. There is even concern that, by scratching over large amounts of leaf litter, soil and rocks, lyrebirds may be altering the Tasmanian forests they have invaded.

A great number of native species have changed in distribution and abundance since European settlement; some are considered invasive and some are viewed as environmental, social or economic pests. Galahs, Little Corellas, Australian Ringnecks, Pied Currawongs and Noisy Miners are just some of the more noticeable examples; they continue their expansion and may prey upon or exclude local species from habitat or nest holes. The Cattle Egret (self-introduced to Australia) and Crested Pigeon (spreading coastwards in south-eastern Australia; see map top left) seem more benign.

The Australia Magpie isn't generally thought of as an invasive species, yet it is super-abundant in our cities and farmlands and has established in New Zealand. Photo by **Michael Weston**

Exporting potential pests

One country's export is another's import, and one country's native bird can be another's pest. Australian birds have caused their share of problems overseas. For example, in New Zealand, Rainbow Lorikeets compete for hollows with native birds, and Australian Magpies create a hazard for aircraft among other difficulties. The risk of establishment of Australian species in other countries needs to be carefully considered in applications to export birds. Calls to export pest species such as cockatoos continue and often disregard the risk that they will establish feral populations overseas.

Hitching a ride: hidden introductions

Recent seizures by the Department of the Environment and Heritage of exotic parrots that were suspected to have been illegally imported, or were the progeny of birds that had been illegally imported, have highlighted the risk of introducing new virulent diseases to captive and wild native Australian birds. This risk is of particular significance to recovery efforts for critically endangered species such as the Orange-bellied Parrot (OBP).

Early in 2006, at a captive-breeding facility, the death of 43 of 62 OBP chicks destined for release raised concerns that an exotic disease was involved. Despite testing, the cause remains a mystery, although a type of avian herpes remains a possibility, and the colony is being kept quarantined. The control and management of diseases in the captive OBP population, and the risk of transfer of disease from introduced species, have been identified as high priorities for preventative action. They have been addressed through the establishment of draft quarantine protocols for the housing of seized exotic parrots and draft hygiene protocols for the prevention and control of diseases, particularly beak and feather disease, in Australian birds.

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Hope for the future: a tiny Orange-bellied Parrot chick, one of only a few hundred individuals of the species that remain. An unknown disease killed 70% of this year's captive crop bred for release to the wild. Photo by **Jon Starks**

Pigs destroy wetland habitat for waterbirds. Photo by **Rohan Clarke**

Invasive Species as Habitat Modifiers

Invasive species can alter bird habitats in a variety of ways, making them unsuitable or less productive for some of the native birds they support, and facilitating the invasion and/or unnatural increase of others. Grazing and trampling by livestock and feral rabbits, goats, buffalo, horses and pigs alter bird habitats, both terrestrial and aquatic; they change vegetation structure and composition and expose native birds or their nests to increased risk of predation.

Few, if any, Australian ecosystems are untouched by weeds. Introduced plants, such as Buffel Grass and Salvinia, can choke out native plants and animals and alter ecological processes (see below). On tidal mud flats in south-eastern Australia, Cord Grass threatens to diminish feeding habitat of internationally significant communities of wading birds by converting mud flats into grassland. The highly invasive Tamarisk tree has spread along several hundred kilometres of the Finke River, reducing native bird, reptile and plant diversity. These are just a few of many examples. Alternatively, in degraded habitats, invasive exotic plants can provide much needed bird habitat—food, shelter and nesting places—and assist regeneration. Native plants can become invasive where natural grazing and fire regimes are disrupted (see p. 9 at lower left) or where they are deliberately planted away from their original habitat.

Pandora's box: the spread of exotic pasture grasses

We can now look back and see myopia and folly in the actions of the Acclimatisation Societies of the late nineteenth century that introduced to the unhomely Antipodes such familiar species as sparrows and starlings, foxes and cats, blackbirds and gorse. We can wonder at the startling self-interest and lack of concern of those who, with care and enthusiasm, introduced Cane Toads to Queensland in the 1930s. We can think that this recklessness was a feature of an earlier less enlightened age and that actions we might take now would be more responsible and not trouble generations hence.

But if we have learnt any lessons from these mistakes, we remain uncertain and irresolute about applying them. Perhaps the worst legacy we will leave is the establishment across much of Australia of exotic pasture grasses, courtesy of the current deliberate spread. While most people would recognise that toads or foxes are un-Australian (and 'nasty'), a landscape changed from Australian grasses to exotic ones may go unnoticed or seem relatively benign.

Since European settlement of Australia, there has been an understandable urge to increase the productivity of this largely infertile continent. This objective has been addressed in many ways, but probably the most pervasive has been the attempt to transform the native vegetation and landscapes into pastures dominated by grasses from other continents, particularly Africa, South America and Asia. In a recent paper, CSIRO researchers Garry Cook and Lesley Dias have chronicled the campaign by pastoralists, pastoral agencies and agricultural scientists to replace native vegetation with exotic grasses across much of the continent. Cook and Dias have documented thousands of introductions, including a greater number of exotic grass species than constitute the entire Australian native grass flora. For the rangelands of northern and central Australia, this campaign largely started in the 1950s, and has continued apace.

There is nothing inherently wrong with African or South American grasses. But there is a problem when these grasses are transplanted to Australia. This is exacerbated when the qualities most sought are as follows: capable of rapid spread, of producing relatively large biomass and of out-competing existing plants; can occur across many environments and with wide climatic ranges; have high reproductive output; and can withstand grazing at high stocking levels. Many of these are the qualities that characterise weed species, and indeed the history of pasture plant introductions to Australia is notable for producing more weeds than beneficial species.

In the rangelands of northern and central Australia, the exotic pasture plants of most environmental concern are Gamba, Para, Buffel, Mission and Grader Grasses and Olive Hymenachne. Many of these species (and particularly Gamba, Buffel and Mission Grasses) are capable of producing fuel loads far higher than those of native grasses. In these fire-prone environments, such fuel loads support fires with an intensity up to 10 times greater than in native vegetation: hence, the impacts and extent of these fires are now on an unprecedented scale.

Society may perhaps reasonably countenance the collateral environmental damage caused by exotic pasture grasses as part of the recognition that lands allocated to pastoralism should be managed primarily to maximise pastoral productivity. But, (i) the exotic pasture grasses generally do not stay contained within the paddocks in which they were first sown, indeed most spread widely, becoming particular pests on Aboriginal and conservation lands, where the relative lack of grazing animals means that their impact is magnified; (ii) these grasses do not necessarily increase pastoral production in the long-term and once widely established are all but impossible to remove; and (iii) a very high proportion of lands (for example nearly 50% in the Northern Territory) in the rangelands is allotted to pastoralism, such that some native species and habitats occur nowhere else other than on pastoral lands.

Pandora's box cont.

While there are national standards and constraints (including weed risk assessment protocols) on the direct importation of plants from overseas, this does not pick up the many thousands of exotic plant species and cultivars that are already here. In most cases, there are no national standards or regulations for the continuing deliberate spread of these plants, and little consistency between States in their management. The exception is when an exotic pasture grass is declared as a weed, but by that stage it is often too late. Retrospectively, we can see a recurring pattern: an exotic pasture species is introduced, widely planted, found to be more detrimental than useful, and ultimately recognised as a weed that should be removed.

If these exotic grasses support a rich biota in Africa or South America, why should we worry about their spread here? The answer should be obvious, that our Australian birds (and other biota) have adapted to the complex and nuanced set of resources offered by Australian plants in natural landscapes. For example, Gouldian Finches depend upon the sequential availability of seeds from across a local spectrum of native grasses. Where any species in this set of grasses is diminished, that continuing sequence may be interrupted and the finch population becomes unviable. Although much remains to be investigated, a series of recent studies has demonstrated that the spread of exotic grasses may generally lead to reduction in the diversity of native plants, an increase in fire severity (with consequential changes in vegetation characteristics), and changes in the composition and availability of resources for birds. Particularly in wetlands, exotic pasture grasses may also choke the landscape, reducing access to foraging sites for a broad range of birds. These problems are becoming apparent as the exotic grasses spread. On current trends that spread will continue inexorably, and the problems we see now will be greatly magnified in decades to come.

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Further reading

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Lonsdale, WM (1994) Inviting trouble: introduced pasture weeds in northern Australia. *Australian Journal of Ecology* 19: 345–354.

Low, T (1997) Tropical pasture plants as weeds. Tropical Grasslands 31: 337–343.

Rossiter, NA, Setterfield, SA, Douglas, MM & Hutley, LB (2003) Testing the grass-fire cycle: alien grass invasion in the tropical savannas of northern Australia. *Diversity and Distributions* 9: 169–176.

Top: A (juvenile) Crimson Finch, one of several granivorous species that may be declining across northern Australia. The proliferation of rank exotic grasses, such as Gamba Grass, to some extent replaces native habitats favoured by the finch but destroyed by livestock, feral pigs and other threats. However, the exotic grasses form monocultures that are biologically impoverished, do not replicate the natural sequence of seeding of native grasses, and produce much fiercer fires. Photo by **Graeme Chapman**

Above: Exotic pasture grasses are spreading across northern woodlands and savannas altering habitat for birds and increasing the extent and severity of fires. Black Kites reap a temporary harvest of small animals fleeing the flames. Photo by **Nicholas Birks, Wildflight**

Rabbits and their predators

Rabbits were introduced to Victoria in 1859, and within 100 years had spread across all but the far north of the continent. They stripped the land and dramatically changed the vegetation. Few native plants and animals would have been unaffected by such gross changes to their habits, and they remain so, but some predatory native species such as the Wedge-tailed Eagle benefited from the abundance of a meaty, perfectly-sized, relatively easily captured animals (which replaced similarly sized native mammals that earlier had gone extinct).

The myxoma virus was released in 1950 and is still helping to keep the lid on rabbit populations, particularly in wetter areas, as is the recently (1995) introduced Rabbit Haemorrhagic Disease (RHD), which is more effective in drylands. RHD has freed some drier areas from high densities of rabbits allowing, for example, regeneration of seedling trees on the barren ridges in the Mulga near Broken Hill, but not in the lower country where sheep graze. In the wake of the virus, predators of the rabbit, such as foxes and Wedge-tailed Eagles, have declined in these localised areas, but are unaffected where there is sufficient alternative prey or pockets of rabbits to sustain them. The long-term prognosis is that the virus will become less effective over time and it is anticipated that rabbit populations will recover more rapidly where eagles and other predators are scarce. Hence, vigilance is necessary and the opportunity should not be missed to keep rabbit densities low by integrating other control methods.

A cascade of threats: *Pisonia* fruits and Gould's Petrel

The introduction of rabbits to Cabbage Tree Island—a 30 ha island offshore from the entrance to Port Stephens, New South Wales—in 1906 severely degraded the primary nesting habitat of the endangered Gould's Petrel, removing the understorey and exposing the petrels to avian predators. Rabbit grazing also prevented regeneration of the rainforest canopy and allowed invasion by exotic plant species. In 1990 the petrel breeding population was about 122 pairs, 25–30% of numbers recorded in the 1970s. Entanglement in the sticky fruits of the introduced Bird-lime Tree and predation by Pied Currawongs and Australian Ravens were imposing a rate of adult and nestling mortality that was unsustainable. The removal of Birdlime Trees in the area of the colony and control of currawongs allowed a rapid increase in the number of breeding birds and the number of young fledged, such that the number of pairs had recovered to 426 in 1995. Rabbits were eradicated by 1997.

Further reading

Carlile, N & Priddel, D (1995) Mortality of adult Gould's Petrels *Pterodroma leucoptera leucoptera* at the nesting site on Cabbage Tree Island, New South Wales. *Emu* 95: 259–264.

Feral Fallow Deer amongst phalaris, both invasive species that can profoundly alter native habitats. Fallow Deer have established populations in eastern Australia. They have potential to become significant pests and should be removed before they spread further. Photo by **Peter Merritt**

Proliferation of native scrub

'The overstocking of the country, coupled with the rabbits, prevented the growth of grass to anything like its former extent, and so caused a cessation of bushfires, which had formerly occurred periodically, and so afforded the noxious scrub a chance of making a headway.'

Royal Commission (1901), quoted in Noble (1997).

Proliferation of native scrub has long been a problem, particularly in semi-arid areas. Brigalow, White Cypress, Hopbush and Turpentine are just a few of several shrubby native species that have increased in density and distribution within their natural range, generally linked to overgrazing and decreased fire frequency and extent since Europeans took over management of the land. In the case of White Cypress, ring-barking and clearing of eucalypts and a series of wet years that encouraged germination appear to be the cause; extinction of some of the native mammal grazers of young cypress pine, such as the Bettong, may also have contributed. Fire sensitive species such as Cypress Pine and other plants unpalatable to livestock spread into grasslands converting vegetation mosaics into extensive, unproductive monocultures of pine. In such landscapes, grassland birds can be disadvantaged and replaced to some extent by woodland insectivores.

Restoration of mosaics rather than wholescale eradication of the scrub is usually the recommended management option and will benefit birds and production. This can be achieved by systematic strategies to control grazing and allow some fuel build up for prescribed fire, promotion of larger properties and acceptance of some scrub, and restoration of a greater diversity to the landscape.

As with all native invaders, in their place these woody species are a valuable part of their ecosystem. A further paradox is that Brigalow is an endangered ecological community.

Further reading

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The sign flags a control program for Kikuyu, an African grass introduced to Lord Howe Island where it smothers Flesh-footed Shearwater (muttonbird) breeding habitat. Photo by **Michael Weston**

Invasive Species as Predators

Foxes, cats and rats are the main introduced predators to Australia. It is often said that foxes cause greater damage to wildlife than cats; pointing to the lack of extinctions in Tasmania and on Kangaroo Island, where there have been cats but no foxes for the past 200 years, in contrast to the mainland. However, the evidence rests on mammal extinctions and may not apply to birds. Certainly, cats on some (fox-free) islands have had a major impact on birds, as they can have in 'islands' of habitat on the mainland.

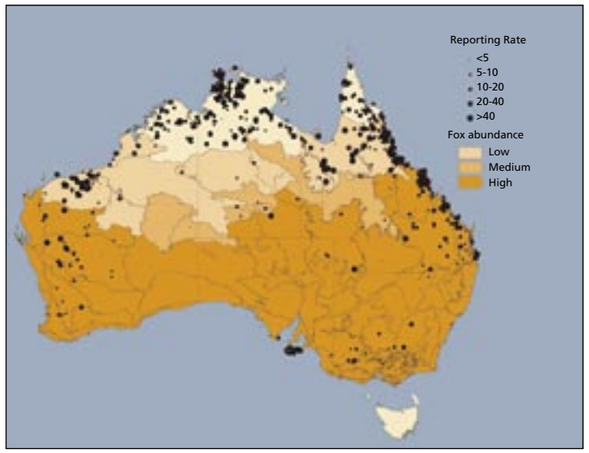
Nobody doubts that introduced predators such as foxes and cats kill a multitude of birds throughout Australia, and diet studies yield long lists of species consumed, but this is not evidence for impact on populations (see p. 12). Birds on the Australian mainland have evolved with a suite of clever predators and a certain level of predation is natural, even necessary. To an unknown extent introduced mammals replace native mammalian hunters of birds, most of which are extinct. However, this should not be cause for complacency. Where native birds are in low numbers, or have evolved in the absence of mammalian predators, predation by introduced mammals can be devastating. Ground-nesters are most at risk from foxes (see Bush Stone-curlew map at right; also lower p. 29), but cats, in particular, can climb to tree nests (see p. 13).

Island birds have been less fortunate than those on the mainland. Island bird faunas are often naïve to mammalian predators and have low rates of breeding that do not allow for much mortality from predation. Cats, rats, pigs and ants threaten several birds on Australia's islands, such as Christmas, Norfolk and Lord Howe (see pp. 11 and 28). The recent willful introduction of foxes to Tasmania gives cause for great concern (see Preventing Invasion section).

In urban areas uncontrolled pet cats and dogs operate as invasive predators (see p. 12).

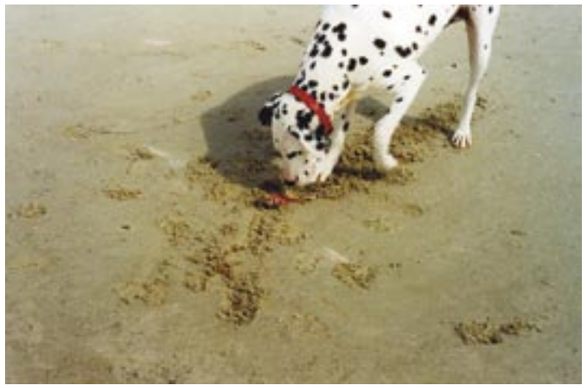
An increase in predators may put pressure on prey species, regardless of whether the predator is native or introduced. For example, predation by increasingly abundant Pied Currawongs has been implicated in the decline of native bush bird populations and Silver Gulls, an exceptionally abundant species that exploits even the most inland of wetlands and preys heavily upon the eggs and chicks of colonially breeding birds such as Banded Stilt. But as yet, there is no evidence that any of these native invaders cause population declines in their prey (see p. 22). This may sound unlikely, but common species can be remarkably resilient.

Predators interact with each other as well as with their prey populations and this has implications for their impact and control. Dingoes are thought to suppress fox populations, and cat populations can be kept in check by foxes. For example, both cats and foxes prey on rabbits. Typically, when rabbit numbers are high, so too are foxes, but cat numbers are suppressed. When rabbit populations crash fox numbers do also, but cats remain relatively stable. This is because cats are less dependent on rabbits and more easily increase their take of other prey such as native birds and reptiles. Hence, control of foxes alone is likely to result in an increase in cat numbers and their impact on birds. Similarly, the broad-scale dingo/wild-dog control undertaken in most States is likely to be substantially increasing the abundance of foxes and feral cats, to the detriment of conservation and lamb production.



Foxes' greatest impact appears to be on ground-nesting birds, such as the Bush Stone-curlew. The Bush Stone-curlew was once numerous across much of the mainland, except the arid inland; although groundcover changes are also involved, it has declined dramatically where there are foxes. Where foxes are absent, such as on Kangaroo Island, or at low densities, such as across much of the north, the stone-curlew is reported much more frequently. The graph shows the Bush Stone-curlew reporting rate and the distribution of the fox (hatched area). Reporting rate is the number of surveys during which the stone-curlew was recorded as a percentage of all surveys in that 1-degree block, extracted from the Birds Australia Atlas of Australian Birds; fox distribution is from Environmental Resource Information Network, Department of the Environment and Heritage (Robley et al. 2004).

Pets or pests?: uncontrolled domestic pets can be the most abundant introduced predator in some areas, such as on southern Australian beaches, where this dog has destroyed a Pied Oystercatcher nest. Photo by **Priscilla Park (Birds Tasmania)**



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Rats and seabirds

Three species of introduced rat (Black Rat, Brown Rat and, to lesser extent, Polynesian Rat) prey upon the eggs and chicks of numerous species of albatross and petrels. On Macquarie Island, Black rats inhabit the tussock grasslands utilised by most albatross and petrel species, and opportunistically prey upon eggs and unattended chicks, principally of the smaller burrowing petrels. Black Rats also occur on Lord Howe and Norfolk Islands. They are thought to have contributed to the loss of Kermadec Petrels, Little Shearwaters and White-bellied Storm-Petrels from Lord Howe Island, and Little Shearwater from Norfolk Island.

Localised control programs for rats have been running on Macquarie, Norfolk and Lord Howe Islands for a number of years but the nature of the terrain and vegetation and the size of the islands has meant that a permanent solution—eradication of rats—has not been attempted.

It is essential to protect seabird populations on adjacent offshore islands and stacks which currently free of rats by maintaining strict quarantine requirements for all visitors and workers.

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Above: The Lord Howe Island Woodhen population stand at just under 200, up from less than 30 in the 1970s as the result of the control of invasive species. Photo by **Ian Hutton**

Below: Invasive species interact with each other and with native species—here a cat struggles to carry a large rabbit. Both are watched by hopeful scavenging ravens and a magpie. Photo by **Nicholas Birks, Wildflight**

Pigs and Lord Howe Island Woodhens

Pigs and goats were introduced to Lord Howe Island for food and later went wild, causing extensive vegetation and habitat changes. By the late 1970s there were less than 30 Lord Howe Island Woodhens left, confined to the summit of the island's two mountains, Mount Gower and Mount Lidgbird. Because the pigs did not occur at these heights, through their predation and destruction of habitat, pigs became the prime suspect in decline of the woodhen population.

In 1980, a captive breeding program was initiated with three healthy pairs of woodhens brought down from Mount Gower by helicopter. They began laying eggs a few weeks after arriving and by late 1980 15 healthy chicks had hatched.

In 1981, two pairs of the captive-bred birds were released in an area under the cliffs of Mount Gower, identified as the best site for a new woodhen colony. The birds survived and by 1984, 82 woodhens had been released and the breeding facility was closed.

Meanwhile, feral pigs and cats were eradicated, the feral goat population was significantly reduced, and domestic cats were phased out. The population of woodhens reached over 200 in 1997. Although it has declined somewhat since, the birds are again living in many parts of the island, including residents' backyards.

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Like most invasive animals foxes are bold and adaptable. They eat almost anything organic, from small to medium-sized birds and mammals to insects, fruit and carrion. Here a fox defends the remains of a kangaroo from ravens and a Wedge-tailed Eagle. Photo by **Nicholas Birks, Wildflight**

Cats and birds: management begins at home

The time of arrival of cats in Australia is often debated, but the current view is that they arrived and established widespread feral populations after European colonisation in 1788. Now domestic and feral cats are widespread; feral cats are found across the continent, in all habitats, and on many offshore islands. Their spread and colonisation of the continent was probably facilitated when large numbers were released in parts of western New South Wales in the 1860s in a vain attempt to control an outbreak of rabbits, and again, on the Nullarbor, in the early 1900s. The principal period of invasion of the arid zone appears to have been the last decade of the 19th century and the first of the 20th.

Records of the prey items brought home by domestic cats and examination of stomach contents of feral cats provide a phenomenal inventory of the species of Australian animals that are vulnerable to cat predation. At least 212 species of birds, 64 mammals, 87 reptiles and 7 amphibians as well as various invertebrates are taken. The majority of cats' prey items are less than 200 g in body mass, but they will capture prey up to their own body masses (3–4 kg). A wide variety of bush birds, as well as waterbirds and seabirds, are included in these inventories. But these inventories do not provide a firm basis on which to assess the extent to which predation by cats threaten native species.

The average numbers of prey collected by populations of domestic cats in Australia ranges from five to 32 items per cat per year, about 25% of which are birds. In urban areas there are at least two cats per hectare, so these figures suggest domestic cats harvest a minimum of 10–64 vertebrate prey items per hectare, which includes up to 15 birds per hectare per year, a high proportion of the bird population in urban areas. This is likely to be an underestimate since not all prey items will be brought home for cat owners to document.

Estimates of the numbers of prey and densities of feral cats are much harder to obtain. Home ranges of feral cats are typically in the vicinity of 2–10 km^2 but, because of overlapping home ranges, densities are probably in the vicinity of 0.3–1 feral cat per km^2 or 0.003–0.1 feral cats per hectare. Assuming feral cats consume about 1000 prey items per year (in areas where rabbits are plentiful it will be much less than this), feral cats may crop about 3–10 prey items annually per hectare. Thus a free-ranging domestic cat population is likely to exert a much higher predation pressure on fauna in urban areas than feral cats do away from urban areas. There is a good reason for this. Owners provide their cats with food and so uncouple domestic cats from the vagaries of a fluctuating food supply so that they can potentially take fauna at a rate that is unsustainable. Feral cats on the other hand must contend with fluctuations in their food supply and their population densities are ultimately limited by prey availability. When one prey species becomes scarce, feral cats are likely to switch to another or to be forced to move to other areas.

The extent to which cats have contributed and continue to contribute to extinctions of Australian fauna will always be debated. Nonetheless, attempts to re-establish populations of regionally extinct fauna, particularly small to medium-sized mammals, have largely failed, except where exclusion fencing is used, because of an inability to eliminate feral cats by other means. Unlike foxes, feral cats are not easily baited. Developing attractive cat-specific baits or biological control may provide some hope, but these must be humane and the domestic cat population must be protected and appropriately managed.

The first step in developing an Australia-wide program to control feral cats starts with managing domestic cats. Domestic cats make great companion animals and some simple actions can greatly improve their welfare and also prevent them from hunting urban wildlife. Desexed cats live longer on average, and tend to stray less, so desexing is beneficial and prevents over-production of kittens. Providing identification to cats (either a disc on a collar or a microchip) helps authorities identify owned cats and return them to their owners, which is of benefit to both the cat and the owner. The common ploy of placing bells on a cat's collar to prevent it from hunting, however, is limited in its effectiveness—cats with bells can still hunt successfully. Containment is the only action that prevents them from hunting. Domestic cats can be kept indoors without hardship and owners should be encouraged to provide them with a stimulating inside environment, perhaps extending to an enclosed area outside. This not only prevents owned cats from killing but stops them roaming, so they cannot spray, defaecate or fight on neighbouring properties or run the risk of being hit by a car, all of which is good for the welfare of the cat and for neighbourly relations. In this way, cats can be appreciated for the great companion animals that they are, without contributing to the loss of Australia's wildlife.

BY DAVID PATON *and* DANIEL ROGERS, *Adelaide University, South Australia*

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Cats and cockatoo chicks

The extent of damage that feral cats cause to native birds in Australia is largely unknown. However, it should not be assumed that large size or nesting in tree hollows provides protection from predation. The Western Australian wheatbelt form of the Red-tailed Black-Cockatoo weighs over 650 g and nests in hollows in trees, yet it is subject to predation by feral cats. Between 1975 and 1980, CSIRO Division of Wildlife Research undertook a study of its ecology. The breeding biology was studied on several patches of woodland around Nereeno Hill, near the town of Three Springs in the northern wheatbelt. During that period 428 nesting attempts were monitored. Of these, at least 31 (7%) were known to have failed because of predation on chicks by feral cats. The worst season was the spring of 1978 where 10 (17%) of the 58 nesting attempts failed because of cat predation. Predation was confirmed as the cause of death by the presence of cats in nest hollows with the remains of freshly killed chicks and/or fresh cat scratch marks on the sides of trees leading to the hollows where chicks had been taken.

BY DENIS A SAUNDERS, *Weetangera, ACT*

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Left: A gull with evil intent harasses nesting Banded Stilts. In parts of Australia Silver Gulls have become superabundant because they benefit from the changes wrought by humans; their increased numbers sometimes pose a significant threat to populations of other ground nesting birds. Photo by **Graham Carpenter and K Belchambers**

Below: Even domestic cats can harm wildlife such as this beach-nesting Hooded Plover. Photo by **Michael Weston**

The hybrid offspring of a cross between a rare Black-eared Miner and a common Yellow-throated Miner at Birds Australia's Gluepot Station; alteration of habitat has brought the two into contact. Photo by **Graeme Chapman**

Invasive Species as Competitors

Some invasive species compete for resources with non-invasive species. These resources may be food or breeding sites, roosts or space. Competition for food has not been well studied, though it has been suggested, for example, that introduced bees compete with nectar-feeding birds (see pp. 15 and 16) and feral goats, sheep and rabbits compete with Malleefowl. Introduced seed-eaters such as doves, sparrows and finches, could compete for seed with native granivores such as the Orange-bellied Parrot. The critically endangered parrot forages on saltmarsh in coastal south-eastern Australia, where large numbers of introduced Gold and Green Finches and House Sparrows also feed (see graph below). In 72% of surveys during which an Orange-bellied Parrot was recorded, at least one other introduced species was also present and then usually in greater numbers. In Queensland, competition from the introduced Nutmeg Mannikin has been blamed for declines in the Chestnut-breasted Mannikin, Zebra Finch, Double-barred Finch and Red-browed Finch.

However, co-occurrence and similar dietary composition does not always lead to intense competition. For example, the Kelp Gull, which apparently established in Australia in the 1940s, may eat the same food types as the endemic Pacific Gull, but eats them in different proportions and apparently prefers to forage in different habitats. A study of Common Mynas in Melbourne showed that although they were aggressive to other species 0.8 times per hour, they were not considered to be excluding other birds from food resources (also see top, p. 22).

Competition for breeding sites is well known for hollow-nesting species. Studies have found that mynas occupied up to 37% of hollows in urban ACT and starlings occupied 21% of hollows in a section of riverine woodland in South Australia. Around Alice Springs, Rock Doves nest in tree hollows along the Todd River. The feral honeybee occupied 1–8% of hollows in various parts of Victoria, and can even displace large birds such as Tawny Frogmouths. Invasive native birds and mammals (e.g. Brush-tail Possum) add to the competition (see top p. 15 and Rainbow Lorikeet and starling/myna maps opposite), which is exacerbated by the limited supply of this critical resource. Nonetheless, some of these species use different types of tree holes and, although it is often suspected, such competition has seldom been demonstrated to be a threat to entire species (e.g. see pp. 15 and 22).

One insidious form of competition is at the genetic level, where invasive species hybridise with other species, and their genes effectively compete with the endemic ones. The introduced Mallard sometimes hybridises with the endemic Pacific Black Duck, which, despite this, remains common in Australia (though hybridisation is a significant threat to the species in New Zealand). The alteration of habitat in the Mallee of South Australia and Victoria is thought to have brought the common Yellow-throated Miner into contact with the threatened Black-eared Miner, and subsequent hybridisation threatens one of Australia's most endangered birds.

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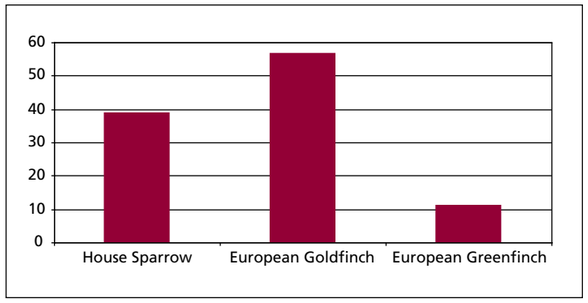
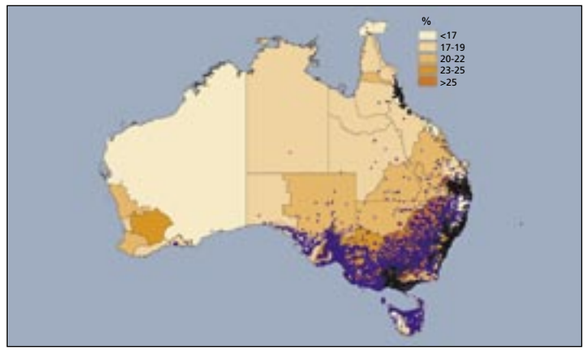
Introduced food competitors occur at most Orange-bellied Parrot locations. The graph shows the occurrence of three introduced granivores recorded on the surveys during which Orange-bellied parrots were recorded.
Source: Atlas of Australian Birds.



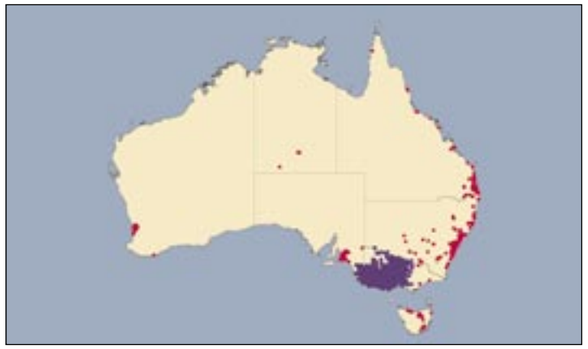
Competition for nest holes

Galahs and introduced Long-billed Corellas are extending their range in the West Australian wheatbelt. Earlier breeding and more aggressive natures allow them to oust Carnaby's Black-Cockatoos (Short-billed Black-Cockatoo), Muir's Corella (southern Western Corella) and other endangered local species from their traditional nest hollows. While habitat through clearing and resulting deterioration of remaining woodland fragments is the cause of the cockatoos' declines, such competition may prove to be the straw that breaks the camel's back.

Little Corellas have spread greatly as natural landscapes are turned to farmland; the corella competes for scarce nest holes with other native species and is an agricultural pest (see pp. 20–21). Photo by **Lynn Pedler**



Starlings and mynas potentially compete with native species for tree holes. In the east, both species, particularly the Starling, occur in regions with high numbers of species dependent on tree holes to breed. The percentages of Atlas of Australian Birds records since 1997 that are of hollow nesting species, averaged across NRM regions, are shown on the base map, with the distribution of two tree hole usurpers, the Common Myna (black circles) and Common Starling (blue circles) overlaid.



Not only are they increasing in abundance in many cities, but Rainbow Lorikeets have established in south-western Australia, thanks to transportation and artificial feeding by humans. Bigger and markedly more aggressive than the native Western Rosella, the lorikeets are likely to outcompete and displace them. Atlas of Australian Birds records since 1997 showing the natural range (purple circles) and the introduced, expanding population in the Perth area (red circles).

Honeybees and birds, food and tree holes—no simple answers

Both feral and managed honeybee hives are widespread across Australia. These introduced bees harvest nectar and/or pollen from the flowers of a wide variety of Australian plants. Many of these plants provide floral resources for honeyeaters and lorikeets, as well as a wide variety of other native fauna. By consuming nectar and pollen, honeybees have the potential to compete with native fauna, and may also disrupt or alter pollination services of plants. This has sparked considerable debate amongst conservationists, ecologists and the apiary industry, since many apiarists depend on access to native forests and reserves. Without that access, apiarists may be unable to provide strong hives at specific times of the year to pollinate various horticultural crops, such as almonds.

The extent of any competition between honeybees and native fauna for floral resources will depend on the importance of particular floral resources to the survival and reproductive success of various native fauna, and whether harvesting of these resources by honeybees significantly reduces the ability of native fauna to harvest the resources they need. If honeybees were only removing a small proportion of the available nectar and pollen, then they would be unlikely to have a significant effect. However, this is often not the case—honeybees can remove more than 90% of the nectar and/or pollen produced by some plant species.

If abundant, honeybees can deplete supplies to such a low level that there is insufficient nectar present to meet the much higher energy requirements of birds. Honeyeaters and lorikeets, being warm-blooded, can visit flowers from dawn and will often forage for an hour or more prior to honeybees arriving. This gives the birds an advantage, but the honeybees can out-compete them for most of the remainder of the day.

New Holland Honeyeaters expand their feeding territories according to the scale of nectar loss to honeybees and harvest most of the food they need during the first part of the day. Thus, patches of flowering plants may support fewer honeyeaters when honeybees are active. Adult male honeyeaters are dominant to females, hence, when resources are scarce, females are disadvantaged and sex ratios may become biased towards males.

These instances of a competitive interaction need to be balanced against situations where honeybees have no measurable effect on native fauna. Because of extensive clearance of native vegetation, natural systems are now seriously perturbed. Plant-pollinator interactions are particularly sensitive to perturbations and in many systems there are now inadequate numbers of birds to fully service

Honeybees and birds cont.

the pollination requirements of the plants, including various eucalypts, banksias, grevilleas and heaths, particularly winter flowering species. Nectar accumulates and can drip unexploited from flowers. In these situations, removal of nectar and pollen by honeybees has no impact on the numbers of native fauna visiting flowers. In fact the honeybees may actually provide some pollination services to the plants, allowing higher rates of seed production.

Given the changed conditions there is no simple rule about whether honeybees should or should not be tolerated in natural systems. Perhaps the safest option is to allow continued access to those natural areas currently being used by apiarists, but to set aside other representative areas to be free of honeybees. In these latter areas all managed hives could be excluded for a 2 km buffer zone and all feral colonies sought out and removed. Monitoring the responses of the flora and fauna to the removal of honeybees would provide a strong basis for subsequent management of honeybees in other areas. The focus of management programs, however, should be on feral colonies of honeybees rather than managed colonies, because colonies of feral honeybees are present throughout the year including periods when little is flowering and competition is likely to be greatest. Beekeepers, on the other hand, typically shift their managed hives from one location to the next every one to three months to exploit flowering peaks of different plant species.

In addition to using floral resources, feral honeybees potentially compete with native fauna (including birds) for tree holes. Although there are many cases where a particular hollow used by birds in one year is subsequently taken over by a feral colony of honeybees, the evidence for serious competition remains weak. Did the honeybees displace the birds and did that stop those birds from breeding, or did they simply shift to another nearby hollow? Or did the birds initially abandon the hollow, which was subsequently colonised by bees? Answers to these questions have not been provided and are critical to assessing the extent of competition. In addition, the impact of honeybees on hollow-nesting birds requires an understanding of whether suitable hollows are the key limiting factor in nesting success, rather than food availability, for example.

Close inspection indicates that the hollows preferred by honeybees often differ from those used by native birds. Entrances to hollows used by honeybees, for example, are often narrow and far too small for birds to gain access, or the cavities have no floor and/or openings at the bottom. Furthermore, many of the birds that use cavities of similar volume to those used by feral honeybees are abundant species (Galah, Sulphur-crested Cockatoo, corellas etc) suggesting that tree hollows are not limiting for them. In the few studies where some assessment of hollow use has been made, many unoccupied hollows were also present. However, the continuing loss of rural trees many of which carry hollows without replacement may ultimately result in increased competitive interactions over a diminishing resource. The solution, though, is to address the underlying cause—the loss of the mature hollow-bearing trees from rural landscapes and the lack of recruitment for these trees—in addition to addressing the interaction between birds and bees in use of hollows.

BY DAVID PATON *and* DANIEL ROGERS, *Adelaide University, South Australia*

Bumblebees: a new threat to birds?

Two species of social bee have established in Australia. Introduced in the 1820s, the Western Honeybee is almost ubiquitous, and a Eurasian species of bumblebee has become widespread and abundant in Tasmania following its introduction in 1992. Both bees feed on nectar and pollen from a wide variety of introduced and native plants. Numerous species of Australian birds also use nectar as a carbohydrate source, and several Australian parrots obtain protein from pollen. Hence, the bees are potential competitors with many native birds for carbohydrates and/or protein.

Being smaller than birds, bees continue to forage at nectar standing crops below that at which birds can forage efficiently. Nevertheless, the capacity of birds to forage earlier in the day than honeybees, and when it is too cold for honeybee activity, affords them some escape from competition.

However, in the case of bumblebees, their competitive impact on birds is increased by an ability to forage at lower temperatures than other insects. Bumblebees are able to take nectar and pollen earlier in the day than honeybees, and when it is too cold for honeybees to forage, thereby reducing the amount of time that birds can forage in the absence of exotic bees. For this reason, the competitive impact of bumblebees probably exceeds that of honeybees.

At least two nationally endangered birds—the Swift Parrot and Regent Honeyeater—are potentially at risk from competition by bees. The birds' breeding is restricted largely to times of spring nectar flows, particularly those of eucalypts. In south-eastern Tasmania, both bees are the major consumers of nectar and also take pollen from flowers of Blue Gum and Black Gum during the breeding season of Swift Parrots, when the flowers of these two gums are the major food sources for the parrots. By reducing food availability to Swift Parrots during their breeding season, these introduced bees potentially have the same effect as destruction of Blue Gum and Black Gum forests, a factor that has long been considered a threatening process for the Swift Parrot.

Climatic modelling shows that the potential distribution of bumblebees encompasses almost all areas from which the Regent Honeyeater has been reported since European settlement and all of the key breeding areas for this species, suggesting that if bumblebees spread to the Australian mainland they could become an additional threat to the endangered honeyeater.

BY ANDREW HINGSTON, *Honorary Research Associate, University of Tasmania*

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Feral honeybees have invaded a tree spout formerly used by parrots.
Photo by **Nicholas Birks, Wildflight**

Preventing Invasion

Introduction of exotic species is not a thing of the past: the risk that more invasive species will arrive in Australia continues (see top, p. 18). Even worse pests could arrive. The establishment of wild populations of efficient predators such as Mustelids (stoats and weasels) could bring about the devastation of birds such as that seen in New Zealand. In addition, several invaders already in Australia are poised to invade other parts; for example bumblebees in Tasmania threaten to invade the mainland and Common Mynas threaten to invade Tasmania. Common Starlings have been prevented from invading Western Australia until recently (see lower pp. 18–19) and Barbary Doves are newly established in Adelaide, Alice Springs and Tennant Creek.

Prevention is better than cure. The best way to achieve this is to control importations into Australia, respond quickly to new incursions, and prevent the spread of already established invasives to currently isolated habitats, such as islands. Opportunities to remove exotic species from the wild, before they become pests, are best taken when numbers are low. This opportunity was missed with sleeper species such as the Yellow Crazy Ant on Christmas Island and Mimosa on the mainland, which exploded 70 or more years after they became established and now cost millions of dollars to control. An emerging potential environmental problem is the spread of several species of deer.

The principal Australian Government legislative instruments relating to import control are the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Quarantine Act* 1908. The importation of potentially invasive species is regulated by the *Quarantine Act*, which prevents or controls the entry, establishment and spread of pests and diseases that will or could likely cause significant damage to humans, plants, animals and other aspects of the environment (see top, p. 18). The EPBC Act also provides a framework for the regulation of exports and imports of live animals and plants. Under the Act, a list of species suitable for live import has been established; species not on the list are prohibited. Applications for importation of potentially invasive species are continual.

Within Australia, translocations of invasive species also continue to occur, either through escape from captive or cultivated populations, release of pets, unintentional assistance or malicious introductions. Careful surveillance and swift action can prevent their establishment. For example, detection of Common Mynas in northern Tasmania prompted a rapid response that appears to have successfully removed the new arrivals, which were already nesting. Unfortunately, also in Tasmania, rapid and concerted action against foxes, apparently deliberately introduced in 1999–2000, has been unable to stem an apparently increasing population, already estimated to number as many as 50. Their spread across this formerly fox-free island will be catastrophic. Their eradication should be a national priority, although it will be a difficult task when numbers are low and the island is large (see p. 24), it will be even more difficult when numbers have increased.

Australia's islands have had a poor history with respect to deliberate or accidental introductions. Those few that are currently free of invasives are vulnerable, and quarantine efforts are at the forefront of management of the threat of invasion. For example, a breeding site for Soft-plumaged Petrels, Maatsuyker Island (Tasmania), is free of feral predators. However, its proximity to mainland Tasmania (10 km off the southern coast) makes the accidental introduction of predators a significant potential threat. In order to reduce the risk of unintended introductions, quarantine guidelines have been developed for volunteers and supply services that visit the island. Similarly, sub-Antarctic Heard Island has no introduced vertebrates, such as cats or rabbits. The prevention of introductions associated with human visits is a major issue for the management of the island, and strict protocols are in place.

A recent review by the Australian Biosecurity Group identified several gaps in Australia's biosecurity shield. They included:

- **No comprehensive early warning surveillance.** Australia pays dearly for not having comprehensive national early warning programs. Because Fire Ants in Brisbane were overlooked for several years, they will cost at least $175 million to eradicate. By comparison, New Zealand's National Invasive Ant Surveillance Program detected the ants at Napier only about a year after they invaded and their eradication cost only $1.38 m.
- **Inadequate contingency plans for environmental weeds, pests and diseases**. Australia has effective contingency plans in place to quell incursions by agricultural pests, and is developing a system to combat marine pests. A similar set of defenses needs to be developed for other environmental pests, weeds and diseases.
- **Mismatches between laws**. Australia lacks an effective national regulatory approach to tackling weeds, pests and diseases. Laws vary from State to State and there is no over-arching Commonwealth law. This creates problems for industries that trade nationally, such as the nursery industry, and leads to serious anomalies.
- **Inadequate protocols to decide eradication priorities and who pays**. When a new pest is found, vital action is often delayed by uncertainty about which agency should accept the responsibility and cost.
- **Inadequate funding for research and management of environmental weeds and pests**.
- **Lack of community awareness**. Most Australians do not understand the scale of the threat.

An Indian Ringneck Parakeet perches on a backyard clothes line (see pp. 18–19); before feeding at a bird feeder. Such feeding stations can help exotic species establish and spread into the bush. Photo by **Marion Massam**

Everyone has a role to play in the early detection of new populations of invasive species—if you see a plant or animal that doesn't belong, contact the relevant state authorities immediately. Do not feed introduced birds even if they are friendly and attractive; if they spread they may displace native animals or become an agricultural pest. Make sure pets do not escape and never deliberately release an animal that is not native to the area. Be a responsible gardener (see p. 19).

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Risk assessments for exotic birds

Introduced non-native birds pose major threats to the Australian environment and agriculture. Twenty-six species of exotic birds have already established in the wild in Australia. Several of these species are significant pests, including the Common Blackbird, House Sparrow, Common Myna and the Common Starling. An additional 225 exotic bird species are held in captivity (Vertebrate Pests Committee 2006), including many species held in low security cages in private aviaries. An example of an exotic bird commonly kept as a pet in Australia is the Indian Ringneck Parakeet. This species occurs naturally in Africa and India and has established in the wild in many countries as a result of pet birds escaping. Between April and September 2006, 14 Indian Ringneck Parakeets were removed from the wild in Perth, Western Australia after, in some cases, months of survival, and a further seven were confirmed as still flying free. Wild populations could compete with native, tree-hollow nesting birds, as well as potentially damage grain and horticultural crops.

Governments have a responsibility to ensure that risk assessments are conducted to identify species that pose a high threat of establishing pest populations if they should be released from captivity, and to ensure that such species are either kept out of Australia, or if kept here, they are held with appropriate levels of security. A national approach is necessary to ensure that birds that have significant pest potential in one part of Australia are not kept under low security in other regions, where they could escape, establish and spread.

The Bureau of Rural Sciences has developed a risk assessment model to support government decisions about which exotic birds species should be banned from import into Australia, or kept here only under high security, because of their potential to establish wild pest populations. The Bomford model evaluates a range of factors for an exotic bird species, including its climate match to Australia, its history of establishing exotic populations elsewhere, and its pest status overseas, to calculate a risk score of low, moderate, serious or extreme. The Australian Government receives frequent applications to allow new exotic bird species to be imported into Australia. Risk assessments are conducted before amendments that allow new species to be imported into Australia are made to the live import list.

Only a small number of the 225 species of captive exotic birds that are already present in Australia have been assessed using Bomford's model. The Indian Ringneck Parakeet has been assessed and received an extreme risk score. All exotic bird species currently present in Australia need to be assessed, with the highest priority

given to species considered to be pests in their overseas range. If bird keepers are allowed to hold species that have a serious or extreme risk score, they need to be educated about the importance of ensuring that the birds are kept under appropriate levels of security. Bird keepers, landowners and the general public also need to be educated about the importance of promptly reporting any escapes of exotic aviary birds or sightings of unusual birds in their area. The earlier escapees are detected, the greater the chance that eradication can be achieved. Once a population has established a breeding population that has spread from the release site, eradication may not be possible.

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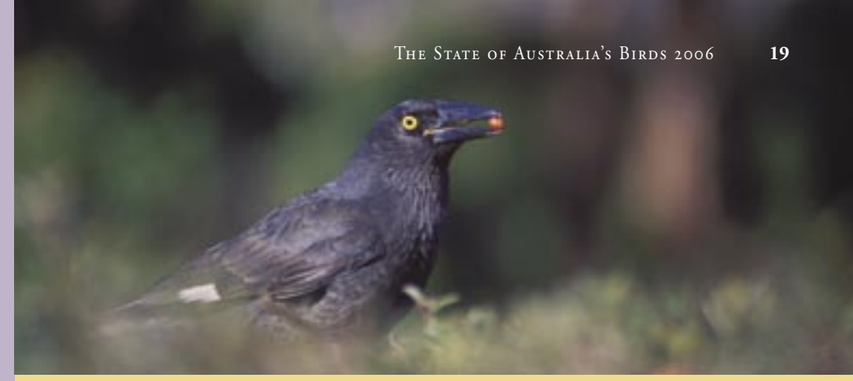

Pied Currawongs are one of many native species that enjoy berries of introduced garden plants. The currawongs benefit from the nutritious food, which is often produced at times of the year when natural food is scarce, and help to spread the seeds. Photo by **Peter Marsack, Lochman Transparencies**

Gardeners, weeds and birds

Birds are one of the greatest dispersers of weeds throughout Australia. They eat the fleshy fruits of invasive plants and deposit the seeds in another area where they germinate and give rise to new infestations. Birds that spread weeds include silvereyes, currawongs, honeyeaters, figbirds, bowerbirds, cassowaries and fruit-pigeons. They are attracted by brightly-coloured fruits, rich in sugars or other nutrients, some of which are available at times of year when fruit is otherwise scarce. These features also appeal to gardeners such that gardens and birds combine to cause weed infestations.

Some birds turn to introduced plants where land clearing and urbanisation have removed the native fruits that originally sustained them. It is important that local native fruit and nectar-bearing trees are included in bush restoration and urban parks and gardens, so that birds then spread native plants. Gardeners need to be aware that plants such as Mock Orange in the subtropics and cotoneasters in cooler areas support increased abundances of birds such as currawongs that also prey on nestling birds and spread the weeds into the bush.

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Barbarians at the gates: Feral bird incursions in Western Australia

In Western Australia, at least 50 species of bird have been introduced and released into the wild and at least 14 have become established. The Pest Animal Control Co-operative Research Centre (CRC) recently estimated that the economic, environmental and social impact of 11 of the worst vertebrate invaders was a minimum of $720 million per year.

Several non-native species arrive fairly regularly but are removed. The Eurasian Tree-Sparrow is an accidental import via shipping into ports and probably along the coast, arriving regularly since 1966 and very regularly since 2001. Tree-Sparrows are established in the wild in Victoria and New South Wales but not in Western Australia, where two significant infestations of more than 50 birds have been eradicated in recent years. Similarly, House Sparrows and Common Mynas are established in the wild in eastern Australia but not in Western Australia. Two significant infestations (about 70 and 15 birds) of House Sparrows have been eradicated in recent years and occasional mynas arrive and are removed. In addition, native species from the eastern States, such as the Rainbow Lorikeet and Long-billed Corella, are also invading the State.

Three potentially more damaging exotic species, assessed as posing an extreme threat to agriculture and the environment (see above), continue to threaten to invade. The House Crow of southern Asia is an uncommon accidental import via shipping into Western Australian ports. It has not become established in the wild due to the efforts of the Western Australian authorities, who remove all birds on sight, and the vigilance of ships' masters. The crow is likely to prey on native bird species and harass other species.

The Indian Ringneck is widely held in captivity by bird fanciers around Australia, including Western Australia. High numbers of the common green colour form mean that these individuals have little value and although handsome the birds are noisy. In combination with the limited ability of the authorities to ensure the ringneck's secure keeping, this increases the risk of escape or release. The ringneck has been reported from many locations in the wild in Western Australia, with small groups persisting for many months, and one group was reported to have bred and successfully raised offspring. Most infestations have been detected at bird feeders maintained by residents and are removed primarily by trapping.

Until 1971, the State was free of Common Starlings. Each year, many birds are destroyed in western South Australia and eastern Western Australia to prevent movement over the Nullarbor into Western Australia (over 54,000 individuals so far). But Starlings are long distance fliers and self-introduction has led to small populations being periodically found; some of which have been successfully eradicated and one maintained at a low level (Condingup, east of Esperance).

However, in 2001, a population was detected near Munglinup, approximately 100 km west of Esperance. Research and surveillance showed that the extent of the infestation was greater than initially thought. Documenting the increased problem lead to an increase in the resourcing of the Starling Control Project from $400,000 in 2004/2005 to $750,000 in 2005/2006. Since the population was first identified, over 1000 birds have been removed.

Then early in 2006 two more populations, one in the Coomalbidgup area, about 30 km to the east, and the other in the Jerdacuttup area 30 km to the west, were discovered. Another was found at Mason Bay about 60 km to the south-west in late March. In late February 2006, it was decided to declare the situation an emergency incident, as it was considered beyond the Department of Agriculture and Food's ability to manage using normal procedures. In June 2006 a cabinet submission was successful in gaining $2.1 million dollars for a containment and surveillance strategy (total operational funds $2.5 million plus up to $300,000 of assistance from the WA Department of Environment and Conservation).

The situation is complicated by the presence of multiple flocks of this wary species and the difficulties of undertaking control activities in the paperbark swamps they inhabit. The starling emergency also highlights the difficulties of mounting an appropriate response against a species that can be hard to detect until numbers increase significantly.

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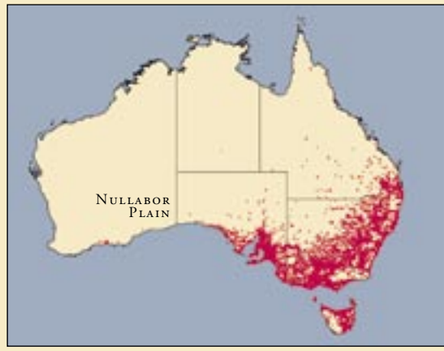

Starlings were introduced by acclimatisation societies in the 1880s and spread across the temperate south-east and beyond. Until recently a concerted effort to prevent their invasion of the south-west, assisted by the natural barrier of the Nullarbor Plain, has been successful. But now this environmental and agricultural pest has breached the barriers and in the last few years has established substantial populations in difficult to access areas in the Esperance region. (The map shows records since 1997 in the Atlas of Australian Birds).

Starlings have established at Munglinup swamp where the terrain makes it difficult to find and destroy them. Photos by **Marion Massam** *(left)* and **Rohan Clarke** *(far left)*

A House Crow was detected at Port Hedland in 2003 and two were on Rottnest Island in May 2006; all were removed. Photo by **Marion Massam**

Assessing the Threat from Established Invasive Species

People determine whether an animal becomes a pest either by moving it physically, by modifying habitats or land uses, or by altering their own perceptions. What is a pest to one person may be a valuable resource to another. For example, a feral pig might viewed as a valuable resource by hunters and meat processors; but a pest by farmers or lovers of wetlands birds. Such diversity of opinion is one of the main reasons that past pest control has had varying success.

Attitudes to animals, whether native or introduced, change with time and circumstance. Good examples of this are the Common Myna, which has captured attention by its 'cocky' behaviour, and the Cane Toad, which is toxic and 'ugly'. As yet, there is little evidence that either significantly damage native bird populations. Starlings have been here longer and attract less interest than mynas—perhaps we have become accustomed to them?

Control efforts are costly and time consuming and funding is limited. Hence, it must be decided whether the threat posed by an invasive species is real or perceived and how significant it is (see below and p. 22, and lower pp. 24–25) and whether control efforts are likely to be effective in alleviating the impact (see next section: Control of Invasive Species), and a commitment must be made to monitoring effectiveness; otherwise the effort is likely to be misconceived and misdirected.

Changing perceptions: ravens strung along a fenceline in the 1970s—a leftover from a bygone era when gamekeepers believed it was a deterrent to other ravens that might prey on the lambs in their charge. Today, this is illegal and ravens are no longer perceived to be such terrible pests. Photo by **Graeme Chapman**

Cockatoo management in Victoria: how cost-effective?

Long-billed Corellas, Sulphur-crested Cockatoos and Galahs ('cockatoos') are typically gregarious species, gathering at noisy communal roosts and in large flocks at favourable food sources. Such habits have led to a range of conflicts between the birds and some rural residents. Cereal farmers are particularly affected when cockatoos gather in large flocks on germinating winter cereal crops where birds can cause significant damage that sometimes requires resowing of a crop. In addition, cockatoos frequently roost in trees in towns where their noise and damage (pulling loose nails from roofs; digging up bowling greens, tennis courts and other sporting facilities; chewing insulation on electricity cables) has led to calls for action.

This was not always the situation. In the 1830s, Long-billed Corella numbers crashed within a few years of the introduction of sheep to south-eastern Australia and the subsequent reduction in availability of Long-billed Corella's major food—the tuberous roots of the Yam Daisy. Food loss, combined later with competition from rabbits for food in late summer, were identified as causes of a sustained decline in the number of Long-billed Corellas and a substantial reduction in the species' range to a small area in western Victoria. The introduction of myxomatosis to control rabbits in the 1950s, and the more recent changes in agriculture in western Victoria (from the dominance of sheep production to increased areas of cropping), probably enabled the population to expand again (there was a 63% increase in reporting rate between the two Birds Australia Atlases 1977–1981 and 1998–2002). The range of the Long-billed Corella is now steadily expanding eastwards and the bird is common in Melbourne, where it was rarely recorded in the 1980s. At the same time, the range of the Little Corella is expanding into southern and eastern Victoria, where the Galah arrived some decades earlier. Concern about the problems attributed to these increasing populations led the Victorian Government in 1996 to declare the Long-billed Corella, Galah and Sulphur-crested Cockatoo to be unprotected, under certain conditions, throughout Victoria.

Cockatoos are known to be capable of causing significant economic losses to some grain farmers, although there is a lack of objective data on the nature and extent of these losses. In some areas, because of the potential for bird damage, growing sunflowers is not a viable economic option. Elsewhere, nut crops may suffer significant losses to Galahs and Sulphur-crested Cockatoos.

The social impacts on the community of such bird damage can be significant. The time, effort and costs associated with sowing and re-sowing crops and actively preventing crop damage leads to frustration amongst some landholders and may support a perception that individual farmers' economic livelihoods are threatened by these birds.

The Department of Sustainability and Environment (DSE) has identified that long-term solutions to such problems no longer lie entirely within government agencies. Recently, the major focus of this pest management strategy has shifted from bird destruction to techniques aimed at minimising community concern. Government strategy was guided by the following principles:

- **the community as a whole needs to assume ownership of, and responsibility for, problems caused by cockatoos and work jointly towards solutions;**
- **land managers need to be assisted to develop and adopt viable means of cockatoo damage control as standard management practice, as they do with other pests and diseases; and**
- **industry needs to take on responsibility for management of a problem that affects them in ways similar to other barriers to production.**

Long-billed Corellas, Sulphur-crested Cockatoos and Galahs are among the species that have benefited from human alteration of the landscape, however, they can damage crops—here a wheat field stripped at the edge—and public amenity. Trapping is one way to temporarily reduce their numbers. Photos courtesy of **Barry Kentish**

Government, therefore, aims to engage with local communities and stakeholders to facilitate strategies, processes and mechanisms to ensure that the cockatoo problem is addressed at the local level. Since 1999, farmers have been able to use the services of government-funded programs to alleviate cockatoo damage. The DSE has undertaken programs to educate landholders on properties at risk from bird damage about methods to reduce cockatoo abundance (e.g. improved farm 'hygiene' and a subsequent reduction of spilt grain) and provide training in, and deployment of, trapping and gassing techniques.

Trapping and gassing involves birds being attracted to a trap site by offering food. When sufficient birds are present they are trapped with nets and euthanased with carbon dioxide gas. The aim of this method is to break up the larger flocks, which are a major cause of concern for landholders, with minimal loss of birds. The goal is not to reduce the overall population of birds.

The success of the cockatoo management strategy is difficult to ascertain. The reduced level of concern among the local farming community demonstrates the effectiveness of the program in that regard. However, local uptake of responsibility for management of the birds has been minimal, and the extent of crop damage has not been monitored to assess any change.

In conclusion, the extent to which cockatoos are an economic and social pest species remains unclear. Current damage estimates are founded more on local perceptions of the problem than on objective estimates of actual costs. The costs in terms of production loss to individual farmers and the industry as a whole must be determined at both local and regional scales, and weighed against the costs of ongoing management. Only then can the cost-effectiveness of current management strategies be evaluated dispassionately.

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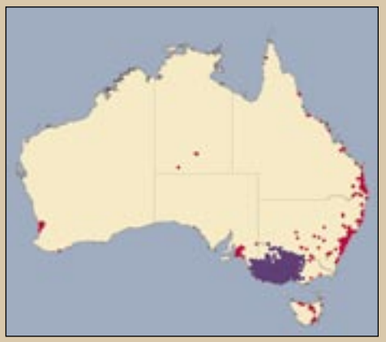

Originally a bird of inland south-eastern Australia, the Long-billed Corella dramatically declined with pastoral settlement, but its population has recovered in recent years and spread with changes in land use and via escape or release of pets. As records in the Atlas of Australian Birds since 1997 demonstrate, the corella's distribution has expanded from its natural range in western Victoria and south-eastern South Australia (purple circles) to far flung parts of Australia (red circles). In places it is viewed as an agricultural pest and it also competes for nest holes with local species.

Indian Mynas have taken our eastern cities as their own and their seemingly cocky attitude annoys some, but are they really displacing native species? Photo by **Rohan Clarke**

Common Mynas and Noisy Miners: minor or major causes in the decline of small birds in cities?

Of great concern to many people is the obvious decline of fauna in some of our cities. Many comment that mammals, lizards and frogs have been lost, and they particularly miss the birds that are no longer seen in gardens and parks. Recently, two species have been implicated in the loss of small birds: the exotic Common Myna and the native Noisy Miner. These are considered to act as 'bullies', preventing other species from inhabiting areas where they preside.

In gardens in Eastern Australia, both species are very common. The 2000 Birds in Backyards survey undertaken in greater Sydney showed that Common Mynas were present in about 80% of gardens and Noisy Miners in just under 50%. The Atlas of Australian Birds suggests that both species were in the top six most abundant species in both summer and winter surveys in Sydney. In Melbourne, the myna was also in the top six species in both seasons and the miner ranked in the top 15 and occurred in 36% of gardens. The pattern was reversed in Brisbane. Noisy Miners ranked in the top six in both summer and winter, and Common Mynas ranked in the top 15 and were found in about 30% of surveys. However, this ubiquity in eastern cities does not prove that either species affects small bird diversity.

Common Mynas prosper wherever humans live. They can be an economic problem because they damage both fruit and grain crops and some believe they are a potential health problem. They nest in tree hollows or similar places such as artificial cavities under roofs. Tree hollows are also used by native species such as parrots, and there have been observations of Crimson and Eastern Rosellas being displaced from hollows by aggressive Common Mynas in Canberra. Mynas are said to be capable of evicting even large birds such as Kookaburras and Dollarbirds. There is, therefore, the potential for Common Mynas to displace hollow nesting species from such areas.

However, there is always competition for hollows and the abundance of parrots suggests that Common Mynas are not limiting their abundance. Parrots such as Rainbow Lorikeets (Melbourne, Brisbane and Sydney), Scaly-breasted Lorikeets (Brisbane), Musk Lorikeets (Melbourne), Eastern Rosellas (Melbourne and Sydney) are common. Furthermore, such aggressive nesting behaviour is unlikely to affect small passerine species which nest in foliage.

Common Mynas generally forage in open grassy areas while small birds tend to forage in shrubs and trees or on the ground near foliage. Hence, the potential for aggressive interactions between these species during foraging is quite low.

The Noisy Miner is another matter. It is a honeyeater that lives in colonies of individuals that vigorously defend feeding and breeding territories from all birds. Traditionally, it occupies open grassy woodland at the edges of forests and woodlands, but appears to be more common in both urban and agricultural areas. In one study in agricultural Victoria, Noisy Miner colonies were removed from remnant woodland resulting in an increase in the number of bird species. Roadside studies in both the Southern Highlands (New South Wales) and the Wimmera (Victoria) have documented negative relationships between Noisy Miners and species richness.

The Birds in Backyard study in Sydney recorded similar patterns in the city. Where Noisy Miner occurred, each of the seven small birds studied—Eastern Spinebill, Willie Wagtail, Silvereye, Red-browed Finch, Superb Fairy-wren, New Holland Honeyeater and Eastern Yellow Robin—were less likely to be present. On the otherhand, the presence of Common Mynas had no effect. Furthermore, in the Illawarra, a recent study has shown that Yellow Thornbills and New Holland Honeyeaters were four times less likely to be recorded in areas where Noisy Miners were defending territories; species such as the Eastern Spinebill, Grey Fantail and Spotted Pardalote were 1.8–2.5 times less likely to be present; and eleven small species, including Brown Thornbills, Eastern Yellow Robins, Red-browed Finch and Weebills, were absent from Noisy Miner territories. Yet, even these results are not conclusive evidence of Noisy Miners' exclusion of small birds, they may simply reflect habitat suitability. That is, in these gardens the habitat might not be particularly suitable for some small birds even in the absence of miners. A removal experiment would be more conclusive.

If we are to effectively address declines, we need to understand their causes through solid science not guesswork. Appearances can be deceptive. At present, despite their cocky demeanor, there is little evidence to suggest that Common Mynas are affecting bird diversity in cities. However, there is good evidence for the controlling role of Noisy Miners. Of course, both species thrive in cities and suburbs where the habitat and food suits them; unless those change, removal of either species will have no more than a short-term impact because they will reinvade.

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Currawongs: cause or symptom?

The Pied Currawong is among a minority of native birds that have benefited from human activities. Fragmentation of the landscape and the planting of introduced plants that provide winter berries has led to its increase and a change in movement patterns. Its habit of preying on eggs, nestlings and fledglings causes distress to parent birds and nature lovers alike. The currawong also spreads the seeds of some of the woody weeds, such as cotoneaster and privet, on which it feeds. But does the currawong have a significant impact on native bird populations as some fear?

Studies have shown that currawongs prey mostly on common species, some of which are introduced, such as Common Starlings and Common Blackbirds. Not surprisingly, predation rates decrease markedly when the currawong is removed from an area. However, this does not mean that currawongs affect the sustainability of populations. It is possible that their nest predation replaces another cause of death, such as starvation, rather than adding to the total rate of mortality in the first year of life, and hence has no impact on recruitment to the breeding population. Further research is needed to clarify their true impact.

If currawongs are shown to be a problem, the answer is not their removal, but restoration of the ecological balance that kept them in check. Nevertheless, in the short-term, local control can be effective in situations where it can be targeted to protect endangered species such as Gould's Petrel while habitats recover (see p. 9).

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Some of the complexity of control of invasive species is illustrated by Double Gee (Spiny Emex), an accidentally introduced weed of crops—its savage spines even encrust Landrover tyres (see below). In the Western Australian wheatbelt it has become a staple of Red-tailed Black-Cockatoos, which gather in large flocks to feed on it (above). Herbicides used to control the weed are killing remnant native vegetation along road verges that supports Short-billed (Carnaby's) Cockatoos, so that Red-tails are gradually replacing Carnaby's. Photos by **Graeme Chapman**

Control of Invasive Species

While responsibility for the management of established pests rests fundamentally with State, Territory and local governments as well as landholders and industry, the Australian Government plays a role in funding and setting strategic frameworks from a national perspective.

It would be desirable to rid Australia of the worst invasive species, but this is not achievable in most cases (see top, p. 24). An exception is on offshore islands, where the scale is not too great and limited access means that invasive species cannot easily re-invade once they are removed. For example, cats have been eradicated from Gabo Island, Victoria.

When eradication is not practicable, and action is desirable, strategic management is the most popular approach to control. This takes three general forms:

- one-off management: e.g. building a predator-proof fence to protect animals; modifying and restoring habitat (see lower pp. 24–25); biological control such as myxomatosis;
- targeted management: e.g. protection of a particular species or area (see p. 26 at left) or control targeted at pest animals causing the greatest damage (see below); and
- sustained management—ideally initial knock down followed by periodic mop-ups (see right, p. 26).

Many methods exist to control invasives, these include aerial baiting, trapping, fencing, biological control, ripping and poison. Control of one pest species often needs to be integrated with control of others, and sometimes with restoration of natural habitat. For example, removal of one invader may exacerbate the damage caused by another (see lower p. 28).

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Does increased pest control result in reduced pest damage?

The relationship between pest density and the level of damage caused is often poorly known. Usually, it is assumed that by reducing the numbers of the pest, the degree of damage will also decline. However, this is not necessarily so. Pest damage can remain high even at relatively low pest densities. For example, it is believed that older, more wily foxes are the primary predators of Malleefowl chicks near nest mounds. These are the hardest animals to catch, hence reduction of the fox population is unlikely to reduce its impact on the birds. Control targeted at these problem animals is likely to be more effective than aiming to reduce the overall density of the pest population.

Bounty systems fail for a similar reason—because they encourage action where the target animal is most numerous rather than where it is doing the most damage.

Requirements for successful eradication

The first three points are essential for eradication to be possible; the last two indicate whether eradication is preferable to on-going control.

1. Rate of pest removal exceeds rate of increase at all population densities. This requirement is very difficult to achieve, because pest removal rate reduces as population density reduces, and remaining animals become more difficult and expensive to target and control.
2. Immigration of pests into the control area is zero. The distribution of many pest species on mainland Australia is so large that it would not be possible to implement high-level control in all areas simultaneously and immigration would be inevitable.
3. All pest animals are at risk. Even if there was a very wide range of available control techniques for pest animals, it is unlikely that complete control could be achieved over large areas.
4. The pest can be detected at low densities. Unless this requirement can be achieved, confirmation of eradication is not possible; the current Tasmanian fox eradication campaign is faced with this problem.
5. Discounted cost: benefit analysis favours eradication over ongoing control. The cost of control per pest animal increases exponentially as pest population density declines, to the extent that an attempt to remove the last few animals in an area could cost tens of thousands of dollars per animal.
6. Suitable socio-political environment. Control techniques need to be considered to be specific, safe and relatively humane; a guarantee of long-term financial support is required, to avoid wasting any initial investment.

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Top left: Salvinia is an invasive floating aquatic fern from South America that has become established in Queensland and the Northern Territory. It can rapidly form mats that completely cover water storages, affecting water quality, water flow, wildlife—including Magpie-Geese and Wandering Whistling Ducks—irrigation and recreational activities. Chemical, mechanical and biological control (a weevil) are being used to limit its spread. Photo by **Jiri Lochman, Lochman Transparencies**

Above: Although dead bodies of invasive predators can give comfort they are no guarantee that stock or wildlife are any less at risk. Photo by **Peter Merritt**

Dealing with indigenous despots

Watching a Noisy Miner saunter confidently down a Macquarie Street footpath in central Sydney picking up lunchtime scraps gives the distinct impression that this bird 'owns the place'. Regrettably, for much of eastern Australia this has become the case, to the detriment of many other native birds. Noisy Miners belong to the genus *Manorina*, native honeyeaters renowned for living in complex colonies of kin which aggressively defend their communal territory from virtually all other species of bird. While the Noisy Miner is probably the most familiar to Australians, its close relatives the Bell Miner and the Yellow-throated Miner have also been implicated in significant changes in bird communities and habitats in different parts of the country.

The Noisy Miner's communal defence is so effective that it commonly achieves a virtual monopoly on any piece of habitat it chooses to colonise and its domination of rural and urban landscapes is increasing. It is among what author Tim Low has labelled 'winners' from white settlement, and its ascendancy has contributed to many other species becoming 'losers'. Although the miner's range within Australia does not appear to be increasing dramatically, according to *The New Atlas of Australian Birds*, its increasing domination of remnant vegetation within that range is of major concern. Researchers such as Ian Davidson estimate that of the 10–20% of eucalypt woodlands remaining in southern and eastern Australia, the vast majority (probably 90%) are already dominated by Noisy Miners.

Noisy Miners were probably much less common prior to white settlement. Their preferred habitat was probably clumps of eucalypts adjacent to open grassy clearings, not too far from water. Clearing of woodlands and forests for agriculture and urbanisation has inadvertently created tens of thousands of hectares of prime Noisy Miner habitat: lots of grassy clearings edged by eucalypts. Being adaptable generalists, the miners continue to colonise more and more habitat, to the exclusion of many other native species, some of which, like the endangered Regent Honeyeater, are left with few places to forage unmolested.

For many years researchers recognised that where Noisy Miners were present in small remnant woodlands, other small insectivorous birds were less abundant. However, it was unclear whether the absence of small birds was due to the habitat being so degraded that only Noisy Miners could live there, or that the Noisy Miners were excluding the other species. An experimental study we conducted demonstrated categorically that Noisy Miners were excluding the other species. On removal of Noisy Miners from small remnant woodlands, a multitude of small insectivorous birds immediately flooded in and utilised the resources previously unavailable to them. Further, our research in Grey Box remnants indicated that the level of leaf damage from herbivorous insects improved following the removal of Noisy Miners, compared to control sites left unmanipulated. By excluding small insectivorous birds from remnant woodlands, Noisy Miners may be contributing to rural tree decline. It is likely that the spread of eucalypt dieback will accelerate if there is a further decline in avian diversity in rural and urban landscapes. This is an issue of economic importance to agricultural communities, not just one of aesthetics.

Noisy Miners are native honeyeaters that aggressively exclude smaller native birds from habitat patches; their super-abundance is the result of fragmentation and alteration of woodlands and addressing that is the key to their control. Photo by **Rohan Clarke**

Widespread removal of Noisy Miners from the landscape is not feasible. However, if we understand what makes a site attractive for colonisation by Noisy Miners, we can at least attempt to avoid creating more habitat that suits them. Although Noisy Miners have long been regarded as an 'edge species', until recently there has been little research done to identify how far from edges they will penetrate into remnant vegetation, nor the kind of edges they prefer. Work in both Queensland and Victoria has revealed that Noisy Miners will commonly dominate as much as 150–300 m in from a remnant's edge. This has profound implications for: (a) the size remnants need to be to have any 'Noisy-Miner-free' core habitat (> 36 ha); and (b) the width habitat corridors need to be if they are to avoid being dominated by Noisy Miners (> 600 m). Additional research has shown that along remnant edges Noisy Miner colonies typically occur at corners of the remnant, where corridors join the remnant or where clumps or protrusions of canopy vegetation extend into the paddock from the remnant. Worse, in inland Queensland, remnants hundreds of thousands of hectares in size are dominated by miners throughout.

One focus of many revegetation efforts to date has been the creation of habitat corridors connecting patches of remnant vegetation to facilitate the movement and dispersal of wildlife across the landscape. Although the studies mentioned above suggest Noisy Miners are very likely to dominate such corridors and diminish their value as dispersal routes for small insectivorous birds, these habitat connections are still important for the conservation of other wildlife like small mammals and reptiles. In addition to planting corridors, habitat restoration efforts should consider measures for making the edges of remnants less attractive to Noisy Miners by avoiding the creation of corners, clumps and protrusions. Steps could also be taken to enclose protrusions within 100 m of the edge and revegetate out to these new boundaries, with the objective of 'rounding' and 'smoothing' the perimeter of the remnant (see figure at right). Such extensions of the boundaries of remnants could also preserve isolated hollow-bearing trees in paddocks. A focus on restoring non-eucalypt woodlands which do not support miners may be important in appropriate regions.

Research we have conducted in the mallee regions of north-west Victoria suggest the Yellow-throated Miner of the semi-arid and arid zone is having a somewhat similar impact to that of the Noisy Miner. Yellow-throated Miners are monopolising the thin roadside strips of remnant vegetation that run between the vast paddocks cleared for cereal cropping and grazing. Even small groups of miners (5–10) can successfully exclude the majority of small insectivorous birds that would otherwise move along these vitally important habitat corridors. If we are to maintain the remaining diversity of birds, there is an urgent need to create miner-free refuges in these landscapes.

A third member of the genus, the Bell Miner, has long been linked to eucalypt dieback in forest habitats along the east coast of Australia from Melbourne to Bundaberg. The expansion of the dieback associated with the presence of Bell Miners over the last decade has been so dramatic that it has earned its own acronym—BMAD—Bell Miner Associated Dieback! Tens of thousands of hectares of forest in north-eastern NSW and south-eastern Queensland are affected. Research has demonstrated that through their territorial exclusion of other insectivorous species of birds, Bell Miners allow sap-sucking bugs called psyllids to multiply into infestations that contribute to the death of some canopy tree species. While it is tempting to blame the Bell Miners for this habitat degradation, this begs the question of what it is about a site that predisposes it to hosting an infestation of psyllids. Researchers have proposed many different kinds of disturbances that might result in eucalypts putting on a flush of young or epicormic growth that is inadvertently attractive to psyllids, which then attract Bell Miners. These include stress due to changed hydrological conditions (water-logging or drought), soil pathogens (like Cinnamon Fungus), elevated nutrient levels in the soil, the absence of frequent low-intensity fires, competition from weeds and micro-climatic changes associated with forest fragmentation and clearing.

While some have advocated the removal of Bell Miners, this does not always result in the recovery of the trees. If the psyllid burden is not the primary reason the trees are stressed on a site then they are unlikely to recover just because the psyllid burden is removed. Much more research is needed to identify the factors that predispose a site to infestation by psyllids and colonisation by Bell Miners. Such research should clarify what role, if any, human activities have in making a site attractive and what can be done to avoid or redress any imbalance created.

In conclusion, it must be stressed that these three species of native miner are not behaving in some aberrant manner. It just happens that we have altered landscapes in ways that have profoundly tipped the balance in their favour—at great cost to many other species. How we have changed the landscape to the benefit of Noisy Miners and Yellow-throated Miners and what can be done to limit the impact these birds have is becoming clear. Whether we will take responsibility for rectifying the mess we have created is less certain.

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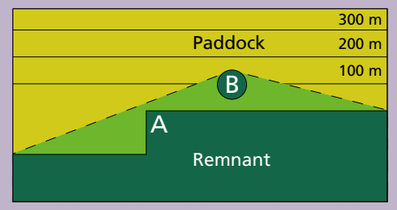

The edge of a large remnant with two projections: A – a corner; and B – a clump. The broken line marks the perimeter of the proposed revegetation (lime green) extending into the paddock, enclosing both projections, and smoothing the remnant to lessen domination by miners.

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House Sparrows are long established in the east, but not the west. In the south-west infestations have been eradicated; these were some of the birds removed from Fremantle in 2005. Photo by **Marion Massam**

Threatened birds and alien species: a NSW perspective

Invasive species management has historically been based around the assumption that control will lead to biodiversity conservation; however, the level of control required is rarely known, nor is it known whether control alone will lead to the recovery of those species at risk. In addition, examinations of the species at risk have been undertaken across a broad section of biodiversity, which only adds to the complexity.

In an attempt to address these shortcomings, the New South Wales Department of Environment and Conservation (DEC) has assessed the impact of invasive species on the 114 bird species and six specific bird populations listed under the NSW Threatened Species Conservation Act 1995. Invasive species were considered to be the most important threat to native birds after land clearing. Seventy-five per cent of the threatened birds and five of the six populations were judged to be at risk from invasive species. Of the 85 threatened bird species at risk from invasive species, pest animals threaten 74 (87%) and weeds 25 (29%); 14 species are threatened by both pest animals and weeds. Clearly, survival of the majority of the State's endangered birds cannot be guaranteed unless invasive species, specifically pest animals, are managed.

A total of 15 pest animal and 19 weed species pose a threat to birds in NSW. The five pest animals commonly identified are cats, foxes, wild dogs, rabbits and pigs; rodents also pose a significant threat. The weeds commonly identified as a threat to birds are Asparagus Fern, Bitou Bush and Camphor Laurel; however, none poses a threat to more than three bird species. In contrast, cats and foxes each threaten over half of the bird species, many of which are threatened by both predators.

Invasive species also threaten birds through removal and degradation of habitat (e.g. through grazing and weed invasion). For example, analysis of monthly counts at Pelican Island, near Port Macquarie, showed that shorebird numbers decreased following an increase in density of Bitou Bush and Lantana. Once these weeds had been controlled, the number of shorebirds soon increased.

Management strategies for invasive species, specifically designed to conserve native species, include Threat Abatement Plans (TAPs). The DEC has developed a TAP for foxes which aims to reduce their impact. The TAP identifies the species most at risk from fox predation and the sites at which fox control is most critical for the survival of those species. The plan involves collaboration with other agencies, community groups and private landholders. Wherever possible control is applied in an experimental way and the response is monitored. The Fox TAP identifies 16 birds species at risk from fox predation: Albert's Lyrebird, Malleefowl, Little Tern, Australasian Bittern, Brolga, Plains-wanderer, Australian Bustard, Beach Stone-curlew, Bush Stone-curlew, Pied Oystercatcher, Hooded Plover, Flock Bronzewing, Squatter Pigeon, Southern Scrub-robin, Grey Grasswren, and Chestnut Quail-thrush. Eight of these birds are priorities for fox control. The Fox TAP is currently undergoing a five-year review, and information on the success or otherwise of these programs will be available in the near future. However, the initial results are promising. For example, fledgling success and recruitment of Little Terns in 2005 were higher in fox controlled sites than in non-control sites. Funds have recently been secured to continue the fox control programs in the TAP for the preservation of shorebirds for another three years.

In addition, the DEC has developed a Bitou Bush TAP that lists 15 bird species and one bird population suspected to be at risk in NSW, and sites at which control could be beneficial. Additional information on the status of birds will be collected during the implementation of the TAP to help assess the exact nature of the threat, and how best to aid the birds' recovery through Bitou Bush control.

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Local eradication: House Sparrows at a homestead

Experience in north-eastern Victoria has shown that the dependence of House Sparrows on human settlements provides a means to eliminate this pest from the local environment. Depopulation by harbour removal and trapping, has meant that a farm homestead that once supported a population of several hundred House Sparrows has had no resident birds for over 13 years.

Beginning in 1983, over 630 sparrows were trapped. Roosting places around the house were removed or blocked with fly-wire. The numbers trapped declined to zero in 1994 and it was not until 1999 that small numbers reinvaded and were immediately removed (see graph).

The ability to depopulate a rural area with a single trap has implications for ecological restoration. It shows that it is possible to change the pest status of House Sparrows on a local scale, from resident to, at most, uncommon seasonal visitor.

Use of this approach over a catchment, based on individual householder action, would reduce overall House Sparrow density. Whether the sparrows are a significant enough pest to warrant the effort must be decided by the individuals concerned.

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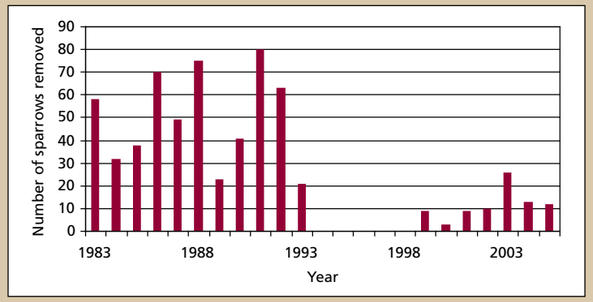
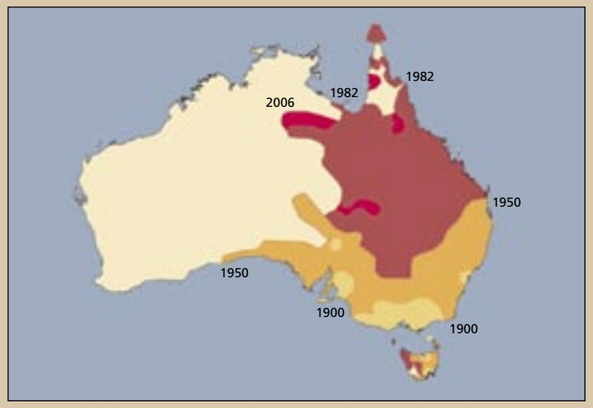


The number of House Sparrows removed from a homestead near Mansfield between 1983 and 2005 using a single trap; there have been no resident sparrows for over 13 years.



The spread of the House Sparrow since its introduction in the early 1860s. By 1950 (tan) it had invaded most of the south-east and by 1982 (maroon), it had occupied most of Tasmania and extended its mainland range far northward. Its northward and westwards push continues.

Protecting Threatened Birds from Invasive Species

Predator-proof fences can serve to protect colonies of nesting threatened species. Photo by **Michael Weston**

The EPBC Act provides for the identification of Key Threatening Processes (KTPs) and the preparation and implementation of Threat Abatement Plans (TAPs), as well as national recovery plans for the threatened species. KTPs affect a number of threatened species (see table p. 28) and a wide range of more common species. Some also have economic and social, as well as environmental, impacts. Hence, State/Territory and Australian Governments invest significant amounts in the control of a few key invasive species. For some weeds and foxes, for example, individual landholders are also expected to keep populations on their land to acceptable levels.

Based on the cost of control, production losses and research, but including few environmental costs, pests and weeds are conservatively estimated to cost Australia $4.7 billion annually—$4 billion for weeds and $720 million for feral animals. Between 1992 and 1999 the Australian Government committed $4.7, $1.2 and $2.1 million to fox, feral cat and rabbit research and control programs, respectively. In one national park, Kakadu, nearly $1 million a year has been going into the fight against just one weed, Mimosa, a prickly shrub which smothers grasslands around wetlands, destroying habitats and preventing access for grazing waterbirds such as the Green Pygmy-goose, amongst other wildlife; several biological control agents have been released with some success.

Particularly on islands, the protection of threatened species has been quite effective, although not without its problems (see pp. 28–29). For example, the Yellow Crazy Ant was accidentally introduced to the Australian Territory of Christmas Island between 1915 and 1934, but has only in recent years exploded in population—forming high-density super-colonies of millions of ants, which have impacted on 25% of the island's forest and killed thousands of the keystone species, the Red Crab. Despite early fears, the ants did not attack birds but may ultimately impact on them via vegetation changes from decimation of the crabs—making it possible for introduced rats to spread—and farming of scale insects. The Australian Government has spent more than $1.5 million over the last five years, starting with ground baiting in the first two years, followed by extensive aerial baiting annually towards the end of the dry season, which has been highly effective. Nevertheless, the ants are still in evidence and surveillance continues for supercolonies; this unique ecosystem will remain under threat for as long as the ants occupy the island.

The environmental cost of invasive species is huge. Australia has lost 25% of its mammal species and half the bird communities from Norfolk and Lord Howe Islands, in large part due to invasive species. In NSW alone, African Bitou Bush is considered to be a major cause of population decline in 63 rare and threatened native species. African grasses fuel hot bushfires that scorch rainforest pockets and stop young trees from establishing in Top End woodlands, destroying bird habitat, and contributing to carbon emissions and global warming. Often we neither understand the true impact of invasive species, nor how to place a dollar value on the environmental cost (see below).

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What is a bird worth?

In any 'triple bottom line reporting', that is, reporting against economic, social and environmental impacts, environmental estimates are troublesome. Can a value be placed on the life of a bird eaten by a fox? Yet this is a real cost to the environment that needs to be factored in. Similar problems arise when assessing the cost-effectiveness of control programs and where best to concentrate conservation efforts.

The community may gain value from biodiversity by being able to see birds of interest. The absence of these species as a result of predation by an invasive species imposes costs on the community because the amenity value of ecosystems is degraded. Pimentel and colleagues used this amenity value as a proxy in their estimates of the cost of predation of birds by pests in the USA. They arrived at a value of $US 30 per bird, based on surveys that showed that a birdwatcher spends $0.4 per bird observed, a hunter spends $216 per bird shot and an ornithologist spends $800 per bird reared for release. In the absence of similar data for Australia, McLeod used a much more conservative sum of $1 per bird to arrive at figures of $190 million as the value of native birds killed by foxes and $18 million by cats each year.

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Key Threatening Processes listed under the *Environment Protection and Biodiversity Conservation Act 1999* relating to invasive species and the birds listed as threatened under the Act which they are thought to threaten.

Listed Key Threatening Process	EPBC listed threatened species known or perceived to be threatened by the Key Threatening Process
Competition and land degradation by Feral Goats.	Malleefowl.
Competition and land degradation by Feral Rabbits.	Gould's Petrel.
Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant on Christmas Island, Indian Ocean.	Abbott's Booby; Christmas Island Frigatebird; Christmas Island Goshawk; Christmas Island Hawk-Owl.
Dieback caused by the Root-rot Fungus *Phytophthora cinnamomi*.	None specified.
Predation by exotic rats (Black, Brown and Pacific Rats) on Australian offshore islands of less than 1000 km^2 (100,000 ha).	Green Parrot (Red-crowned Parrakeet); Norfolk Island Golden Whistler; Norfolk Island Scarlet Robin; White-chested White-eye; Cocos Buff-banded Rail.
Predation by Feral Cats.	Green Parrot; Little Tern; Night Parrot; Swift Parrot; Malleefowl; Orange-bellied Parrot; Norfolk Island Southern Boobook; Western Ground Parrot; Mount Lofty Southern Emu-wren; Black-breasted Button-quail.
Predation by the European Red Fox.	Malleefowl; Little Tern; Night Parrot; Orange-bellied Parrot; Western Ground Parrot; Mount Lofty Southern Emu-wren; Black-breasted Button-quail.
Predation, habitat degradation, competition and disease transmission by Feral Pigs.	Southern Cassowary; Black-breasted Button-quail; Eastern Bristlebird.
Beak and Feather Disease affecting endangered *psittacine* species.	Orange-bellied Parrot; Green Parrot; South-eastern Red-tailed Black-Cockatoo; Kangaroo Island Glossy Black-Cockatoo; Carnaby's Black-Cockatoo; Swift Parrot; Night Parrot; Western Ground Parrot; Golden-shouldered Parrot; Coxen's Fig-Parrot.
The biological effects, including lethal toxic ingestion, caused by Cane Toads.	None specified.
The reduction in the biodiversity of Australian native fauna and flora due to the Red Imported Fire Ant.	Twenty-four bird taxa including Eastern Bristlebird, Buff-breasted Button-quail, Golden-shouldered Parrot, Western Ground Parrot, Plains-wanderer and Malleefowl.

Norfolk Island: a slew of invasive species and bird extinctions

On the Norfolk Island group, clearing of the majority of the rainforest has probably had the greatest impact on the terrestrial birds, seven out of 15 of which are extinct, but invasive plants and animals have also played a large role. African Olive and guava, introduced in the 1800s, choke parts of the forest, altering its structure so that much of it is now too dense for species such as the Scarlet Robin and Golden Whistler (listed as vulnerable) and White-chested White-eye (critically endangered). These woody weeds also provide food for introduced Crimson Rosellas, which aggressively compete for nest holes with the endemic Green Parrot, and Black Rats, which prey on nesting parrots (and other species).

Rats were identified as the cause of failure of six of 15 unsuccessful Green Parrot nests in 1983–1991—they even killed incubating females. By the early 1990s only four breeding females and 32–37 individuals remained. A combination of rat-proofing of natural nests, and Crimson Rosella and cat control, returned the population to 200–300 by 2004. Similarly, the Southern Boobook population has been recovered from one female in 1986 to about 40 individuals. This was achieved by hybridisation with the male of a closely related subspecies from New Zealand and other supportive activities including the provision of rat-proof nest boxes which must be kept free of introduced starlings and Crimson Rosellas.

The removal of woody weeds from the National Park, 11% of the main island, is a substantial and ongoing task. The birds will remain conservation dependent for the foreseeable future.

On Macquarie Island rabbits (here overlooking a Royal Penguin colony) destroy sensitive native plants and remove ground cover, causing erosion and exposing small nesting birds such as prions and petrels to increased risk of predation from skuas and other predators. Photo by **Rohan Clarke**

The importance of strategic, integrated management: Cats, rabbits and petrels

Two centuries ago sailors and sealers inadvertently introduced cats to many of Australia's islands where they have wreaked havoc amongst seabird colonies. Cats were brought to sub-Antarctic Macquarie Island in 1820; in recent times it was estimated that the approximately 500 cats were killing 60,000 seabirds annually. From 1997–2001 the Tasmanian Government, funded by the Australian Government, humanely trapped and destroyed 2450 feral cats. Specially trained dogs were used to locate the last few and since June 2000 the island has been cat-free. In 2004, the globally endangered Grey Petrel bred on the island for the first time since the 1960s, bringing hope that other threatened seabirds such as the Blue Petrel might too.

Unfortunately, removal of cats and a longer breeding season (thought to be the result of global warming) has caused a rabbit 'plague', which is damaging the fragile vegetation and exposing burrowing petrels to increased predation by skuas. The petrels are again decreasing. To manage if not eradicate the rabbits, an aerial baiting program is planned for winter when the seabirds are at sea, but has been delayed by State/Federal wrangling over responsibility.

Further reading

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Above: A shattered egg with a few tell-tale possum hairs adhering. Possums usually breach the egg at the top and crumble the shell inwards as they eat its contents. Photo by **Lynn Pedler**

Left: A female Kangaroo Island Glossy Black-Cockatoo in one of over 80 artificial nest hollows in trees protected by pruning and metal collars from predatory possums. Photo by **Lynn Pedler**

Foxes, possums, Glossy Black-Cockatoos and nest protection

In parts of mainland Australia, the ground feeding habits of Common Brush-tailed Possums are severely restricted by the introduced fox. This efficient predator may reduce possum populations and the use they make of plentiful ground level food resources, such as agricultural pastures and crops, to the extent that mainland possums are uncommon in many areas and appear to have become largely arboreal feeders. Where foxes are absent, such as on Kangaroo Island, changes in possum behaviour and abundance are apparent. Any nocturnal excursion will reveal a high density of possums feeding not only at all levels in areas of natural vegetation but among grazing wallabies in nearby pastures. Anecdotal evidence from early Kangaroo Island residents suggests that possum numbers are higher than before much of the clearance for farming, and fertilisation of pastures, took place in the 1950s.

When monitoring of the nests of the island's endangered Glossy Black-Cockatoos commenced in 1995 it became clear that possums were not just competitors for hollows in which to live, but significant predators of both eggs and nestlings.

Excluding possums from nests is achieved using recycled corrugated iron, nailed as a metre-wide collar to tree trunks. In cases where their canopies meet, adjoining trees need to be pruned, or their trunks also ringed with iron, to prevent possums climbing across. Fortunately, Glossy Black-Cockatoos often reuse the same hollows in successive years, but ongoing work is required to maintain the metal collars and to locate any new nests in unprotected trees. About 200 nests are now protected, including over 80 trees with artificial hollows. Other cockatoo species, owls and ducks also breed in these possum-free nests.

In 1996, prior to exclusion of possums, only 23% of nests produced a fledgling, and the population of less than 200 Glossy Black-Cockatoos was declining. Now, with protection from possums, 49% of nests are successful and recent censuses show a population of about 300, increasing at 2–3% per year.

BY LYNN PEDLER, *South Australian Glossy Black Cockatoo Recovery Program, coordinated by SA Department for Environment and Heritage, Kingscote, South Australia.*

Predator management for the protection of Hooded Plovers

Introduced predators, such as the Red Fox, are known to depress the reproductive success of many ground-nesting birds, including the Hooded Plover, sometimes to the point where populations decline. Consequently, management of these predators has been a focus of recovery efforts, and has included a number of approaches, some underway and some under feasibility and performance testing:

- **Population control, whereby foxes are removed in an effort to reduce their populations. In some instances, such as on peninsulas or islands, eradication is possible and population removal is the goal. There have been trials of fox-baiting in the immediate vicinity of nests which have indicated a marginal increase in the survival rates of eggs.**
- **Reducing access to Hooded Plover eggs by caging nests so that predators cannot reach the nest. Cages have resulted in high hatching success but, for unknown reasons, appear to reduce fledging success.**
- **Reducing access to flightless chicks by providing chick shelters in breeding areas where natural shelter does not occur. These are currently being investigated.**
- **Training foxes not to eat eggs ('conditioned aversion') so that they remain on their territory (thus keeping other foxes at bay) but do not prey on Hooded Plovers. This approach is currently being investigated.**
- **Electric fences around Little Tern colonies have also benefited nesting plovers, by preventing access of predators to nests and young.**

All of the above approaches suffer from the problem that they require ongoing input of resources and none of them offer a long-term solution. It is hoped that they will be a stop-gap measure, which will help struggling populations until other more general approaches to fox control (e.g. new baits, new delivery devices, biological control) become available or plover populations are substantial enough to sustain the predation.

Learning to Live with Invasive Species

Many of today's invasive species, opportunistic species that prosper in human-dominated environments, are likely to persist into the future (see below). The widespread introduced species are here to stay and in general there's not much we can do about them. More native species will become invasive and the spread of others will continue (see currawong graph); in most cases they are the symptom, not the cause of problems—the sign of a general ecological malaise brought by changes to the land.

The news isn't all bad. Some introduced species provide ready food for native species inhabiting highly modified habitats, for example, Peregrine Falcons living in capital cities prey primarily upon Rock Doves and some native predators can safely eat Cane Toads (see p. 31). Major current avian invaders, such a mynas, currawongs and corellas can be expected eventually to reach the limits of their spread and settle down at some lower level of abundance, as is typical of invading species.

Boxthorn and Blackberry provide food and refuge for birds in habitats stripped of similar native plants. Other weedy species, such as Camphor Laurel and Lantana, and some 'invasive' native birds that spread seeds, are assisting in rainforest regeneration. Some of these weeds can be controlled once they have served their purpose as a stop-gap, but care must taken that their removal does not jeopardise the survival of native bird species.

If we can preserve and restore a greater area of native habitat, protect our most threatened species from the invaders, and prevent further introductions, there may be a place for all.

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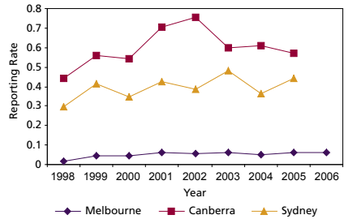
Lured by the moderated conditions and a supply of food year round, Pied Currawongs are still invading Australia's eastern cities. Atlas of Australian Birds data from regularly surveyed 2-ha sites in Canberra, Sydney and Melbourne illustrate the increase. (Reporting rate is the number of surveys during which that species was seen as a proportion of all surveys).



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Boxthorn, at right with endangered Orange-bellied Parrots; and blackberry, at left with a pair of Superb Fairy-wrens. Both are invasive species widely regarded as pests, yet they provide food, nest sites and refuge for small birds in the absence of similar native species. Photos by **Rohan Clarke**

Invaders in the cities: Terrorists or companions?

Humans are the premier example of an invasive species having spread to colonise the entire planet, occupying all habitats from oceans to desert. Although we seldom think of ourselves as 'invaders', much less as an 'invasive species', we do think a lot about the 'invasions' of other species. Mostly we see invasive species as obstacles to our well-being and to the survival of species we think 'belong'. Whatever we think, not all invasive species are introduced or even foreign and not all invasive species displace other species. Most enhance local biodiversity and make where we live more interesting. Nowhere is this truer than in Australian cities and no invaders are more part of our lives than urban birds.

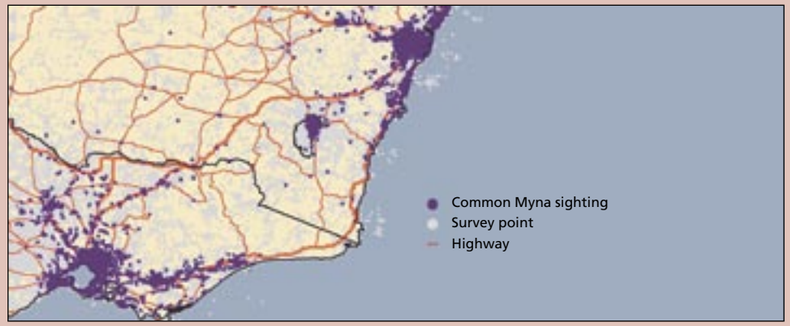
Many urban birds are 'invaders' and most are Australian species. In the absence of a city they may not have occured in that place at all or not in such abundance. About the only 'foreign' birds common in Australian cities are Common Blackbirds, Common Mynas, House Sparrows and Rock Doves in the east and Senegal, Rock and Spotted Turtle-Doves in Perth. Perth also has Laughing Kookaburras (see map at right) and Rainbow Lorikeets (see map on p. 15) introduced from eastern Australia. Although most urban birds are native, relatively few are species we encounter in neighbouring bushland.

Each city in Australia has its own unique avifauna, but no matter how much they may differ, all urban bird communities have common attributes. Cities and their suburbs sustain some of the highest densities of birds found anywhere on the continent. Urban environments provide habitat, food and water in abundance for birds. Nest sites abound, as well as a profusion of berries, fruits, seeds, nectar, insects and small vertebrates, and handouts of everything from sugar and seed to cheese and meat for birds bold enough to take them. But despite the abundance of birds, urban environments are much poorer in species than more natural environments.

The reasons why some birds fail in the urban environment and others do well are pretty simple. Many birds cannot survive in cities or suburbs, mainly because the structure of urban vegetation is inappropriate and the non-indigenous plants which dominate urban environments support too few insects. In particular, the smaller birds are often missing, especially the ground-foragers and the insect-eaters of the understorey and canopy vegetation, although these may persist in urban remnants of native vegetation. In their place is a suite of larger birds—such as Noisy Miners and Pied Currawongs in eastern cities—which reach levels of abundance far greater than in non-urban environments; these are commonly aggressive, driving away or preying on other species. The 'true foreigners', including Common Mynas and Common Blackbirds, probably have little or no effect on native species and occupy urban niches that would otherwise be bereft of birds.

For the survivors, the urban matrix with its grassy open spaces, scattered trees, shrubbery and weedy edges mimics the grassy woodlands where they naturally occur. This includes many parrots, such as Eastern Rosella and Sulphur-crested Cockatoo, as well as Crested Pigeons and Noisy Miners. Urban commensals, such as Australian White Ibis, Silver Gulls, Pied Currawongs and Rainbow Lorikeets, have responded to the abundance of food and water provided by people and their parks and gardens.

The Laughing Kookaburra was introduced to Tasmania and south-western Australia over a century ago, in part because of a misguided belief it was an effective snake killer. Atlas of Australia Birds records since 1997 showing the natural range in purple and the introduced range in red.



Common Mynas are still expanding their range southwards. They have remained a commensal (living with humans); their spread and establishment is tied to roads and cities and towns, as this map of south-eastern Australia illustrates. Despite a poor public image, their impact on native species may be negligible. Source: Andrew Dunn, Applications of the Atlas of Australian Birds Project.

Does it matter if our cities are dominated by urban commensals, by invaders? Probably not. The functioning of urban ecosystems and our dependence on them has little to do with the kinds of birds found in cities. Cities are ecosystems with massive requirements of food and water from remote farms and catchments, energy from fossil fuels, and technologies which are the product of human creativity, spanning the world. What is important is that our cities have birds.

Birds add colour, movement and song to otherwise bland urban landscapes. They make our lives more interesting. For some, they are a reason for living. Does it really matter if they are 'invaders' or even 'foreign'? In reality, they have as much right to enjoy our cities as we do and are no more terrorists in the urban landscape than we are. Urban birds are the ones that live in cities; cities are their habitat, not something they have 'invaded' or from which they have driven away other birds. Enjoy them for what they are: companions, neighbours and friends.

by Harry F. Recher, *School of Natural Sciences, Edith Cowan University, Joondalup, Western Australia*

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Adapting to invaders: Predatory birds and Cane Toads

Unlike some weeds, invasive animals rarely benefit local birds. The Cane Toad is continuing its march westwards and southwards. The general consensus is that toads cause population declines in some native fauna via predation, competition, disease and their extreme toxicity to predators. The main impact on birds seems to by poisoning, and a few deaths have been reported—a Barking Owl, for example—but no large scale mortality. However, some crafty birds, such as the Torresian Crow and Black, Whistling and Brahminy Kites flip the toad onto its back, break through the abdomen and eat the flesh and viscera from the inside, thus avoiding the poison glands.

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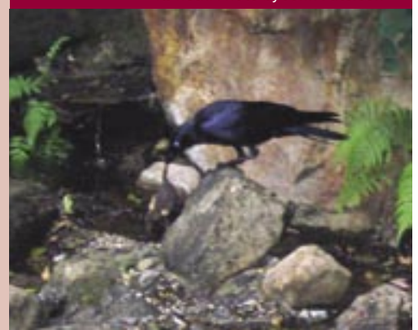
A Torresian Crow captures a Cane Toad at Mt Coot-tha, Queensland; in defence the toad has exuded poison from the glands on either side of its neck. Photo by **John Paterson**



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Feral Pigeons (Rock Doves) are mainly pests to human property in and around cities but they may transmit disease to native pigeons. Photo by **Nicholas Birks, Wildflight**

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A Great Heron captures a Redfin Perch, a popular angling species introduced from Europe in the 1860s that has become a pest by competing with and preying on native fish. In Australia's already strained south-eastern waterways, such fish often take the place of diminishing native species in the diet of waterbirds. Photo by **Peter Merritt**

Cover photo: A feral cat takes a Painted Button-quail. Ground nesting and feeding birds are particularly at risk from cats and foxes, just two of the more obvious invaders among the many that threaten Australia's birds. Photo by **Jiri Lochman, Lochman Transparencies**

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