Australia's faunal extinction crisis

An inquiry by the Senate Environment and Communications References Committee

Submission by the Invasive Species Council

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About the Invasive Species Council

The Invasive Species Council was formed in 2002 to advocate for stronger laws, policies and programs to keep Australian biodiversity safe from weeds, feral animals, exotic pathogens and other invaders. We are a not-for-profit charitable organisation with over 2000 supporters. Our work is funded by donations from supporters and philanthropic organisations.

Inquiries

Invasive Species Council

Address:	PO Box 166, Fairfield Vic 3078, Australia
ABN:	27 101 522 829
Web:	invasives.org.au
Email:	isc@invasives.org.au
Phone:	0438 588 040
Contact:	Andrew Cox, CEO

Contents

1. Introduction

We address four main issues in this submission:

1. invasive species as a dominant cause of faunal decline and extinction – of greatest relevance to ToR (d);
2. key threatening processes (KTPs) and threat abatement plans (TAPs) as an essential approach to conserving threatened fauna – of greatest relevance to ToRs (d), (h), (i);
3. islands as sites of extremely high vulnerability for faunal extinction, particularly due to invasive species, and as opportunities for protecting threatened fauna – of greatest relevant to ToRs (d), (l); and
4. the importance of ambition, inspiration, monitoring, prevention and appropriate institutions – of greatest relevant to ToRs (i), (l).

These issues warrant a concerted focus by the committee, for they go to the heart of why Australia is failing to stop animal extinctions and reverse declines. Unless harmful invasive species can be prevented, eradicated or controlled, unless the KTP and TAP functions under the Environment Protection and Biodiversity Conservation (EPBC) Act are used effectively, and unless islands have stronger biosecurity, it is inevitable that threatened fauna will continue to decline and go extinct and that more fauna will become threatened.

Following is a brief overview of each issue. For each of the first three issues, we attach a report that constitutes the main body of our submission.

2. Invasive species as extinction drivers

See **Attachment 1**: Low T. 2017. *Invasive species: a leading threat to Australia's wildlife*. Invasive Species Council.

Australia has been greatly impoverished by the extinction and decline of its highly distinctive wildlife. The losses to date have primarily been caused by invasive species, as documented in Attachment 1: 'invasive species have been overwhelmingly the main cause of animal extinctions in Australia, primarily responsible for at least three-quarters of the mammal losses, about half the bird losses and all frog and lizard losses'. The mammal losses have been particularly dire – Australia's loss of 29 endemic mammal species account for more than a third of the world's total (Woinarski et al. 2015).

The rate of extinctions has not declined, and invasive species have caused the majority of recent extinctions. Four of the five vertebrates that have gone extinct in the past decade – two totally extinct and two extinct in the wild – have been due to invasive species. They were all endemic to Christmas Island and inhabited a large national park:

- Christmas Island pipistrelle (*Pipistrellus murrayi*), extinct in 2009
- Christmas Island forest skink (*Emoia nativitatus*), extinct in ~2010
- Blue-tailed skink (*Cryptoblepharus egeriae*), extinct in the wild in ~2010
- Lister's gecko (*Lepidodactylus listeri*), extinct in the wild in ~2011

A fourth lizard, the coastal skink (*Emoia atrocostata*), also disappeared from Christmas Island in about 2010, but the species as currently defined still survives in north Queensland, New Guinea and Asia. There are suspicions the Christmas Island form was a separate species, but this cannot be confirmed because no specimens were collected (Smith et al. 2012; Attachment 1).

Asian wolf snakes (*Lycodon capucinus*), first reported on Christmas Island in the late 1980s, are the most likely main cause of the lizard losses, with other exotic predators – cats, black rats and Asian giant centipedes – perhaps also contributing to the decline.

Christmas Island offers a sobering case study of the destruction that can be wrought by invasive species. It is also a case study of preventable extinctions (eg see Woinarski et al. 2017). The action taken to try to conserve these species was too slow and too late, a common problem, particularly on islands.

Invasive species are a threat for most threatened species. There have been two major assessments of the prevalence of different threat categories impacting species listed under the EPBC Act. The most recent, by Kearney et al. (in press), based on IUCN categories of threat, found that invasive species affect the largest number of listed threatened vertebrate species: 94% (see Table 1 below). System modifications (e.g. fire) affect 66% of listed vertebrates and agricultural activity 70%. The other study, by Evans et al. (2011), using different threat categories, found that habitat loss was the leading threat, affecting 84% of listed vertebrates (see Table 2 below). Introduced species affected 76% of the vertebrates. However, Evans et al. classified exotic diseases separately (as part of a diseases category), which means the total for introduced species would be about the same as that for habitat loss. Inappropriate fire regimes affected 35% of the listed vertebrates. Similar trends apply for listed invertebrates.

Depending on how threats are classified, it is clear that invasive species and habitat loss are the leading threats for vertebrate animals in Australia, with inappropriate fire regimes and agricultural activity also major threats. It is also clear that most threatened species face multiple threats.

The majority of animal extinctions have been caused by a few invasive species – primarily cats, foxes, rats and chytrid fungus. However, dozens of other invasive species are also major threats. Kearney et al. (in press) note that 230 non-native species are listed in the SPRAT database as threats to listed species (not just threatened animals).

Although most of the big invasive species threats have been in the country many decades – introduced deliberately or accidentally before Australia had an effective biosecurity system – new invasive species keep arriving, and some of these will become future causes of decline and extinction. Red imported fire ants, electric ants and yellow crazy ants are examples of recent accidental arrivals that could severely threaten native animals. The first two are subject to national eradication efforts, and yellow crazy ants in the Wet Tropics to regional eradication (but not other populations in Queensland and the Northern Territory). One very recent arrival is an unidentified bacterial pathogen that has killed Lister's geckoes in captivity on Christmas Island (Attachment 1, Low 2017). It was first recorded in October 2014 when it resulted in the death of 40 geckoes, a 100% mortality rate among those infected. There are fears this disease will reach mainland Australia and infect other native reptiles.

The fact that new invasive species keep arriving means that conserving native species requires not only controlling or eradicating established species but also preventing new harmful arrivals. Australia's biosecurity performance needs to improve if we are to prevent new declines and extinctions.

Table 1: Prevalence of threats to listed threatened species by Kearney et al (in press)

	Amphibians	*Birds*	*Fish*	*Mammals*	*Reptiles*	*Invertebrates*
Threat	N=29	N=84	N=34	N=74	N=51	N=48
Invasive species	100	95.2	97.1	97.3	82.4	79.2
Ecosystem modifications	66.5	72.6	79.4	62.2	54.9	79.2
Agricultural activity	69	82.1	47.1	73	60.8	72.9
Human disturbance	51.7	35.7	38.2	27	23.5	20.8
Climate change	44.8	56	55.9	37.8	29.4	45.8
Transportation	41.4	16.7	2.9	17.6	11.8	14.6
Over-exploitation	48.3	40.5	52.9	28.4	21.6	50
Urban development	24.1	26.2	29.4	14.9	33.3	31.2
Energy production	10.3	20.2	47.1	16.2	31.4	10.4
Pollution	44.8	19	61.8	6.8	19.6	25

% of listed threatened species affected	81-100%	61-80%	41-60%	21-40%	0-20%

Table 2: Prevalence of threats to listed threatened species by Evans et al. (2011)

	Amphibians	*Birds*	*Fish*	*Mammals*	*Reptiles*	*Invertebrates*
Threat	N=22	N=104	N=43	N=84	N=48	N=22
Habitat loss	72.7	87.5	81.4	79.8	91.7	77.3
Introduced species	86.4	80.8	67.4	76.2	70.8	54.5
Inappropriate fire regimes	36.4	42.3	-	44	31.3	54.5
Disease	72.7	29.8	7	11.9	6.3	-
Pollution	31.8	22.1	32.6	9.5	27.1	22.7
Over-exploitation	18.2	49	41.9	27.4	27.1	22.7

3. The importance of KTPs and TAPs

See **Attachment 2**: Invasive Species Council. 2018. *KTPs & TAPS: Australia's failure to abate threats to biodiversity*. Discussion paper. Invasive Species Council.

Australia's national processes to protect and recover threatened species are failing. One major reason for this are deficient processes for mitigating major threats through the listing of key threatening processes (KTPs) and the preparation and implementation of threat abatement plans (TAPs) under the EPBC Act. An effective KTP/TAP system is essential for arresting loss of Australia's biodiversity, and developing solutions for major threats is typically more effective and more cost-effective than a species-by-species approach, and also benefits myriad other, often poorly known, species at risk from KTPs.

Attached is a discussion paper on KTP and TAP processes (Attachment 2) that analyses the major flaws of the system and makes broad recommendations for reform. Later this year, the Invasive Species Council will host a workshop to further develop an environment sector proposal for reform. Here we very briefly summarise the eight major flaws of the current system and outline five major categories of reforms needed.

Summary of KTP & TAP process flaws

1. **Limited coverage of major threats**: There are no KTP listings for inappropriate fire regimes, altered hydrological regimes or grazing; the land clearing KTP has no TAP; and the majority of invasive species threats are encompassed within the 'novel biota' KTP, a moribund listing that lacks a TAP. This means the KTP/TAP system is not applied for most major threats to biodiversity and only partially for invasive species.

2. **Stymied listing of invasive species**: For the past six years at least, there has been a refusal to assess invasive species KTP nominations or list any more invasive KTPs. The main reason given in six cases is that invasive species threats are encompassed within a catch-all 'novel biota' KTP. In a seventh case, the environment minister refused to list the KTP, contrary to advice by the Threatened Species Scientific Committee. Stymieing further invasive species listings appears to be a deliberate strategy to limit funding demands.

3. **Slow, tedious and ad hoc KTP listing processes**: The listing of KTPs is mostly ad hoc, relying on public nominations and ministerial prerogative, and the assessment processes are slow and tedious. The three KTP listings of the past decade (excluding the novel biota KTP nominated by the scientific committee) have taken three to four years from nomination to listing. Two rejected nominations took five and seven years to complete, and one nomination still under assessment is more than 10 years old. No KTP nomination since 2011 has even been assessed.

4. **Moribund KTP listings**: Almost a third of listed KTPs have no TAP. This could be acceptable if there were already effective processes for abating those threats. But this is mostly not the case. The threat level for KTPs without TAPS – particularly land clearing, climate change, escaped garden plants, noisy miners and novel biota – are all likely to have increased since their listings. There is no requirement

to show that alternative abatement processes are effective, to monitor abatement progress, or to initiate action if existing processes prove ineffective.

5. **Limited abatement progress**: Due to a lack of monitoring and regular reporting, the only feasible way of assessing the effectiveness of most threat abatement efforts is through the five-yearly reviews of TAPs required under the EPBC Act. But only half the KTPs can be assessed in this way: six KTPs lack a TAP and four TAPs have not been reviewed despite being overdue by one to four years for review (or their reviews have not been made publicly available). Eleven TAPs (52%) have been reviewed at least once, although only three by independent reviewers. Those reviews indicate that good progress was achieved for four TAPs, moderate progress for four TAPs and poor progress for three TAPs. Although fewer than half of KTP listings have resulted in moderate to good progress on threat abatement, the examples of good abatement progress demonstrate that major threats to Australian biodiversity are surmountable.

6. **Slow TAP processes**: It has taken an average four years to prepare or revise TAPs for the nine KTPs listed since 2001 that have a TAP. Most TAPs are reviewed within five to six years, but then it often takes several years for TAPs to be revised after a review – it took eight years to revise the root-rot fungus TAP, and five years after a ministerial decision to revise the fox TAP, it has still not been updated. Of 15 existing TAPs, 60% (9) are more than 6 years old and 27% (4) are 10 years old.

7. **Limited obligations and accountability**: Although the Australian Government has international obligations to abate threats to biodiversity, there is no obligation under the EPBC Act to list the major threats or act on them. The environment minister has complete discretion about whether to accept the advice of the Threatened Species Scientific Committee to assess a KTP nomination, list a KTP or prepare a TAP. The minister can also delay decisions for years and starve the assessment processes of funding. This means our national system for recognising and abating threats is highly vulnerable to political interference. Moreover, KTP listings come obligation free. Even if the minister decides that a TAP should be prepared, the EPBC Act obliges the federal government to do little to implement it, apart from in Commonwealth areas. A KTP listing or TAP also does not generate any obligations for other governments, landholders or anyone whose actions may exacerbate the KTP. There are no requirements for the federal government to monitor or report on KTP status. The one reporting obligation is the 5-year review of each TAP, but with no requirement for this review to be independent.

8. **Limited leadership, commitment and funding**: Although the federal government is limited in the extent to which it can compel other governments or individuals to undertake threat abatement, it can apply considerable pressure through strong leadership, incentives and funding for abatement, and use of its own laws to partially compensate for state or territory failings. These have been largely missing in KTP/TAP processes. Abating KTPs has been a low federal government priority. Leadership has improved to some extent with the appointment of a Threatened Species Commissioner as a champion for threatened species and facilitator of partnerships. This has generated considerable focus on the feral cat KTP (and a modest level of additional funding for abating that threat). There is no information about how much Australia spends on abatement (from government and non-government sources), nor how much is needed to properly implement

abatement plans. It is clear from the limited progress that the gap between available and needed funding is considerable.

Summary of changes needed

1. **Make threat abatement a high national priority**: An essential first step is greater recognition that an effective KTP/TAP system is essential for arresting loss of Australia's biodiversity, and that developing solutions for major threats is typically more effective and more cost-effective than a species-by-species approach, and also benefits myriad other, often poorly known, species at risk from KTPs. To drive reform of the KTP/TAP system, Australia needs an ambitious (but realistic) conservation strategy that specifies long-term goals for threat abatement. That ambition needs to be then reflected in each of the TAPs. Enlisting commitment from state and territory governments is essential. The federal government should pursue an intergovernmental agreement with the states and territories to achieve long-term abatement goals for recovery of threatened species and ecological communities.

2. **Strengthen governance and accountability**: The assessment and listing of KTPs and preparation of TAPs should be free of political influence and not subject to ministerial discretion. We endorse the recommendation by the Places You Love Alliance for an independent National Sustainability Commission to undertake such functions. It is also worth considering co-governance models, such as exemplified by the industry-government partnerships, Animal Health Australia and Plant Health Australia. More meaningful, independent and regular reporting is needed. The five-yearly TAP reviews are important and, for the sake of credibility and rigour, should be done by expert reviewers independent of government. An annual progress report (based on meaningful abatement indicators) should be presented to the federal parliament. This needs to be underpinned by monitoring of threatening processes and the species and ecological communities at risk.

3. **Systematically list KTPs for all matters of national environmental significance**: The KTP list under the EPBC Act should be the authoritative list of major threats to Australian biodiversity. The listing process needs to be more systematic to properly reflect the major threats. A systematic expert process can be supplemented by a public nomination process to fill gaps and keep the KTP list up to date. Australia's KTP list should be scientifically determined. As with similar processes at the state level, the decision to assess and list a KTP should emerge wholly from an independent scientific process.

4. **Strengthen obligations for abatement**: For each KTP, it should be mandatory to prepare a TAP (or equivalent) to specify long-term abatement goals and shorter-term targets, the research and actions needed to achieve them and a monitoring regime. A TAP should serve as a national statement of what is needed to achieve abatement and as the basis for monitoring and reporting on the status of the KTP and abatement progress. A TAP should be required even where abatement can best be achieved through existing processes or relies on processes beyond the control or influence of the federal government. This ensures that the federal government takes responsibility under the EPBC Act for specifying the desired conservation direction and monitoring progress. If state and territory governments fail to participate in implementing TAPs, the federal government should be obliged to consider options for over-riding or compensatory measures, such as using its own laws to limit land

clearing or regulate trade in invasive plants. Obligations should extend to individuals and corporations. All Australians are bound by the EPBC Act to avoid having a significant impact on matters of national environmental significance. They should also be bound to avoid actions likely to significantly exacerbate a KTP.

5. **Commit to long-term funding to achieve abatement targets**: A government demonstrates it is serious about mitigating harms when it is prepared to fund the necessary actions. To assess funding needs, each TAP should include an estimate of costs to achieve 10–20-year targets. New funding sources such as levies and taxes should be considered to provide long-term base funding for implementing TAPs.

4. The importance of island biosecurity

See **Attachment 3**: Invasive Species Council and Island Conservation. 2017. *Norfolk Island: protecting an ocean jewel. Recommendations for stronger biosecurity for the Norfolk Island group*. Invasive Species Council and Island Conservation.

Islands are special places for biodiversity. Their isolation often gives rise to a highly endemic biota. But when that isolation is breached by humans and human-introduced species, those unique species are often highly susceptible to decline. Having evolved with fewer competitors, predators and parasites than species on continents, they often have poor defences against invaders. And invasive species often thrive on islands for this reason – there are fewer predators, competitors and pathogens than in their land of origin, as well as vacant ecological niches. (Australia with its unique fauna and susceptibility to invasive species has functioned like an island.) Because of their susceptibility, island fauna are disproportionately represented in lists of threatened and extinct species. Christmas Island, Norfolk Island and Lord Howe Island are particularly sad examples of this. Since European settlement, Christmas Island has lost four endemic mammals and at least three endemic reptiles; Norfolk Island has lost seven endemic birds and six endemic snails; and Lord Howe Island has lost eight endemic birds and at least 11 endemic invertebrates.

Conversely, islands often offer sanctuary from invasive species – seven Australian mammals extinct on the mainland due to cats and foxes are now confined to islands (Woinarski et al. 2015). Islands often also offer excellent opportunities to recover threatened species because of the potential to eradicate invasive species. The likes of cats, foxes, rats, pigs and goats cannot be eradicated from the mainland with available methods but it is feasible on islands. By 2014, worldwide, there had been 203 successful eradications of 13 invasive animal species on 157 Australian islands (see http://diise.islandconservation.org). Australia has been a global leader in island eradications, and it is one of the very few ways by which we have made advanced biodiversity conservation over the past few decades.

A striking example of the benefits of eradicating invasive species (particularly predators) from islands is Macquarie Island. Until recently, globally important seabird populations and unique sub-Antarctic ecosystems were being destroyed on Macquarie by feral cats, rabbits, ship rats and house mice. Since completion of the eradication program in 2014, populations of eight threatened bird species have either stabilised or recovered. An assessment by Birdlife Australia in 2016 found they are now less likely to go extinct and recommended that their conservation status be down-listed. As a result, Birdlife International has down-listed one species from critically endangered to endangered, one from critically endangered to vulnerable, five from endangered to least concern and two from vulnerable to least concern – by far the largest-ever down-listing of Australian threatened taxa (see http://datazone.birdlife.org/country/australia for listings, a far more accurate reflection of the status of Australian birds than listings under the EPBC Act). Birdlife International won't change the status of an additional six threatened seabird species for now, but for most species, encouraging signs of their recovery are evident.

For all the reasons mentioned above – the unique wildlife of islands and their susceptibility to invasive species, and the sanctuary functions and conservation potential of islands – rigorous biosecurity is essential.

Attached is a report on Norfolk Island, an island exemplifying the importance of biosecurity (Attachment 3). In it we outline the conservation values of Norfolk Island, including rare and endemic fauna species, and major invasive threats such as cats, rats, Argentine ants and weeds. We describe the existing inadequate biosecurity arrangements and recommend changes to strengthen biosecurity.

Australia needs a comprehensive national plan of action for island biosecurity. An NGO proposal for a National Island Biosecurity Initiative, endorsed by the Invasive Species Council, includes the following elements (Nias et al. 2010):

1. Prioritisation of Australia's islands based on each island's ecological values and risk assessment, with cost estimates for the eradication of existing invasive species
2. Individual biosecurity systems for high priority islands and regional biosecurity management systems for other islands, including:
    - strict quarantine processes to prevent harmful incursions and imports
    - regular surveillance of high- and medium-priority islands, and occasional surveillance of lower-priority islands
    - biosecurity training for island managers and best-practice biosecurity practices
    - capability for responding quickly to new incursions (including the ready availability of equipment and expertise)
    - biosecurity education for island dwellers and visitors.

5. The need for ambition, inspiration, prevention and monitoring

Underlying Australia's extinction crisis are institutional and cultural failings. Currently, the country lacks the ambition, structures and processes necessary for reversing extinction trends. A few legal tweaks and a bit more funding won't do it. Here, very briefly, are some of the deeper changes needed.

Ambition: The much-criticised draft of *Australia's Strategy for Nature 2018-2030* exemplifies the current lack of ambition for saving Australia's wildlife. It is weak and vague, a strategy for business as usual, not fit for dealing with an extinction crisis. The country needs an ambitious strategy demonstrating a strong commitment to avoid any more extinctions and to reverse the current extinction trends. The strategy needs to be tempered by realism, of course, but also recognise the potential to make great strides and achieve breakthroughs when there is sufficient commitment. An example of the sort of ambition needed is 'Predator Free 2050', New Zealand's plan to eradicate the country's most damaging introduced predators.

Inspiration and leadership: Currently, very low political and cultural priority is given to saving species, apart from icons such as the koala. The goal to solve Australia's extinction crisis must be given national prominence. It should be promoted as an important nation-building endeavour for all Australians and governments. What could be more patriotic than saving the species that make Australia unique? The appointment of a threatened species commissioner as a champion for threatened species has improved national leadership but has not been backed up with other elements indicative of a national priority.

Learning from successes and failures: An important part of improving Australia's performance is to learn from both successes and failures. For example, there should be analysis of the factors contributing to effective threat abatement and species recovery. We should also learn as much as we can from the ultimate failure – when a species goes extinct. We endorse the proposal by Woinarski et al. (2017) for a process equivalent to a coronial inquiry each time a species goes extinct – 'to identify what went wrong, and how laws, policies and practices can be improved to reduce the likelihood of future extinctions' (this reference is provided as **Attachment 4**).

Monitoring and analysis: Effective strategies and plans need to be underpinned by comprehensive up-to-date information and detailed analysis. Yet, most threatened species and the threats they face are poorly monitored or not monitored at all and we often lack the sort of analysis needed to inform plans such as the cost of options and long-term prospects for development of effective control options.

Forecasting and prevention: Many future threats can be predicted and measures put in place to prevent them. However, our institutions and policies tend to prioritise existing major threats, and conservation responses are typically reactive, often too little far too late. The adoption of precautionary, preventative and risk-based policies, such as strong biosecurity to prevent new harmful invasive species and respond quickly to new arrivals, will reduce future threats. The recent

national biosecurity review recommended that environmental biosecurity be considerably strengthened (Craik 2017). One essential element of prevention is forecasting (horizon scanning, for example) to enable proactive responses to the changing nature of threats, including social and technological changes, increasing global trade and travel, population growth and climate change. The 10-year review of the EPBC Act recommended the establishment of a forecasting unit within the federal environment department (Hawke 2009).

Appropriate institutions: We endorse the proposal of the Places You Love Alliance for an independent Sustainability Commission to undertake tasks such as species recovery and threat abatement planning. This should foster continuity, and partly overcome problems of political short-termism and political interference.

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Report author: Tim Low

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Contact

Andrew Cox, CEO
Email: contact@invasives.org.au
Phone: 0438 588 040

invasive species council

Introduction

Report author Tim Low

Australia has an invidious reputation as a place of extinction, having lost more mammal species than any other country. Foxes and feral cats are blamed for most of the losses. Australia's smaller mammals proved very vulnerable after evolving in isolation on a continent lacking carnivores that operate like these. The same isolation has left Australia's wildlife susceptible to any number of introduced organisms, including cane toads with their unusual toxins, trout released into rivers, hoofed animals, wolf snakes on Christmas Island, and exotic diseases. Weeds too have caused much harm, displacing rare plants and transforming threatened ecological communities.

Habitat loss is often assumed to be the main threatening process in Australia, but the evidence indicates that invasive species have caused the most animal extinctions, and pose the main threat to some animal groups. The evidence for this comes from a number of sources and is summarised here, firstly as it applies to threatened species (drawing upon three studies), secondly to threatened ecological communities, and thirdly to extinct animals. The global extinction record is also mentioned.

A fox on the hunt in Edithvale wetlands, Victoria.
Photo: Frankzed – Flickr | creativecommons.org/licenses/by/2.0/

Threatened species

The problems facing Australia's threatened species were assessed by seven university researchers in a detailed study published in 2011[1]. They started with the 1700 species of animals and plants listed by the Australian Government as threatened under the Environmental Protection and Biodiversity Conservation Act. They obtained information about threats from a wide range of documents, including recovery plans, threat abatement plants and species profiles. Data was available for 1137 species.

Threats were ordered into eight categories. These included 'Introduced species' and 'Disease'. Because most diseases are caused by introduced pathogens, these qualify as a subset of invasive organisms. The three disease-causing organisms doing the most harm to native species – the chytrid fungus (*Batrachochytrium dendrobatidis*) that has caused frog extinctions, root rot or dieback fungus (*Phytophthora cinnamomi*), and myrtle rust (*Uredo rangelii*) – are all introduced.

The top five threats are shown in Table 1. Introduced plants and animals threaten more than three-quarters of the listed amphibians, birds and mammals and more than half the plants, fish, reptiles and invertebrates. They pose the second highest level of threat for all categories, except frogs (amphibians), for which they rate highest. Had diseases been grouped with introduced species, invasive organisms would probably have emerged as the number one category for mammals as well as frogs. (Most species face more than one threat, so adding Introduced species to Disease would double-count some species. It is also the case that some diseases, such as Psittacine circoviral disease of parrots, and Tasmanian devil facial tumour disease, are not introduced.)

The researchers noted that the number of threatened species in Australia suffering from introduced plants or animals, almost two-thirds of the total, is much higher than in most countries.

The difficulties faced by Australia's mammals were comprehensively reviewed in a major book, The Action Plan for Australian Mammals 2012, written by three leading mammologists and sponsored by the Australian environment department[2]. Noting that many threatened species are declining for multiple reasons, the authors developed a scoring system to assess level of impact. Invasive animals pose such a high level of threat that several of them (cats, red foxes, cane toads, black rats, dingoes/wild dogs) were scored individually and ranked in a table[3] that compared the major threats.

Feral cats emerged as the number one problem for Australia's threatened mammals, with red foxes in third place. (Inappropriate fire regimes came second and habitat loss fourth.) Of the top ten threats, another three involve invasive species: dingoes/wild dogs (7th place), habitat degradation by livestock and feral herbivores (8th) and poisoning by cane toads (9th).

The threats facing plants were assessed in a 2007 study by five academics[4]. They found that habitat loss was the main threat to plants in the past, matching the 2011 study. But they analysed their data by separating past threats from current and future threats, and here a different picture emerged. About 250 plant species are

The three disease-causing organisms doing the most harm to native species – the chytrid fungus, root rot and myrtle rust – are all introduced.

Chytrid fungus has caused six frog extinctions in recent decades, including those of the northern gastric brooding frog (*Rheobatrachus vitellinus*),and southern day frog (*Taudactylus diurnus*), both found in Queensland rainforest, the latter close to Brisbane. Photos: Hal Cogger

Feral cats are the number one problem for Australia's threatened mammals. Photo: Mark Marathon | creativecommons.org/licenses/by-sa/4.0/deed.en

currently threatened by land clearing, compared to about 175 threatened by weed invasion, some 120 threatened by feral grazing, and about 80 threatened by disease (namely introduced *Phytophthora*[5]). Many plants face multiple threats, so it is not possible to add numbers together and conclude that invasive species threaten more species than habitat loss, though that is likely to be the case.

The stark difference between past and current and future threats applies because land clearing has declined over time, while the impacts of invasive species have increased as their numbers and distributions increased. South-western Australia is one region where this is very apparent. Past clearing for wheat and sheep left many plant species surviving precariously on roadsides and in small reserves, where, although protected from further clearing, they face serious threats from weed invasion and *Phytophthora* infection. Unfortunately the phosphite spray used to kill Phytophthora fertilises the soil, increasing weed invasion.

Climate change is often not included as a threat category in Australian assessments. It was included in the mammal assessment, but ranked much lower than cats and other invasive species. Its omission from plant assessments was noted in the 2007 study.

In combination these studies show that invasive species are the top- or second-rated threat for Australia's plants and animals listed as nationally threatened.

TABLE 1. PERCENTAGE OF SPECIES HARMED BY THE MAJOR THREATS TO AUSTRALIAN BIODIVERSITY

	Taxonomic group							Habitat		
	Vascular plants	Amphibians	Birds	Fish	Mammals	Reptiles	Invertebrates	Terrestrial	Freshwater	Marine
Threat	(n=975)	(n=22)	(n=104)	(n=43)	(n=84)	(n=48)	(n=22)	(n=1157)	(n=82)	(n=60)
Habitat loss	79.8	72.7	87.5	81.4	79.8	91.7	77.3	81.2	80.5	76.7
Introduced species	56.4	86.4	80.8	67.4	76.2	70.8	54.5	59.9	74.4	65
Inappropriate fire regimes	45.9	36.4	42.3	-	44	31.3	54.5	47.3	19.5	1.7
Disease	13.9	72.7	29.8	7	11.9	6.3	-	13.9	23.2	31.7
Pollution	10.9	31.8	22.1	32.6	9.5	27.1	22.7	9.3	36.6	63.3
Over-exploitation	14.8	18.2	49	41.9	27.4	27.1	22.7	16.8	18.3	80

Table 3. Summary of the prevalence of eight major threats to Australia's threatened species, expressed as the percentage of species affected by taxonomic group and habitat.

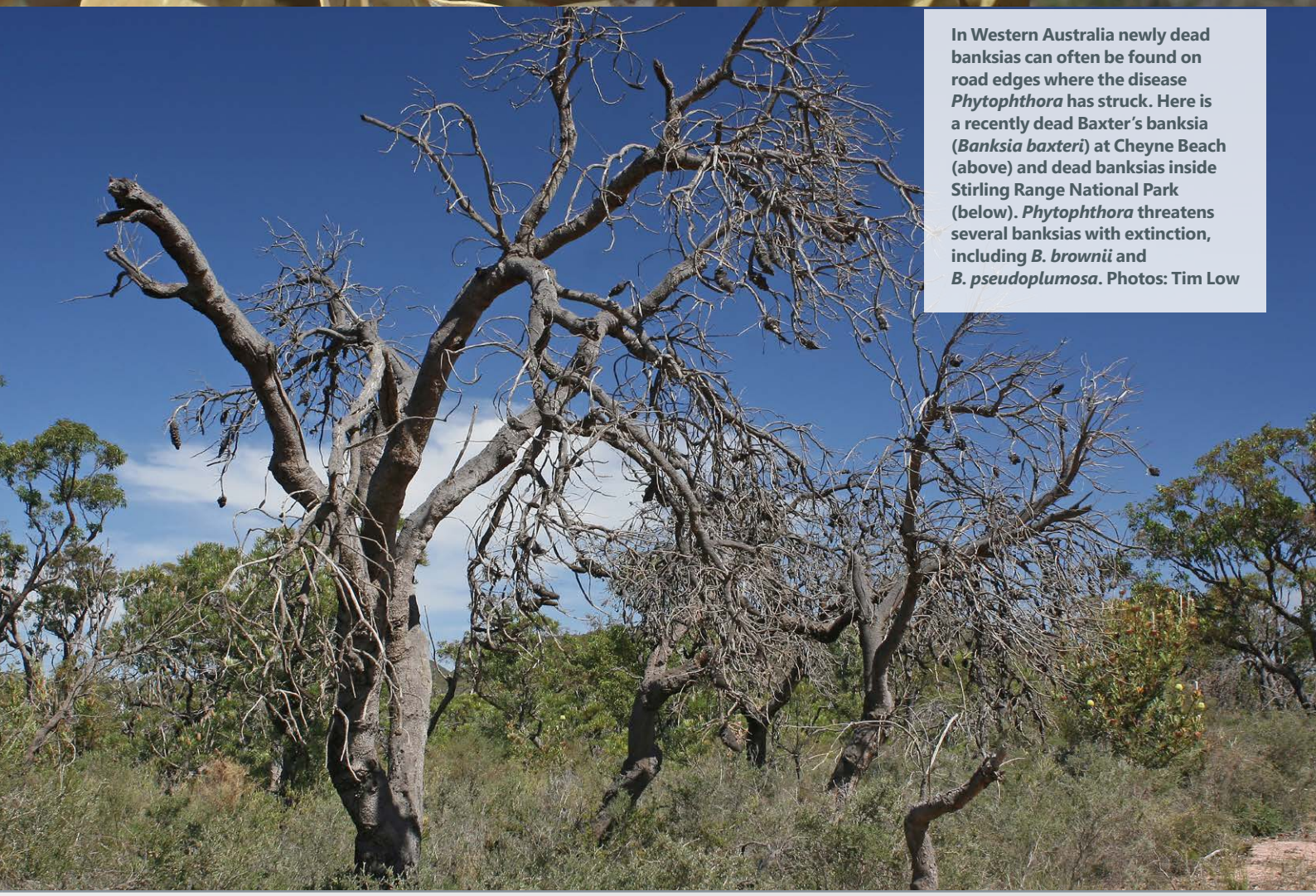
Threatened ecological communities

A typical plight for ecological communities is that small remnants survive land clearing, only to succumb to weed invasion and diseases. Australia has about 80 communities on the EPBC Act list of Endangered Ecological Communities, and to gain an indication of how many face threats from invasive species, the first 30 listed alphabetically as at May 2016 were considered.

The review of these listings and the associated recovery plan shows that all but six of these face threats from invasive species. Weeds were listed as a threat to 20 of the 30 communities. Other threats include *Phytophthora*, rabbits, feral horses and myrtle rust. Of the six communities in the sample that do not face threats from invasive species, four are root mat communities confined to caves.

Examples of ecological communities under threat from invasive species include the Banksia Woodlands of the Swan Coastal Plain (endangered), the Blue Gum High Forest of the Sydney Basin Bioregion (critically endangered), and Brigalow (endangered). Invasive species often interact with other threats. In Brigalow, for example, fires that kill the trees are a problem, but only because remnant brigalow stands are invaded by highly flammable introduced grasses such as buffel grass (*Pennisetum ciliare*), Rhodes grass (*Chloris gayana*) and green panic grass (*Megathyrsus maximus*).

Weeds were listed as a threat to 20 of the 30 communities. Other threats include Phytophthora, rabbits, feral horses and myrtle rust.



In Western Australia newly dead banksias can often be found on road edges where the disease *Phytophthora* has struck. Here is a recently dead Baxter's banksia (*Banksia baxteri*) at Cheyne Beach (above) and dead banksias inside Stirling Range National Park (below). *Phytophthora* threatens several banksias with extinction, including *B. brownii* and *B. pseudoplumosa*. Photos: Tim Low

Extinct animals

The Action Plan for Australian Mammals 2012 provides the most up to date list of extinct mammals, and also analyses extinction causes[7]. Of the 28 completely extinct mammals it lists, no evidence is available to explain one extinction (Dusky flying-fox), although disease was mentioned as a possibility. Of the 27 species for which an interpretation was possible, invasive species was the main cause of extinction for 22, and a probable or possible factor in the extinction of all the others. Cats and foxes are blamed for most extinctions, although an invasive pathogen caused the demise of two island rodents[8]. Habitat loss was the main cause of extinction of only one species, the Toolache wallaby. Habitat degradation caused by livestock and feral herbivores is thought to have contributed to a number of extinctions in a subsidiary role.

Australia's extinct birds are listed on the Australian Department of the Environment's website as part of the EPBC Act List of Threatened Fauna[9]. Australia has seven bird species listed as extinct under the EPBC Act (this excludes extinct subspecies, and species that survive overseas)[10]. The threats to these birds are listed under recovery plans (see Table 3) and they show that black rats have been the main cause of extinction of birds in Australia.

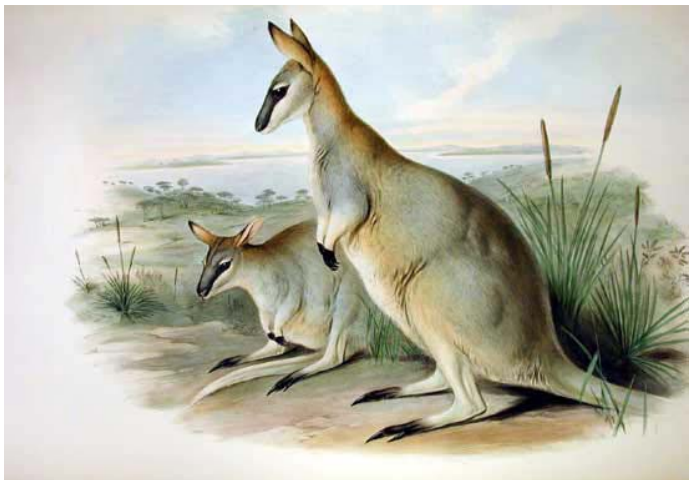
This is consistent with a study of bird extinctions around the world since the year 1500, which found that invasive species had caused more extinctions of bird species and subspecies (58.2 per cent altogether) than any other cause.[11] Hunting and trapping caused the second largest number of extinctions. Rats and feral cats on islands were the introduced species responsible for most losses.

Australia has one completely extinct reptile and another two species that are extinct in the wild but survive in captivity. These reptiles, all from Christmas Island, do not yet appear on the EPBC Act list of extinct species but their demise is well-documented by biologists[12] so it is included here. They are the Christmas Island forest skink (*Emoia nativitatus*) and blue-tailed skink (*Cryptoblepharus egeriae*), last seen in the wild in 2010, and Lister's gecko (*Lepidodactylus listeri*), which disappeared a year or so later. The forest skink is completely extinct but the other two species survive in captive colonies. A fourth lizard, the Coastal Skink (*Emoia atrocostata*), also disappeared from the island, but this species, as currently defined, survives in north Queensland, New Guinea and Asia. There are suspicions that the Christmas Island form represented a separate species, but this cannot be confirmed because no specimens were collected before its demise.

A team of eight biologists who analysed the lizard declines blame their demise on introduced predators.[13] Three Asian wolf snakes (*Lycodon capucinus*) captured a few weeks before blue-tailed skinks were last seen in the wild had the skinks in their stomachs. A Lister's gecko was also found in a wolf snake's stomach, at the last site from which both lizard species were seen. Wolf snakes were first reported on the island in the 1980s, and

Three Asian wolf snakes (*Lycodon capucinus*) captured a few weeks before blue-tailed skinks were last seen in the wild had the skinks in their stomachs. A Lister's gecko was also found in a wolf snake's stomach, at the last site from which both lizard species were seen.

Pig-footed bandicoot. Illustration: John



Toolache wallaby. Illustration: John Gould

Extinct Mammals	Main Proposed Threats
Thylacine (*Thylacinus cynocephalus*)	Hunting
Pig-footed bandicoot (*Chaeropus ecaudatus*)	Cats, foxes
Desert bandicoot (*Perameles eremiana*)	Foxes, cats
Yallara (lesser bilby) (*Macrotis leucura*)	Foxes, cats
Desert bettong (*Bettongia anhydra*)	Foxes, cats
Nullarbor dwarf bettong (*Bettongia pusilla*)	Cats, foxes
Desert rat-kangaroo (*Caloprymnus campestris*)	Foxes, cats
Broad-faced potoroo (*Potorous platyops*)	Cats, exotic disease
Central hare-wallaby (*Lagorchestes asomatus*)	Foxes, cats
Eastern hare-wallaby (*Lagorchestes leporides*)	Foxes
Toolache wallaby (*Macropus greyi*)	Habitat loss
Crescent nailtail wallaby (*Onychogalea lunata*)	Foxes, cats
Dusky flying-fox (*Pteropus brunneus*)	Hunting, habitat loss
Lord Howe long-eared bat (*Nyctophilus howensis*)	Black rats
Christmas Island pipistrelle (*Pipistrellus murrayi*)	Invasive species & poisoning
White-footed rabbit-rat (*Conilurus albipes*)	Cats
Capricorn rabbit-rat (*Conilurus capricornensis*)	Cats
Lesser stick-nest rat (*Leporillus apicalis*)	Cats
Short-tailed hopping-mouse (*Notomys amplus*)	Cats
Long-tailed hopping-mouse (*Notomys longicaudatus*)	Cats
Large-eared hopping-mouse (*Notomys macrotis*)	Cats
Darling Downs hopping-mouse (*Notomys mordax*)	Cats
Broad-cheeked hopping-mouse (*Notomys robustus*)	Cats, habitat degradation
Long-eared mouse (*Pseudomys auritus*)	Cats
Blue-gray mouse (*Pseudomys glaucus*)	Habitat loss, cats
Gould's mouse (*Pseudomys gouldii*)	Cats
Maclear's rat (*Rattus macleari*)	Trypanosome disease

Table 2. Australia's Extinct Mammals. The main proposed threats are those listed as having the highest consequence rating (usually 'catastrophic'). The common names used follow Strahan and Van Dyck (2008).

blue-tailed skinks began declining from near the port soon after. Cats, black rats and Asian giant centipedes were blamed for contributing to the decline, perhaps operating in concert as a 'super predator'. That all four lizards disappeared from inside a large national park provides a graphic example of how habitat protection does not guarantee species survival if invasive species run free.

The EPBC Act lists four frogs as extinct – the southern gastric brooding frog (*Rheobatrachus*

Extinct Birds	Main Threat
Tasman Starling	Black rat
Lord Howe Gerygone	Black rats, or introduced disease
Norfolk Island Kaka	Hunting
White Gallinule	Hunting
Paradise Parrot	Burning, overgrazing, drought, etc.
White-chested White-eye	Black rats and habitat loss
Robust White-eye	Black rats

Table 3. Australia's Extinct Bird Species.

White-chested white-eye. Illustration: John Gould

silus), northern gastric brooding frog (*Rheobatrachus vitellinus*), sharp-snouted day frog (*Taudactylus acutirostris*) and southern day frog (*T. diurnus*). The Australian threat abatement plan for Chytridiomycosis, the disease caused by chytrid fungus, says the loss of all four species is consistent with an epidemic of chytridiomycosis.[14] Another two species, the mountain mist frog (*Litoria nyakalensis*), not seen since 1990, and the northern tinker frog (*T. rheodactylus*), are also feared extinct due to the disease.[15]

Chytrid fungus is recognised as an agent of extinction in Central and South America as well as Australia[16], with claims it represents the 'greatest threat to biodiversity of any known disease'[17]. The Australian government has produced a threat abatement plan to tackle it.

The EPBC Act lists one fish as extinct in the wild, the Pedder galaxias (*Galaxias pedderensis*). It thrived after the flooding of Lake Pedder, until the water body was invaded by introduced brown trout and native climbing galaxias, neither fish having occurred in the lake before[18]. This disappearance can be largely attributed to invasive trout, which are blamed for several dramatic galaxias declines[19], although the Pedder galaxias did not go extinct because some were released in Lake Oberon where they survive today in the absence of trout.

The EPBC Act lists only one extinct invertebrate (an earthworm), but this underestimates the situation. To give one example, the Lord Howe Island Biodiversity Plan (2007) mentions ten extinct beetles and an extinct snail in its own genus (*Epiglypta howinsulae*)[20]. This plan blames black rats for the extinction of the snail, and mentions them as a possible explanation for the loss of the beetles.

Black rats are considered a serious threat to endangered snails on Lord Howe Island. One that is extinct already is *Epiglypta howinsulae*. Photo: Toby Hudson

In the absence of proper data it is not possible to assess the main cause of invertebrate extinctions in Australia.

No analysis is provided here of extinct plants, because of difficulties in assessing threatening processes. Consistent with the analysis by Burgman et al. (2007), any such assessment would probably conclude that habitat loss has been the major cause of plant extinctions.

Table 4 shows the extinctions caused by invasive species by category. Only those extinctions attributed mainly to invasive species are included. Only one vertebrate species, the toolache wallaby, has succumbed mainly to habitat loss.

i) The NEBRA sets out emergency response arrangements, including cost-sharing arrangements, for biosecurity incidents which predominantly affect the environment and/or social amenity, and where the response is largely for public benefit. This includes marine pest incidents.

Threat	Species Lost	Percentage of all recognised extinctions
Cats and/or red foxes	18-20 mammals	64-71% of mammals
Black rats	3-4 birds 1 mammal 1 snail	43-57% of birds 4% of mammals
Chytrid fungus	4-6 frogs	100% of frogs
Trypanosome disease	2 mammals	7% of mammals
Wolf snake & other predators	1-4 lizards	100% of lizards
Total	**30-38**	**~75% (vertebrates)**

Table 4. Invasive Species and Number of Extinctions they have caused in Australia.

Fox. Terry Spivey Photography

The table shows that invasive species have been overwhelmingly the main cause of animal extinctions in Australia, primarily responsible for at least three-quarters of the mammal losses, about half the bird losses and all frog and lizard losses.

Under the EPBC Act, 37 plant species are listed as extinct. For 33 species, the reasons for extinction are unknown or not recorded. Loss of habitat, changes to hydrology, grazing and small populations are variously noted as the likely causes for extinction of the other four species.

Introduced species also rank very highly as a cause of global extinctions. A study of extinctions since AD 1500 of plants, amphibians, reptiles, birds and mammals, using data from the IUCN Red List, found that introduced species were 'the second most common threat associated with species that have gone completely extinct'[21]. They rated as the most common threat blamed for extinctions of mammals, reptiles and amphibians, and for vertebrates generally.

A 2016 review of the IUCN Red list found that invasive predators were implicated in extinctions around the world of 87 birds, 45 mammals and 10 reptiles – representing 58% of these groups' contemporary extinctions. Invasive mammalian predators endanger a further 596 species at risk of extinction, with cats, rodents, dogs, and pigs threatening the most species overall.[22]

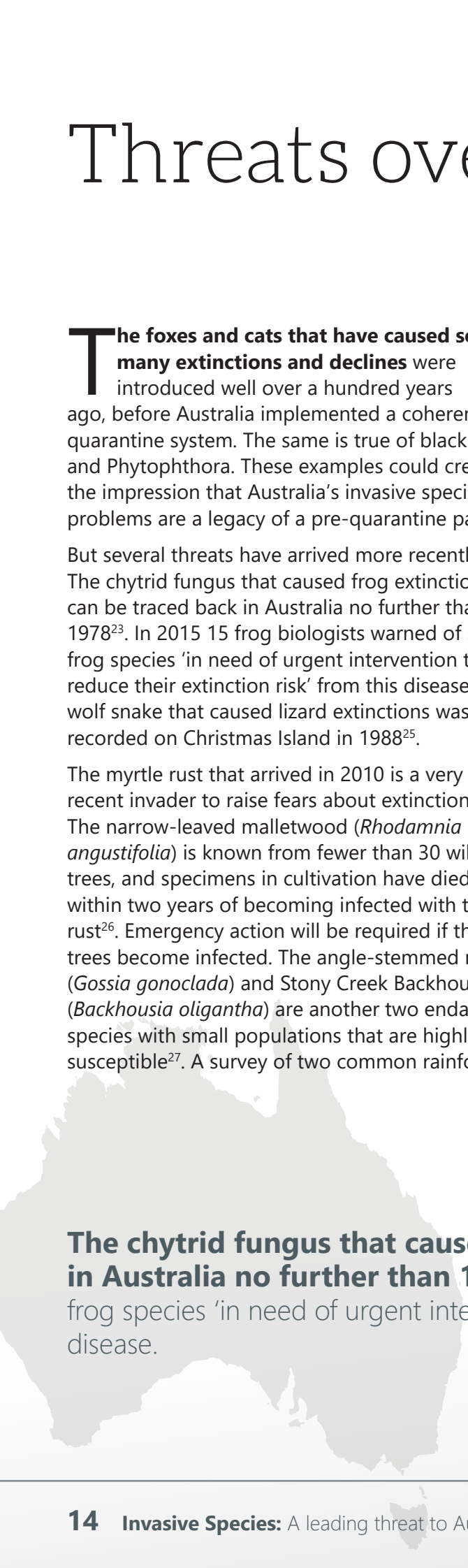
Threats over time

The foxes and cats that have caused so many extinctions and declines were introduced well over a hundred years ago, before Australia implemented a coherent quarantine system. The same is true of black rats and Phytophthora. These examples could create the impression that Australia's invasive species problems are a legacy of a pre-quarantine past.

But several threats have arrived more recently. The chytrid fungus that caused frog extinctions can be traced back in Australia no further than 1978[23]. In 2015 15 frog biologists warned of seven frog species 'in need of urgent intervention to reduce their extinction risk' from this disease[24]. The wolf snake that caused lizard extinctions was first recorded on Christmas Island in 1988[25].

The myrtle rust that arrived in 2010 is a very recent invader to raise fears about extinction. The narrow-leaved malletwood (*Rhodamnia angustifolia*) is known from fewer than 30 wild trees, and specimens in cultivation have died within two years of becoming infected with the rust[26]. Emergency action will be required if the wild trees become infected. The angle-stemmed myrtle (*Gossia gonoclada*) and Stony Creek Backhousia (*Backhousia oligantha*) are another two endangered species with small populations that are highly susceptible[27]. A survey of two common rainforest trees affected by the disease – native guava (*Rhodomyrtus psidioides*) and brush turpentine (*Rhodamnia rubescens*) – found 'Severe infection and crown loss, dieback and tree mortality … across their entire native range', resulting in 57% of native guava trees that were inspected dying in less than five years[28]. The authors of this study raised the prospect that both trees will be listed as threatened, even though they are currently common. There are other forms of myrtle rust that may enter Australia in future and kill other plants, including young eucalypts, as is happening in plantations in South America, where the rust originated.

Another serious disease has arrived even more recently. An unidentified bacterial infection is killing critically endangered Lister's geckoes (*Lepidodactylus listeri*) on Christmas Island. Recorded in October 2014, this pathogen was not detected on the island during a disease assessment conducted by Taronga Zoo in 2010. As noted earlier, Lister's gecko recently became extinct in the wild, with Asian wolf snakes attracting most blame, and the species survives only in two captive colonies, one on the island and the other at Taronga Zoo. Forty captive geckoes on the island have died, representing a 100% mortality rate among those infected. There are now fears this disease will reach mainland Australia.



The chytrid fungus that caused frog extinctions can be traced back in Australia no further than 1978. In 2015 15 frog biologists warned of seven frog species 'in need of urgent intervention to reduce their extinction risk' from this disease.

The Christmas Island forest skink (*Emoia nativitatis*) became extinct in May 2014 when the last individual died in captivity. Abundant in the 1990s, when 80 could be seen around a single fallen tree, it went into freefall after Asian wolf snakes appeared on the island in the 1980s. Photo: Hal Cogger

Conclusion

As shown above, analyses of available information indicate that invasive species are the main threat facing Australia's declining mammals and frogs, and possibly its plants. Invasive species have been the main cause of extinction of Australia's mammals, birds, reptiles and frogs, and of animals generally. The invasive species causing the most extinctions have been feral cats, red foxes, black rats, chytrid fungus and a trypanosome disease. A wide range of other invasive species are thought to have contributed to some extinctions. This compares with only one vertebrate extinction blamed mainly on habitat loss, that of the toolache wallaby.

If greenhouse emissions are not curbed, climate change may one day overtake invasive species as a cause of extinctions. However, many of its impacts on biodiversity are likely to come by exacerbating invasive species threats. Australia's 2011 state of the environment report said that under climate change the 'current replacement of native species with a smaller number of introduced species capable of supporting a narrower range of ecological functions will intensify. An explosion in the number and impacts of invasive species is plausible ....'.[29] This report notes that the most frequently cited threats in listings under the EPBC Act and in resulting recovery plans are habitat fragmentation and invasive species.

The evidence provided here justifies a stronger focus on invasive species by governments and conservation groups. A very strong focus on biosecurity is justified to prevent future threats. Although some of the species causing and threatening extinctions arrived in Australia a long time ago others are more recent, having entered in the 1970s, 1980s and within the last decade.

The purpose of this report is not to rank threats precisely, but to demonstrate the major role of invasive species in biodiversity loss, and highlight a point often made: that invasive species, along with habitat loss and potentially climate change, represent the three main threats to biodiversity. Before climate change became a front-line issue invasive species were ranked one of the top two threats[30]. Climate change represents a growing threat to Australia's wildlife, and the same holds true of invasive species, since their numbers keep increasing and their impacts keep expanding.

The evidence provided here justifies a stronger focus on invasive species by governments and conservation groups. A very strong focus on biosecurity is justified to prevent future threats.

Scrub myrtle (*Rhodamnia rubsecens*) has been so badly hit by myrtle rust since the disease reached Australia in 2010 that is was nominated for listing as critically endangered. Photo: Tim Low

Endnotes

1 Evans et al. (2011)
2 Woinarski, Burbidge and Harrison (2014)
3 Page 871 of Woinarski, Burbidge and Harrison (2014)
4 Burgman et al. (2007)
5 The Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi lists more than 80 plants threatened by this introduced pathogen (see http://www.environment.gov.au/biodiversity/threatened/publications/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi)
6 Johnson (2006)
7 Woinarski, Burbidge and Harrison (2014)
8 Wyatt et al. (2008)
9 http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna
10 Two dwarf island emus are not included here given evidence they qualify as subspecies of the living emu (Heupink et al. 2011)
11 Szabo et al. (2012)
12 Smith et al. (2012), Director of National Parks (2014), Low (2013), Woinarski et al. (2014)
13 Smith et al. (2012)
14 Department of the Environment and Heritage (2006)
15 Low (2013)
16 Berger et al. (1998), Lips et al. 2006, Skerratt et al. (2007), Berger et al. (1999)
17 Wake and Vredenburg (2008)
18 Crook et al. (1997), http://www.environment.gov.au/node/16477
19 Crook et al. (1997)
20 Department of Environment and Climate Change (2007)
21 Bellard et al. (2015)
22 Doherty et al. (2016)
23 Weldon et al. (2004) examined museum frog specimens to arrive at this date.
24 Skerratt et al. (2016)
25 Fritts (1993)
26 Pegg et al. (2014)
27 Pegg et al. (2014)
28 Carnegie et al. (2015)
29 SoE report
30 Wilcove et al. (1998), Walker & Steffen (1997), Sandlove et al. (2001), World Resources Institute (1992)

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CONTACT US

- web: invasives.org.au
- email: contact@invasives.org.au

@ISCAustralia

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invasive species council

ABN 27 101 522 829

KTPs & TAPs

Australia's failure to abate threats to biodiversity

DISCUSSION PAPER: MAY 2018

invasive species council

Keeping nature safe from dangerous new invaders

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Inquiries

Invasive Species Council

PO Box 166, Fairfield Vic 3078, Australia

Email: contact@invasives.org.au | Web: invasives.org.au | ABN: 27 101 522 829

About the Invasive Species Council

The Invasive Species Council was formed in 2002 to seek stronger laws, policies and programs to keep Australian biodiversity safe from invasive plants, animals, diseases and parasites. The goal is to establish a biosecurity system for Australia that prevents new invasive species and protects Australian species and ecological communities from existing invasive species. The Invasive Species Council is a not-for-profit charitable organisation funded almost entirely by donations from supporters and philanthropic organisations.

Contents

Summary

An invitation to respond

Our aim with this discussion paper is to stimulate discussion within the environment sector (government and non-government) about the changes needed to strengthen Australia's threat abatement processes. We invite feedback and ideas. We hope to hold a workshop in 2018 to develop a conservation sector proposal for reform.

The importance of KTPs and TAPS

Australia's national processes to protect and recover threatened biodiversity are failing. One major reason for this are deficient processes for mitigating major threats – listing key threatening processes (KTPs) and preparing and implementing threat abatement plans (TAPs) under the *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act).

KTP listings are intended to identify major threats to biodiversity and, through a TAP or other processes, drive collaborative national action to mitigate those threats. Currently, 21 KTPs are listed. Collectively, they imperil thousands of threatened species and ecological communities.

In this discussion paper we ask the following questions:

- *How systematic and efficient is the process for listing KTPs?*
- *How effective is threat abatement through the KTP/TAP processes?*
- *What needs to change?*

Invasive species as KTPs

We focus in particular on invasive species, which make up two-thirds of the listed KTPs. A KTP/TAP type process is often the only effective way to address invasive species threats, for abatement is often ecologically, technically and socially complex, and needs to involve several jurisdictions and sectors. We particularly need federal leadership for invasive species threats that are poorly addressed by the states and territories.

How systematic and efficient is the KTP listing process?

Limited coverage of major threats

We cannot save species and ecological communities without abating the major causes of decline. But there are no KTP listings for inappropriate fire regimes, altered hydrological regimes or grazing; the land clearing KTP has no TAP; and the majority of invasive species threats are encompassed within the 'novel biota' KTP, a moribund listing that lacks a TAP. This means the KTP/TAP system is not applied for most major threats to biodiversity and only partially for invasive species (now the leading threat according to a soon-to-published study).

Another limitation of the listing process is that it does not recognise threats to other 'matters of national environmental significance' protected under the EPBC Act, including migratory species, Ramsar wetlands and world heritage areas.

Stymied listing of invasive species

For the past 6 years at least, there has been a refusal to assess invasive species KTP nominations or list any more invasive KTPs. The main reason given in 6 cases is that invasive species threats are encompassed within a catch-all 'novel biota' KTP (listed in 2013). In a 7th case, the environment minister refused to list the KTP, contrary to advice by the Threatened Species Scientific Committee.

Encompassing invasive species threats in the novel biota KTP would be acceptable if it led to coordinated action to address the threats of high priority invasive species. But this has not occurred. Stymieing further invasive species listings appears to be a deliberate strategy to limit funding demands because there is far too little funding for abating the already-listed KTPs.

Slow, tedious and ad hoc KTP listing processes

The listing of KTPs is mostly ad hoc, relying on public nominations and ministerial prerogative, and the assessment processes are slow and tedious. The 3 KTP listings of the past decade (excluding the novel biota KTP nominated by the scientific committee) have taken 3–4 years from nomination to listing. Two rejected nominations took 5 and 7 years to complete, and one nomination still under assessment is more than 10 years old.

The rate of KTP listings and development of TAPs has greatly slowed in recent years. Six KTPs were listed prior to 2000 (carried over from the previous law) and 12 were listed during the first decade of the EPBC Act (2000-2009). Since then (2010-2018), there have been just 3 KTP listings. No KTP nomination since 2011 has even been assessed. The environment minister can ignore advice from the Threatened Species Scientific Committee about which nominations should be assessed.

How effective is threat abatement through TAPs?

Moribund KTP listings

Almost a third (6) of listed KTPs have no TAP – due to the environment minister deeming that a TAP is not 'a feasible, effective or efficient way' to abate the threat. This could be acceptable if there were already effective processes for abating those threats (as verified by monitoring). But this is mostly not the case. The threat level for KTPs without TAPS – particularly land clearing, climate change, escaped garden plants, noisy miners and novel biota – are all likely to have increased since their listings. There is no requirement to show that alternative abatement processes are effective, to monitor abatement progress, or to initiate action if existing processes prove ineffective.

Limited abatement progress

Due to a lack of monitoring and regular reporting, the only feasible way of assessing the effectiveness of most threat abatement efforts is through the 5-yearly reviews of TAPs required under the EPBC Act. But only half the KTPs can be assessed in this way: 6 KTPs lack a TAP and 4 TAPs have not been reviewed despite being overdue by 1–4 years for review (or their reviews have not been made publicly available).

Eleven TAPs (52%) have been reviewed at least once, although only 3 by independent reviewers. Those reviews indicate that good progress was achieved for 4 TAPs, moderate progress for 4 TAPs and poor progress for 3 TAPs. One KTP for which moderate progress was reported, feral cats, has recently been subject to improved abatement effort. Overall, fewer than half of KTP listings have resulted in moderate to good progress on threat abatement.

Nonetheless, the examples of good abatement progress demonstrate that major threats to Australian biodiversity are surmountable. We do not know what distinguishes the effective TAPs, for no analysis has been done to determine the elements of success, and the TAP may not have been the main driver of abatement effort in all cases.

Slow TAP processes

TAP development is very slow. It has taken an average 4 years to prepare or revise TAPs for the 9 KTPs listed since 2001 that have a TAP. Most TAPs are reviewed within 5–6 years, but then it often takes several years for TAPs to be revised after a review. It took 8 years in the case of the root-rot fungus KTP, and 5 years after a ministerial decision to revise the fox TAP, the plan has still not been updated. Of 15 existing TAPs, 60% (9) are more than 6 years old and 27% (4) are 10 years old. This means that only about one-third of KTPs have an up-to-date TAP.

Limited obligations and accountability

Although the Australian Government has international obligations to abate threats to biodiversity, there is no obligation under the EPBC Act to list the major threats or act on them. The environment minister has complete discretion about whether to accept the advice of the Threatened Species Scientific Committee to assess a KTP nomination, list a KTP or prepare a TAP. The minister can also delay decisions for years and starve the assessment processes of funding. This means our national system for recognising and abating threats is highly vulnerable to political interference. The same vulnerability applies to the listing of threatened species and ecological communities and preparation of recovery plans.

Moreover, KTP listings come obligation free. Even if the minister decides that a TAP should be prepared, the EPBC Act obliges the federal government to do little to implement it, apart from in Commonwealth areas. A KTP listing or TAP also does not generate any obligations for other governments, landholders or anyone whose actions may exacerbate the KTP. There are no requirements for the federal government to monitor or report on KTP status. The one reporting obligation is the 5-year review of each TAP, but with no requirement for this review to be independent.

Limited leadership, commitment and funding

Although the federal government is limited in the extent to which it can compel other governments or individuals to undertake threat abatement, it can apply considerable pressure through strong leadership, incentives and funding for abatement, and use of its own laws to partially compensate for state or territory failings. These have been largely missing in KTP/TAP processes. Abating KTPs has been a low federal government priority.

The government unit responsible for administering KTPs and TAPs should be a well-funded, central hub of activity. Instead, as is evident in the slowness of its processes, it is small and threadbare.

Leadership has improved to some extent with the appointment of a Threatened Species Commissioner as a champion for threatened species and facilitator of partnerships. This has generated considerable focus on the feral cat KTP (and a modest level of additional funding for abating that threat) and a small proportion of threatened species.

There is no information about how much Australia spends on abatement (from government and non-government sources), and there has never been an estimate of how much is needed to properly implement abatement plans. However, it is clear from the limited progress that the gap between available funding and funding needed for implementing TAPs is large.

Changes needed

The fundamentals of the current KTP/TAP model seem sound – that major threats should be listed nationally and that, under federal leadership, a listing should then catalyse a plan and collaborative action to abate the threat. And as demonstrated by some successful TAPs, the current model can work well. The major missing element in the current system appears to be a commitment by the federal government to achieve threat abatement.

As with many other environmental problems requiring federal leadership and funding, it will be difficult to achieve reform in the current political environment. Beyond the work of analysis and advocacy, the conservation sector has much more to do, socially and culturally, so that the decline of Australian species and ecological communities becomes of major national consternation. Extinctions must become anathema to most Australians.

Make threat abatement a high national priority

An essential first step is greater recognition that an effective KTP/TAP system is essential for arresting loss of Australia's biodiversity, and that developing solutions for major threats is typically more effective and more cost-effective than a species-by-species approach, and also benefits myriad other, often poorly known, species at risk from KTPs.

To drive reform of the KTP/TAP system, Australia needs an ambitious (but realistic) conservation strategy that specifies long-term goals for threat abatement. That ambition needs to be then reflected in each of the TAPs.

Enlisting commitment from state and territory governments is essential. The federal government should pursue an intergovernmental agreement with the states and territories to achieve long-term abatement goals for recovery of threatened species and ecological communities.

Such commitment is likely to come only if there is substantial public pressure on governments. As part of a broader effort to elevate conservation as a national priority, we need a social change strategy and involvement of community groups in planning for and contributing to threat abatement and monitoring.

Strengthen governance and accountability

The assessing and listing of KTPs and preparation of TAPs should be free of political influence and not subject to ministerial discretion. We endorse the recommendation by the Places You Love Alliance for an independent National Sustainability Commission to undertake such functions. It is also worth considering co-governance models, such as exemplified by the industry-government partnerships, Animal Health Australia and Plant Health Australia.

More meaningful, independent and regular reporting is needed. The five-yearly TAP reviews are important and, for the sake of credibility and rigour, should be done by expert reviewers independent of government. An annual progress report (based on meaningful abatement indicators) should be presented to the federal parliament. This needs to be underpinned by monitoring of threatening processes and the species and ecological communities at risk.

Systematically list KTPs for all matters of national environmental significance

The KTP list under the EPBC Act should be the authoritative list of major threats to Australian biodiversity. The listing process needs to be more systematic to properly reflect the major threats. A systematic expert process can be supplemented by a public nomination process to fill gaps and keep the KTP list up to date.

Australia's KTP list should be scientifically determined. As with similar processes at the state level, the decision to assess and list a KTP should emerge wholly from an independent scientific process.

The KTP list should expand to recognise threats to other 'matters of national environmental significance' protected under the EPBC Act, including migratory species, Ramsar wetlands and world heritage areas. The list should also more adequately encompass emerging threats (as exemplified by the listing of red imported fire ants as a KTP) to stimulate early cost-effective action before they become entrenched threats.

Strengthen obligations for abatement

For each KTP, it should be mandatory to prepare a TAP (or equivalent) to specify long-term abatement goals and shorter-term targets, the research and actions needed to achieve them and a monitoring regime. A TAP should serve as a national statement of what is needed to achieve abatement and as the basis for monitoring and reporting on the status of the KTP and abatement progress. A TAP should be required even where abatement can best be achieved through existing processes or relies on processes beyond the control or influence of the federal government. This ensures that the federal government takes responsibility under the EPBC Act for specifying the desired conservation direction and monitoring progress.

Federal leadership is needed to encourage commitment by all states and territories to implement TAPs. As with other national priorities, this requires intergovernmental agreements, attractive funding arrangements and good negotiation skills.

If state and territory governments fail to participate in implementing TAPs, the federal government should be obliged to consider options for over-riding or compensatory measures, such as using its own laws to limit land clearing or regulate trade in invasive plants.

Obligations should extend to individuals and corporations. All Australians are bound by the EPBC Act to avoid having a significant impact on matters of national environmental significance. They should also be bound to avoid actions likely to significantly exacerbate a KTP.

Commit to long-term funding to achieve abatement targets

A government demonstrates it is serious about mitigating harms when it is prepared to fund the necessary actions. Highly inadequate funding is currently a major impediment to abating most KTPs. To assess funding needs, each TAP should include an estimate of costs to achieve 10–20-year targets. New funding sources such as levies and taxes should be considered to provide long-term base funding for implementing TAPs.

1. Introduction

1.1 The importance of KTPs and TAPs

Australia's national processes to protect and recover threatened biodiversity are failing. Most criticisms have been directed at failures under the *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act) to develop and implement recovery plans for threatened species and to protect their habitats (1–3).

Equally important but receiving less attention are processes under the EPBC Act for mitigating major threats – listing key threatening processes (KTPs) and preparing and implementing threat abatement plans (TAPs).

A threat can be listed as a KTP if 'it threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community' (4). KTP listings are intended to identify major threats to biodiversity and, through a TAP or other processes, drive collaborative national action to mitigate those threats. Currently, 21 KTPs are listed under the EPBC Act (Table 1). Collectively, these KTPs imperil thousands of threatened species and ecological communities.

There are great conservation benefits in a strong focus on KTPs. Most threatened species have threats in common, and relatively few threats cause most declines – for example, cats and foxes are the major threat to mammals (5); chytrid fungus and habitat loss to frogs (6, 7); rodents and cats to island birds and habitat loss to woodland birds (7–10), and habitat loss, invasive species and inappropriate fire regimes to plants (7) – so abating these threats would help recover large numbers of species.

Although abatement is often difficult and expensive, it is well worth it for the conservation gains and the money and effort saved in the long term. Investing in enduring abatement solutions – for example, better control techniques for invasive species or stricter regulation to protect habitat – is usually far less expensive over the long term than species-by-species efforts. It is also cost effective to abate emerging threats, before they become entrenched.

In this paper we critique the KTP/TAP process, asking the following questions:

How systematic and efficient is the process for listing KTPs?

- Are the major threats listed as KTPs?
- How comprehensively are invasive species covered?
- How efficient are listing processes?

How effective is threat abatement through the KTP/TAP processes?

- What progress has been achieved through TAPs?
- How efficient are TAP processes (development, reviews, revisions)?
- How well do TAPs oblige or facilitate implementation?
- Is there strong federal leadership, commitment and accountability?
- How adequate is funding for TAP implementation?

What needs to change?

- What changes are needed to address current deficiencies?

1.2 An invitation to respond

Our aim with this discussion paper is to stimulate discussion within the environment sector (government and non-government) about the changes needed to strengthen Australia's threat abatement processes. We invite feedback and ideas. We hope to hold a workshop in 2018 to develop a conservation sector proposal for reform.

Table 1. Current listed key threatening processes

Key threatening process[A]	Abbreviated KTP	Year listed	Listed spp/ECs impacted[B]
Competition and land degradation by rabbits	Rabbits	2000	>300
Competition and land degradation by unmanaged goats	Feral goats	2000	56
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Root-rot fungus	2000	144
Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations	Longline fishing	2000	18
Predation by European red fox	Foxes	2000	74
Predation by feral cats	Feral cats	2000	>150
Incidental catch (bycatch) of sea turtles during coastal otter-trawling operations within Australian waters north of 28 degrees south	Otter trawling	2001	3
Land clearance	Land clearing	2001	Not stated
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	Climate change	2001	Not stated
Predation, habitat degradation, competition and disease transmission by feral pigs	Feral pigs	2001	159
Psittacine circoviral (beak and feather) disease affecting endangered psittacine species	Beak & feather disease	2001	16 (11)
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Chytrid fungus	2002	27
Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris	Marine debris	2003	20
The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*	Red fire ants	2003	Not stated
Loss of biodiversity and ecosystem integrity following invasion by the yellow crazy ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean	Yellow crazy ants, Christmas Island	2005	10+
The biological effects, including lethal toxic ingestion, caused by cane toads (*Bufo marinus*)	Cane toads	2005	Not stated
Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha)	Exotic rats on islands	2006	Not stated (~20 extinctions)
Invasion of northern Australia by gamba grass and other introduced grasses	Invasive grasses, north Australia	2009	28
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Escaped garden plants	2010	7[B]
Novel biota and their impact on biodiversity	Novel biota	2013	Not stated
Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*)	Noisy miners	2014	>11

Notes: Ordered per year of listing. Pink highlight = invasive species KTPs. **A.** The list of KTPs is at (12). **B.** This is the number of threatened species (spp.) and ecological communities (ECs) mentioned in the TAP, background information or listing advice. The numbers are often not comprehensive (e.g. the threatened spp/ECs impacted by escaped garden plants is considerably higher than the seven exemplified in the listing advice) and they do not include non-listed species that are also impacted. The novel biota and land clearance KTPs each threaten several thousand listed species and ecological communities (7, 13).

1.3 Invasive species as KTPs

We focus in particular on invasive species, which make up two-thirds of listed KTPs (highlighted in pink, Table 1) and for which TAP processes are particularly important ways of abating threats. Invasive species have been the major cause of animal extinctions in Australia and currently imperil more nationally threatened species than any other type of threat (9, 13). Invasive threats are growing, as acknowledged in the guidelines for the novel biota KTP (prepared by the Threatened Species Scientific Committee): 'Despite a wide range of legislation, plans, strategies and initiatives, the impacts of novel biota on Australian ecosystems are increasing' (14).

A KTP/TAP type process is often the only effective way to address invasive species threats – it is mostly impractical to abate them through legislation, and developing effective abatement methods often requires research and a dedicated long-term focus. Abatement is often ecologically, technically and socially complex, and needs to involve several jurisdictions and sectors. As we told the senate inquiry into the 'Effectiveness of threatened species and ecological communities' protection in Australia' (referred to hereon as the 'threatened species senate inquiry'):

> The only way of addressing a lot of these threats is to do what threat abatement planning is meant to do, which is to bring together the players, agree on a plan, identify the priorities and then start implementing the actions that are needed to address these threats. (15)

Most of the responsibility for managing invasive species that threaten biodiversity rests with state and territory governments and private landholders. We particularly need federal leadership for invasive species threats that are poorly addressed by the states and territories. The Invasive Species Council nominated two KTPs involving invasive species threats being exacerbated by the actions of some state governments – tall wheat grass through being promoted as a pasture grass and feral deer by laws and policies protecting them for hunters (see Table 2 and section 2.2).

2. How systematic and efficient is the KTP listing process?

2.1 Limited coverage of major threats

A study soon to be published has found that invasive species threaten 82% of nationally listed threatened species (13). Other major threats are ecosystem modification, mainly due to changed fire regimes and hydrological regimes (74% of listed species) and agricultural activity (57%). A 2011 analysis using different categories found that habitat loss threatens about 80% of listed species and invasive species and disease about 75% (7). We cannot save species without dealing with these major threats. Yet there are no KTP listings for inappropriate fire regimes or hydrological regimes, or grazing, and land clearing is a listed KTP but has no TAP. And although 14 KTPs are invasive species, a large number of major invasive threats are not listed as individual KTPs, but are instead lumped within the 'novel biota' KTP, a moribund listing without a TAP. This means the KTP/TAP system is not applied for several major threats to biodiversity (habitat loss, changed fire and hydrological regimes, grazing) and only partially for the leading threat (invasive species).

Another limitation of the listing process is that it does not recognise threats to other 'matters of national environmental significance' under the EPBC Act, including migratory species, Ramsar wetlands and world heritage areas.

2.2 Stymied listing of invasive species

Although invasive species make up two-thirds of listed KTPs, the current listings of individual species (e.g. feral pigs) or species groups (e.g. escaped garden plants) are far from comprehensive of major invasive threats. But for the past 6 years at least, there has been a refusal to assess invasive species KTP nominations or list any more invasive KTPs. The main reason given in 6 cases (Table 2) is that invasive threats are encompassed within the catch-all novel biota KTP, listed in 2013. In a 7th case, the environment minister refused to list the KTP, contrary to advice by the Threatened Species Scientific Committee, with no reason given.

The novel biota listing covers 6 categories of invasive species – vertebrates, invertebrates, terrestrial plants, aquatic plants and algae, marine organisms and pathogens. Encompassing such a multitude of invasive species in one listing would be acceptable if it led to action to abate the highest priority threats. The threatened species senate inquiry (2013) said it hoped the novel biota listing would lead to 'a more strategic approach to improve management and control of invasive species, and … result in the development of an integrated planning framework to respond to invasive species' (15). This has not occurred.

There are no novel biota TAPs, and the only action apparently catalysed by the listing has been publication of a few fact sheets (16). The listing document acknowledges that the purpose of the listing is mainly for information: 'to recognise the threat that all novel biota pose to the Australian environment and to highlight the vast array of different novel biota and the threats they pose'. Even though the KTP listing document says it is 'anticipated individual novel biota KTPs will continue to be listed as stand-alone KTPs', the main effect of the listing has been to stymie further invasive species listings (Table 2). This appears to be a deliberate strategy to limit funding demands because there is far too little funding for abating the already-listed KTPs (see section 3.4). The guidelines for the novel biota listing state that the list of invasive species KTPs 'has grown so large that individual evaluations could divert the Government's attention and resources for many years' (14).

There have also been refusals to assess KTP nominations for other types of threats, including altered hydrological regimes and the loss or removal of dingos from Australian landscapes (17).

Table 2 Invasive species KTP nominations not assessed, or rejected, since 2008

KTP nominated	Spp/ECs threatened[A]	Reason[B]
Ecosystem degradation, habitat loss and species decline due to invasion in southern Australia by introduced tall wheat grass (*Lophopyrum ponticum*) (18)	28	Not assessed due to the novel biota KTP
Ecosystem degradation, habitat loss and species decline in arid and semi-arid Australia due to the invasion of buffel grass (*Cenchrus ciliaris* and *C. pennisetiformis*) (19)	29	Not assessed due to the novel biota KTP
Herbivory and habitat degradation by feral deer (20)	18	Not assessed due to the novel biota KTP
Introduction, establishment, and spread of, and infection by, exotic rust fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae (21)	Several[C]	Not assessed due to the novel biota KTP
Loss of habitat and native flora due to expansion of the weed lippia (*Phyla canescens*) (22)	42	Not assessed due to the novel biota KTP
The invasion, establishment and spread of *Lantana camara* impacts negatively on native biodiversity including many EPBC listed species and communities (23)		Not assessed due to the novel biota KTP
Introduction in Australian inland waters of native or non-native fish that are outside their natural geographic distribution (24).	9	Rejected by ministerial prerogative

Notes: **A.** This is the number of threatened species (spp) and ecological communities (ECs) for which evidence is provided in the KTP nomination or, for the rejected nomination, the number accepted by the Threatened Species Scientific Committee. **B.** The reasons for not assessing nominations are provided at (17). The ministerial rejection of the non-native fish nomination is noted at (24); no reasons were provided. **C.** The extent of the threat is not clear yet because myrtle rust was first detected in Australia only in 2010.

2.3 Slow, tedious and ad hoc KTP listing processes

Although the Threatened Species Scientific Committee can nominate KTPs itself (as it did for the novel biota listing), the listing of KTPs is mostly ad hoc, relying on public nominations and ministerial prerogative.

The assessment processes are slow and tedious. The 3 KTP listings of the past decade (excluding the novel biota KTP) have each taken 3–4 years from nomination to listing (Table 3). Two rejected nominations took 5 and 7 years to assess. One still under assessment – fire regimes that cause biodiversity loss – was nominated more than 10 years ago. It should be an obvious KTP listing, for inappropriate fire regimes is recognised as one of the leading threats to threatened biodiversity (7, 13).

Several KTP nominations have never been assessed because they have not made it onto the annual assessment priority list. This has been the case for 6 invasive species nominations (as discussed in section 2.2) and for others including one on the impacts of dingo loss and removal and one on altered flow regimes of watercourses (25). The environment minister has discretion over which nominations are assessed (25, 26).

The rate of KTP listings (and the development of TAPs) has greatly slowed in recent years (Figure 1). Six KTPs were listed prior to 2000, carried over from the previous national law, the *Endangered Species Protection Act 1992*. Each of them has a TAP (although not all are up-to-date). During the first decade of the EPBC Act (2000-2009), 12 KTPs were listed, 9 of which have a TAP (not all are up-to-date). Since then (2010-2018), there have been just 3 KTP listings, none of which has a TAP. The most recent KTP nomination to be assessed was made in 2011 (Table 3).

Table 3 Time from KTP nomination to listing or rejection

KTP	Year nominated[A]	Year listed/ rejected	Years taken to list/reject
Invasive grasses, northern Australia	2006	Listed 2009	3
Introduction in Australian inland waters of native or non-native fish that are outside their natural geographic distribution	2006	Rejected 2011	5
Escaped garden plants	2006(?)	Listed 2010	4
Biodiversity decline and habitat degradation in the arid and semi-arid Australian rangelands due to the proliferation, placement and management of artificial watering points	2007	Rejected 2014	7
Fire regimes that cause biodiversity decline	2007	Not complete	>10
Noisy miners	2011	Listed 2014	3

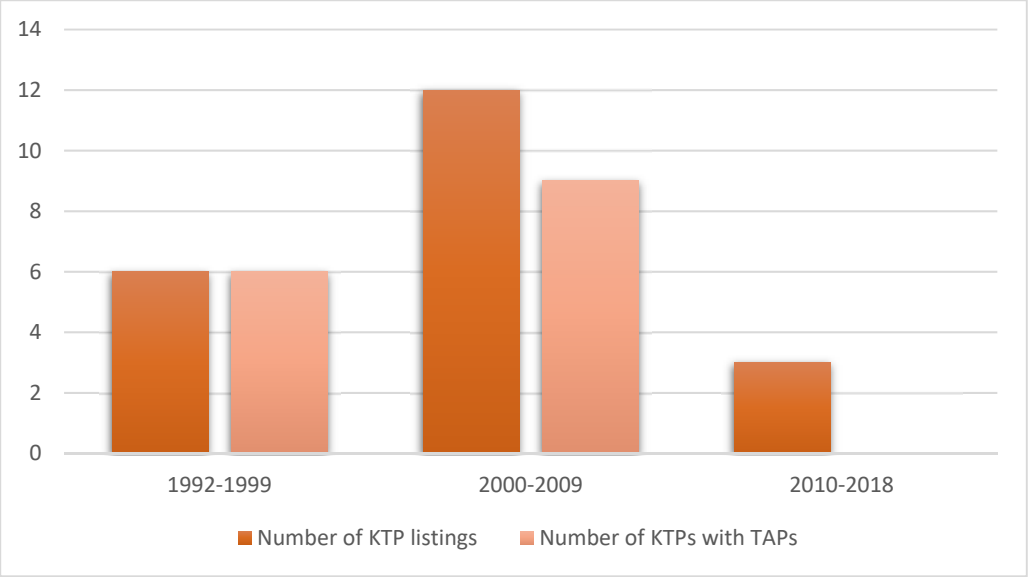
Notes: A. Information about the year of nomination was mostly gleaned from the annual 'finalised priority assessment lists' available at (26). These are the lists of nominated species, ecological communities and key threatening processes approved for assessment by the environment minister each assessment year.

Table 4 Listed KTPs and the status of TAPs

KTP	Year listed	Year of TAP[A]	Latest (publicly available) review[B]
Rabbits	2000	1999/2008/2016	2013
Feral goats	2000	1999/2008	2005
Root-rot fungus	2000	2001/2014	2006
Longline fishing	2000	1998/2006/2014	2011
Foxes	2000	1999/2008[C]	2013
Feral cats	2000	1999/2008/2015	2014
Otter trawling	2001	X	
Land clearing	2001	X	
Climate change	2001	X	
Feral pigs	2001	2005/2017	2011
Beak & feather disease	2001	2005	2012
Chytrid fungus	2002	2006/2016	2012
Marine debris	2003	2009	X
Red fire ants	2003	2006[C]	2012
Yellow crazy ants, Christmas Island	2005	2006[C]	2012
Cane toads	2005	2011	X
Exotic rodents on islands	2006	2009[C]	2015
Invasive grasses, northern Australia	2009	2012	X
Escaped garden plants	2010	X	
Novel biota	2013	X	
Noisy miners	2014	X	

Notes: **A**. Dark grey highlight = no TAP; light grey = out of date TAP or no review. Pink = current TAP (published within the past 5 years or reviewed within the past 5 years and found to be still relevant). **B**. Additional TAPs may have been reviewed but the review not released. **C**. A draft root-rot fungus TAP (intended to replace the 2014 TAP) was released for consultation in 2017 (27). The environment minister decided in 2013 that the foxes TAP would be revised, but a new TAP has not yet been published. The environment minister decided in 2013 that the tramp ant TAP would not be revised; instead threat abatement advice would be developed to supplement it. This is apparently still in preparation. The environment minister decided in 2016 that the exotic rodents TAP would be revised, but a new TAP has not yet been published.

Figure 1. KTP listings – per time period, with TAPs



The nomination process is demanding. Two nominations not assessed due to the novel biota listing were prepared by the Invasive Species Council (tall wheat grass and feral deer, see Table 2). Each nomination took several weeks of volunteer effort, but was rejected (not assessed) for no legally valid reason – a waste of scarce resources and disrespectful of those who prepare nominations (mostly environmental NGOs and researchers). As a result, the Invasive Species Council no longer prepares KTP nominations. However, there is no equivalent alternative process by which to catalyse national collaborative action on major invasive threats.

How effective is threat abatement through TAPs?

3.1 Moribund KTP listings

The EPBC Act specifies that a threat abatement plan must, among other things:

- state the objectives to be achieved, the actions to achieve these objectives and the criteria against which the objectives are to be measured
- provide for research, management and other actions necessary to reduce the KTP to an acceptable level in order to maximise the chances of the long-term survival in nature of native species and ecological communities affected.

This seems like a logical first step to address major threats. After all, how can you abate a KTP without a plan?

Almost a third (6) of listed KTPs have no TAP (highlighted in dark grey, Table 4) – due to the environment minister deeming that a TAP is not 'a feasible, effective or efficient way' to abate the threat (usually on the advice of the Threatened Species Scientific Committee). This could be acceptable if there were already effective processes for abating those threats (as verified by monitoring). But this is mostly not the case. The threat level for at least 5 KTPs without TAPS –land clearing, climate change, escaped garden plants, noisy miners and novel biota – are likely to have increased since their listing (although insufficient monitoring makes it hard to be definitive) and the federal government has not instituted effective processes for abatement or demonstrated strong leadership to promote abatement action by the state and territory governments.

In the case of the escaped garden plants KTP, listed in 2010, the minister claimed there was no need for a TAP due to existing arrangements for preventing new weeds and managing emerging and established weeds (28). But the minister is not required to show that these other processes are effective, to monitor abatement progress, or to initiate action if existing processes prove ineffective. The federal government largely washes its hands of issues such as weed management that it can leave to the states. The sale of dozens of highly invasive nursery plants is still permitted in most states and territories (e.g. 29). Abatement of the weed threat has been substantially undermined by the decision of the federal government to stop funding the Cooperative Research Centre for Australian Weed Management (in 2008) and the Weeds of National Significance program. In 2016 a research and development strategy for environmental biosecurity was finalised (30), but with no extra funding for implementation and no body assigned to coordinate implementation. The federal government is failing to provide the processes, resources and leadership needed to abate the threat of escaped garden plants.

Some KTPs lacking TAPs have 'threat abatement advices' or guidelines instead, which are non-statutory documents prepared by the environment department 'to provide guidance … on activities and research needed to abate the threat' (31). There are currently 4 advices and 1 guideline, all except one on invasive species. The move to advices was recommended in the 10-year review of the EPBC Act as a way of providing early guidance for recovery and regional planning and other decisions under the EPBC Act (32). While an abatement advice or guideline can provide useful information, it is no substitute for a TAP in setting a direction, catalysing national collaboration and providing a basis for reviewing abatement progress. For KTPs without a TAP, the federal government does nothing under KTP/TAP processes to monitor or report on the threat or abatement efforts.

3.2 Limited abatement progress

Due to a lack of monitoring and regular reporting, the only feasible way of assessing the effectiveness of most threat abatement efforts is through the 5-yearly reviews of TAPs required under the EPBC Act. But only half of the KTPs can be assessed in this way: 6 KTPs (29%) lack a TAP and 4 TAPs (19% of KTPs) have not been reviewed (to the best of our knowledge) despite being overdue by 1–4 years for their 5-yearly review (Table 4). Eleven TAPs (52%) have been reviewed at least once, although only 4 in the past 5 years and only 3 by independent reviewers.

Our conclusions drawn from the 11 reviews are summarised in Table 5 and Figure 2. Good progress was reported for 4 TAPs (27% of TAPs, 19% of KTPs), moderate progress for 4 TAPs (27% of TAPs, 19% of KTPs) and poor progress for 3 TAPs (14% of KTPs, 20% of TAPs). One KTP for which moderate progress was reported, feral cats, has recently been subject to a more concerted abatement effort, resulting in much better progress (see section 3.5). But, overall, less than 40% of KTP listings have resulted in moderate to good progress on threat abatement.

Nonetheless, the examples of good abatement progress demonstrate that major threats to Australian biodiversity are surmountable. What distinguishes the effective TAPs? No review has been conducted to determine the elements of success and the TAP may not have been the main driver of abatement effort in all cases. Obvious factors include leadership, adequate funding and a working group responsible for implementation.

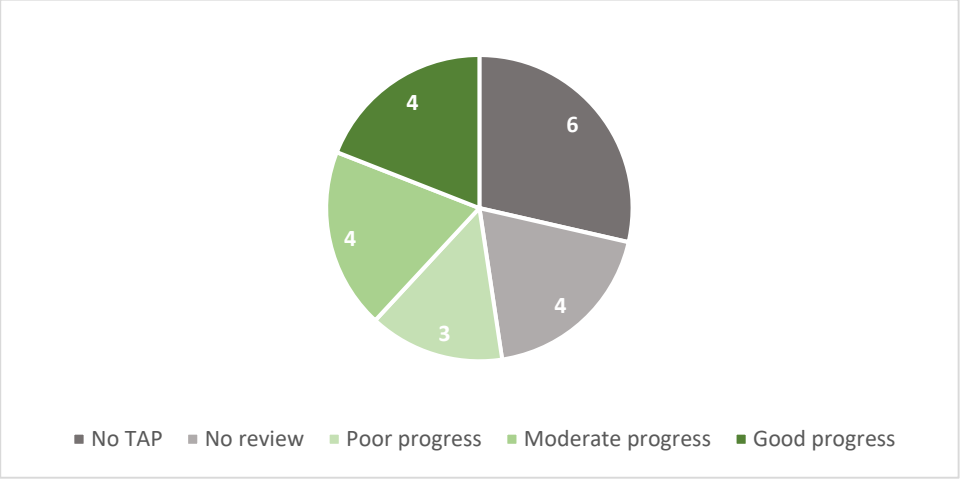
Table 5 Effectiveness of TAPs

KTP	Latest review available[A]	Review findings	Conclusion
Longline fishing	2011 Reviewer unknown[B]	Considerable progress has been made under successive TAPs due to the 'fishing industry, researchers and non-governmental stakeholders working with government … in a feasible, effective and efficient way'.	Good progress
Red imported fire ants	2012 Independent review (33)	'Reasonable progress' against goals, objectives and a number of the actions. This species is subject to national eradication co-funded by federal, state and territory governments.	Good progress
Yellow crazy ants, Christmas Island	2012 Independent review (33)	'Reasonable progress' against goals, objectives and a number of actions (for 6 species). Crazy ants intensively managed on Christmas Island. Addendum: In 2017 a biological control agent was released.[C]	Good progress
Exotic rodents, islands	2015 Government review (34)	Significant advances in eradication & management techniques. Improved information base. Network established, symposiums. Eradications on 3 islands, including Macquarie. Improved capacity for sustained control on priority islands. Biosecurity plans for 2 islands. Limited public promotion. Inconsistent knowledge collection. A number of priority islands still impacted.	Good progress
Feral cats	2014 Government review (35)	Goal of minimising impacts not met. Significant advances in research and control techniques. Island eradications – 1 complete, 3 in progress. Some fenced sanctuaries. New baits. Improved monitoring. Public awareness growing. But land managers still limited in their ability to control cats. Lack of resources for control. Addendum: Since 2015 there has been a greatly strengthened commitment to abatement. [C]	Moderate progress Good progress since 2015
Red foxes	2013 Government review (36)	Except in small areas, goal of abating impacts on biodiversity not met. Asset protection approach widely adopted. Some predator-proof sanctuaries built. Eradication on some islands (program in Tasmania). Improved diagnostics. Some cross-tenure control programs. Better ecological understanding. Improved techniques for monitoring and control. But still much to be done.	Moderate progress
Rabbits	2013 Government review (37)	Progress includes rabbit eradications on several islands & better knowledge of impacts. But control programs have often been ad hoc, lacked strategic prioritisation, and were rarely initiated for threatened species or ecological community recovery (drivers are usually agricultural or social). New strains of RHD identified. Addendum: A new strain of RHD has been released. [C]	Moderate progress
Feral pigs	2011 Government review (38)	Improved tools: guidance to land managers on control, nationally consistent monitoring, updated mapping, 2 new baits. Some federally funded control programs. But impacts in high biodiversity sites not accurately monitored. Few effective, wide-scale programs. Poor public recognition of problem. Limited knowledge of numbers that need controlling to abate threat in particular sites.	Moderate progress
Root-rot fungus	2006 Independent review (39)	TAP lacked timelines, budget and did not identify responsible parties. Objectives not easily measurable. Implementation team not established. Ad hoc, short-term funding precludes a strategic approach to determine and abate the threat. Little improvement in management, continued spread.	Poor progress

Chytrid fungus	2012 Government review (40)	Some progress: national map, historical surveys reliable diagnostic protocols, biology investigated, captive breeding programs, national chytrid working group established. But the two TAP goals have largely not been achieved. Critical gaps in knowledge. Most research work not govt funded. No national coordinated surveillance. Of 68 actions, 8 were completed and 39 were partially completed.	Poor progress
Beak & feather disease	2012 Government review (41)	Working group established. Improved coordination. Dedicated funding needed to establish a good system to capture and disseminate information. Hygiene and disinfection protocols developed. Some research, but gaps in knowledge remain. Exploring potential for vaccine. No surveillance of wild birds due to cost. Of 26 actions, 12 completed, 7 partially completed. But the 2 TAP goals were not met – risks have not diminished.	Poor progress
Marine debris	Effectiveness unknown – no review of 2009 TAP found		
Invasive grasses, northern Australia	Effectiveness unknown – no review of 2012 TAP found		
Feral goats	Effectiveness unknown – no review of 2008 TAP found		
Cane toads	Effectiveness unknown – no review of 2011 TAP found		
Noisy miners	No TAP		
Escaped garden plants	No TAP		
Climate change	No TAP		
Novel biota	No TAP		
Otter-trawling	No TAP		
Land clearing	No TAP		

Notes: **A.** Some TAPs may have been reviewed without the review being published or the TAP revised. All reviews should be made publicly available. **B.** We have not been able to find the review of the longline fishing TAP, so have taken on face value the comment in the latest TAP about the success of previous TAPs. **C.** For a few TAPs we have added an addendum to the review findings column to note recent abatement progress.

Figure 2 Effectiveness of KTP listings for threat abatement



3.3 Slow TAP processes

TAP development is very slow. It has taken an average 4 years to prepare or revise TAPs for the 9 KTPs listed since 2001 (after the EPBC Act came into force) that have a TAP (Table 6).

Most TAPs are reviewed within 5–6 years, but then it often takes several years for TAPs to be revised after a review. It took 8 years in the case of the root-rot fungus KTP (Table 4). The environment minister decided in 2013 that the foxes TAP would be revised, but 5 years later a new TAP has not yet been published.

Of 15 existing TAPs, 60% (9) are more than 6 years old; 27% (4) are 10 years old (light grey highlights, Table 4). We assume the major impediments to more efficient TAP development and revision are too little funding and too few departmental staff. Consultation with state and territory governments is also often time consuming.

Table 6. TAP timeframes for KTPs listed since 2001

KTP	Listing	TAP	Review	Time to TAP[A]
Feral pigs	2001	2005/2017	2011	4/6
Beak & feather disease	2001	2005	2012	4
Chytrid fungus	2002	2006/2016	2012	4/4
Marine debris	2003	2009	X	6
Red fire ants	2003	2006[B]	2012	3
Yellow crazy ants, Christmas Island	2005	2006[B]	2012	1
Cane toads	2005	2011	X	6
Exotic rodents on islands	2006	2009[B]	2015	3
Invasive grasses, northern Australia	2009	2012	X	3

Notes: **A**. 'Time to TAP' is the number of years from the listing until the release of the TAP and then (for 2 KTPs) the number of years from a TAP review until the release of a new TAP. **B.** The environment minister decided in 2013 that the tramp ants TAP (which covers red fire ants and yellow crazy ants KTPs) would not be revised; instead threat abatement advice be developed to supplement the existing TAP. Five years later, this has not yet been published. In 2016 the environment minister decided that the exotic rodents on islands TAP would be revised, but this apparently is still in preparation.

3.4 Limited obligations and accountability

Although the Australian Government has international obligations to abate threats to biodiversity, there is no obligation under the EPBC Act to list the major threats or act on them. The environment minister has complete discretion about whether to accept the advice of the Threatened Species Scientific Committee to assess a KTP nomination, list a KTP or prepare a TAP. The minister can also delay decisions for years and starve the assessment processes of funding. This means our national system for recognising and abating threats is highly vulnerable to political interference. The same vulnerability applies to the processes for listing threatened species and ecological communities and preparing recovery plans.

Moreover, KTP listings come mostly obligation free. In addition to the ministerial discretion about whether to prepare a TAP, the EPBC Act obliges the federal government to do little to implement a TAP. As explained in most TAPs:

> Under the EPBC Act, the Australian Government develops TAPs and facilitates their implementation. The EPBC Act requires the Australian Government to implement TAPs to the extent to which they apply in areas under Australian Government control and responsibility. In addition, Australian Government agencies must not take any actions that contravene a TAP. Where a TAP applies outside Australian Government areas in states or territories, the Australian Government must seek the cooperation of the affected jurisdictions, with a view to jointly implementing the TAP.

A KTP listing also does not generate any obligations for other governments, landholders or anyone whose actions may exacerbate the KTP. The government emphasises in public information that KTP listings are mostly obligation-free (42):

- Listing a key threatening process does not regulate or prevent actions undertaken by the states, territories or individual property managers.
- Listing a key threatening process does not regulate or prevent actions undertaken by property managers.
- Key threatening processes do not trigger the EPBC Act (key threatening processes are not matters of National Environmental Significance under the EPBC Act).
- Listing a key threatening process does not cause any change to property practices.

An essential element for effective threat abatement is a working group with sufficient expertise, stakeholder representation and authority to take responsibility for driving and monitoring implementation progress. It is not clear from most TAPs whether national working groups have been established and, if so, whether the membership extends beyond government stakeholders.

There are few accountability requirements associated with KTPs, with no obligations for monitoring or reporting on KTP status. The one reporting obligation is the 5-year review of each TAP, but with no requirement for this review to be independent.

3.5 Limited leadership, commitment and funding

Although the federal government is often limited in the extent to which it can compel other governments or individuals to undertake threat abatement, it can apply considerable pressure through strong leadership, incentives for implementation and use of its own laws to partially compensate for state or territory failings (see section 4.3 for examples). These have been largely missing in KTP/TAP processes. With a few exceptions, abating KTPs has been a low federal government priority.

Befitting the importance of dealing with major threats to Australian biodiversity, the unit

responsible for KTPs and TAPs should be a well-funded, central hub of activity in the government. Instead, as is evident in the slowness of its processes, it is small and threadbare. The committee conducting the 2013 threatened species senate inquiry said it was 'troubled by the evidence received that the TSSC [the committee assessing KTP nominations] is under-resourced' (15).

However, leadership has improved to some extent in the past 3 years due to the appointment of a Threatened Species Commissioner as a champion for threatened species and facilitator of partnerships to implement recovery and abatement plans. In particular, this has generated considerable focus on the feral cat KTP (and a small number of listed threatened species). The 2015 *Threatened Species Investments and Future Opportunities* document lists $2.5 million worth of funded projects directed at 'tackling feral cats and their impacts' and 5 other projects not yet funded (43). In 2017 about $0.75 million was provided from the Threatened Species Recovery Fund for 3 community projects to implement TAPs, 2 on feral cats (44). This level of federal funding for mitigating the major threat of feral cats is modest, but far more than most other TAPs receive. That the commissioner's KTP (and threatened species) priorities are so few in number highlights the poverty of federal government commitment and resources.

Funding for actions specified in TAPs (even if not driven by the TAP) may come from a wide variety of sources, including state, federal and local governments, non-government, philanthropic and private sources, and research funding bodies. There is also a huge voluntary contribution to managing many KTPs, particularly invasive species. But we have no idea how much is actually spent on abatement, and there has never been an estimate of how much is needed to properly implement abatement plans.

However, it is clear from the limited progress (e.g. Table 5) that the gap between available funding and funding needed for implementing TAPs is large. Inadequate funding was one of the main critiques that emerged from the 2013 threatened species senate inquiry, articulated in dozens of submissions to the inquiry. The cross-party senate committee said it was 'concerned by the evidence received about the lack of funding and implementation' of TAPs (15). It recommended longer-term funding options, targeted funding for implementation of recovery and abatement plans, prioritising funding, and more funding for researching effective control methods for invasive species and for controlling feral animals.

Inadequate funding is evident also in the federal government's refusal to assess any more nominations of invasive species KTPs. The guidelines for the novel biota KTP say that the list of invasive species nominated as KTPs 'has grown so large that individual evaluations could divert the government's attention and resources for many years' (14). These guidelines also acknowledge that 'the impacts of novel biota on Australian ecosystems are increasing', which shows the need for broader and stronger application of the KTP/TAP process.

4. Changes needed

Here we outline broad changes needed to improve the KTP/TAP system. We do not provide detailed recommendations, for our intention is to stimulate discussion and collaboration within the conservation sector, leading to a comprehensive reform proposal.

We start from the premise that the fundamentals of the current KTP/TAP model are sound – that major threats should be listed nationally and that, under federal leadership, a listing should then catalyse a plan and collaborative action – involving federal, state and territory governments, scientists and non-government stakeholders – to abate the threat. As demonstrated by some successful TAPs, the current model can work well. The changes proposed here – mainly to priorities, governance, accountability and funding – are common to many other reform proposals. The major missing element in the current system – essential to all others – appears to be commitment by the federal government to achieve threat abatement. However, we remain open to, and invite ideas for, other models for facilitating threat abatement. In particular, it is worth exploring co-governance models, as mentioned in section 4.2.

As with many other environmental problems requiring federal leadership and funding, it will be difficult to achieve reform in the current political environment. Beyond the work of analysis and advocacy, the conservation sector has much more to do, socially and culturally, so that the decline of Australian species and ecological communities becomes of major national consternation. Extinctions must become anathema to most Australians.

4.1 Make threat abatement a high national priority

Priority within the conservation sector— ambitious conservation strategy—intergovernmental agreement—social change strategy—community involvement

An essential first step is greater recognition that an effective KTP/TAP system is essential for arresting loss of Australia's biodiversity, and that developing enduring solutions for major threats is typically more effective and cost-effective than species-by-species recovery efforts. Abating threats also benefits myriad other species, including those threatened but not listed due to data deficiencies, and those not yet threatened.

To drive reform of the KTP/TAP system, Australia needs an ambitious (but realistic) conservation strategy that specifies long-term goals for threat abatement. One exemplar of the sort of ambition needed is New Zealand's 'Predator Free 2050' goal to eradicate the country's most damaging alien predators (rats, stoats and possums), a goal driving major research effort and energetic collaborations (45). Ambition needs to be then reflected in each of the TAPs. We see something of this energy in the recent drive in Australia to abate the threat of feral cats (46, 47). It is even more evident in the commitment by the federal and state governments to eradicate red fire ants, with a recent agreement to spend $411 million over the next decade (driven in large part by the massive social and economic impacts of fire ants) (48).

Securing commitment from state and territory governments is essential. The federal government should pursue an intergovernmental agreement (via COAG) with the states and territories to achieve threat abatement and recovery of threatened species and ecological communities. Such commitment is likely to come only if there is substantial public pressure on governments. As part of a broader effort to elevate conservation as a national priority, we need a social change strategy. As part of generating greater community commitment, a high priority for each TAP should be to involve community groups, when feasible, in threat abatement and monitoring.

4.2 Strengthen governance and accountability

An independent National Sustainability Commission—co-governance model— review of success elements— national TAP working groups—independent TAP reviews—annual parliamentary reports—monitoring of meaningful indicators

KTP and TAP processes (as well as processes for threatened species and ecological communities) should be free of political influence and not subject to ministerial discretion. We endorse the recommendation by the Places You Love Alliance for an independent National Sustainability Commission to undertake such functions (49).

It is worth considering other governance models as well. The Invasive Species Council has long advocated the establishment of an independent biosecurity body – to be called Environment Health Australia and co-governed by governments (federal, state and territory) and non-government bodies with a strong stake in environmental biosecurity (e.g. environmental NGOs, Indigenous organisations, research bodies) to undertake functions such as contingency planning for new invasive species arrivals. It is modelled on existing government-industry partnerships – Animal Health Australia and Plant Health Australia – and would serve as a 'relationship and brains infrastructure' for grappling with priority environmental biosecurity problems (50, section 12).

The current TAP process has worked well for a few KTPs (section 3.2), so these cases should be analysed to identify success factors. One important element appears to be a national working group for each TAP with government and non-government participants to foster collaboration (as exemplified by the longline fishing TAP).

More meaningful, independent and regular reporting is needed. The five-yearly TAP reviews are important and, for the sake of credibility and rigour, should be done by expert reviewers independent of government. Befitting the priority of threat abatement and to improve oversight, an annual progress report on KTP abatement (based on meaningful indicators) should be presented to the federal parliament. This needs to be underpinned by monitoring of threatening processes and the species and ecological communities at risk.

4.3 Systematically list KTPs for all matters of national environmental significance

Comprehensive authoritative KTP list—systematic expert listing process supplemented by public nominations—no ministerial prerogative—KTPs for all matters of national environmental significance—emerging as well as entrenched threats—much greater efficiency

The KTP list under the EPBC Act should be the authoritative list of major threats to Australian biodiversity. The listing process needs to be more systematic to properly reflect the major threats. This is important not just for education and information, but to facilitate access to national processes and resources for abatement of the highest priority threats, to trigger monitoring of and reporting on all major threats, and as a basis for prioritising research and abatement actions.

A systematic approach needs to move beyond reliance on public nominations. It is important to base listings on credible scientific evidence, but there has already been a lot of work that can be drawn on to comprehensively identify KTPs. An expert process can be supplemented by a public nomination process to fill gaps and keep the KTP list up to date. As with similar processes at the state level (NSW and Victoria) the decision to assess and list a KTP should emerge from a scientific process rather than be the prerogative of an environment minister.

The KTP list should expand to recognise threats to other 'matters of national environmental significance' protected under the EPBC Act, including migratory species, Ramsar wetlands and

world heritage areas. The list should also more adequately encompass emerging threats (as exemplified by the listing of red imported fire ants as a KTP) to stimulate early cost-effective action before they become entrenched threats.

Like that of other KTPs, the listing of invasive species threats should be systematic and comprehensive, and not rejected due to funding limitations. This does not require listing every major invasive species threat as an individual KTP – that would require several dozen more KTPs. KTP categories should be guided by abatement considerations. Some invasive species warrant listing as an individual KTP while others could be listed in taxonomic or functional groups (e.g. invasive freshwater fish, invasive ants) if they can practicably be addressed under the one TAP.

There is no need for KTP listing to be such a tedious, slow process. With the extensive literature on most major threats, it should be a straightforward matter to identify and list the major KTPs. Rather than rely mainly on an ad hoc public nomination process, it would be considerably more efficient for an expert committee to develop a candidate list of KTPs and commission experts (or departmental staff) to prepare an assessment that the scientific committee reviews and uses as a basis for a final decision. It should take no more than a year to assess and list a KTP, and 3 years to develop a comprehensive KTP list.

4.4 Strengthen obligations for abatement

Mandatory TAPs—state and territory obligations—fallback federal options —public obligations

For each KTP, it should be mandatory to prepare a TAP (or equivalent) to specify long-term abatement goals and shorter-term targets, the research and actions needed to achieve them and a monitoring regime. A TAP should serve as a national statement of what is needed to achieve abatement and as the basis for monitoring and reporting on the status of the KTP and abatement progress. A TAP should be required even where abatement can best be achieved through existing processes or relies on processes beyond the control or influence of the federal government. This ensures that the federal government takes responsibility under the EPBC Act for specifying the desired conservation direction and monitoring progress.

Even where federal abatement options appear to be limited, there are often actions they can take. For example, although abatement of the climate change KTP relies heavily on global actions, a climate change TAP could focus on reducing threats that will be exacerbated by climate change (such as many invasive species) and ensuring that mitigation does not exacerbate other KTPs (such as planting biofuel crop species that are invasive).

While the federal government is constrained in what actions it can itself take to implement TAPs, this should not be used as an excuse to abrogate responsibility. Federal leadership is needed to encourage commitment by all states and territories to implement TAPs. As with other national priorities, this requires intergovernmental agreements and attractive funding arrangements.

If state and territory governments fail to implement TAPs, the federal government should be obliged to consider options for over-riding or compensatory measures. Although it mostly cannot compel TAP implementation by other parties, it could for some KTPs use its own laws to partly compensate for laggard state or territory governments – for example, more-rigorous assessments of land clearing as potential 'controlled actions' under the EPBC Act for the land clearing KTP, and regulating trade in harmful weed species (under section 301A of the EPBC Act) for the escaped garden plants KTP.

Obligations should extend to individuals and corporations. All Australians are bound by the EPBC Act to avoid having a significant impact on threatened species (and other matters of national environmental significance). Australians should also be bound by the EPBC Act to avoid significantly exacerbating a KTP.

4.5 Commit to long-term funding to achieve abatement targets

Assessment of funding needs and gaps—new funding sources—long-term investment in enduring solutions

A government demonstrates it is serious about mitigating harms when it is prepared to fund the necessary actions. Highly inadequate funding is currently a major impediment to abating most KTPs.

To assess funding needs, each TAP should include an estimate of costs to achieve 10–20-year targets. New funding sources such as levies and taxes should be canvassed. Long-term base funding should be provided for the implementation of each TAP to foster the development of innovative, enduring solutions (this is particularly important for invasive species KTPs, many of which lack effective control methods). Also assessed should be the economic as well as environmental benefits of effective abatement, which are likely in many cases to far exceed the costs of abatement.

Feedback invited

We welcome comments and ideas about how Australia's threat abatement processes can be strengthened. Please email contact@invasives.org.au.

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CONTACT US

- web: invasives.org.au
- email: contact@invasives.org.au

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NORFOLK ISLAND

Protecting an Ocean Jewel

2017
NOVEMBER

invasive species council

ISLAND CONSERVATION
Preventing Extinctions

Recommendations for stronger biosecurity for the Norfolk Island group

Commitment to collaboration

We support the principle that decisions about the management of Norfolk Island should be developed in collaboration with the inhabitants of Norfolk Island.

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Protecting the environment is a collective effort. We are grateful for the support and advice offered by those undertaking conservation activities on Norfolk Island, including Norfolk Island Flora and Society, Norfolk Island Regional Council, Wild Mob, Parks Australia and the many Norfolk Islanders, mainlanders and others.

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NORFOLK ISLAND

Protecting an Ocean Jewel

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Inquiries

Invasive Species Council
PO Box 166, Fairfield Vic 3078, Australia
Email: contact@invasives.org.au | Web: invasives.org.au | ABN: 27 101 522 829

About the Invasive Species Council

The Invasive Species Council was formed in 2002 to seek stronger laws, policies and programs to keep Australian biodiversity safe from weeds, feral animals, exotic pathogens and other invaders. The goal is to establish a biosecurity system for Australia and the south west Pacific that stops new invasive species and reduce the impacts from existing invasive species. The Invasive Species Council is a not-for-profit charitable organisation funded almost entirely by donations from supporters and philanthropic organisations.

About Island Conservation

Island Conservation began in California as a network of conservationists in 1994. It prevents extinctions by working worldwide where the concentration of both biodiversity and species extinction is greatest—islands. Working together with local communities, government management agencies, and conservation organizations, Island Conservation selects islands that have the greatest potential for preventing the extinction of globally threatened species; develops comprehensive and humane plans for the removal of invasive species; implements the removal of invasive species; and conducts research.

Emily Bay, Norfolk Island, looking out to Phillip Island and Nepean Island. Photo: © Danny Hayes

> *"Perroquets, parrots, Doves, & other birds we saw in great quantitys & so very tame that they might have been knocked down with sticks …*
>
> *The pines which are very numerous are of an incredible growth, one of them which had been blown down, or fell by age, measured 140 feet …"*

– Philip Gidley King, Commandant Norfolk Island, 1788-1790. King established the first European settlement on Norfolk Island.

CONTENTS

Executive summary

One of many changes resulting from the revocation of self-governance on Norfolk Island in July 2016 is the federal government assuming responsibility for most pre-border and border biosecurity. This transition offers the opportunity to establish an exemplary island biosecurity system. Stronger biosecurity is very much needed, for invasive species are the major driver of extinctions on Norfolk and Phillip Islands and new harmful exotic species continue to arrive and establish on the islands.

This report was prepared to highlight the considerable conservation values of the Norfolk Island group and the importance of rigorous biosecurity to prevent the establishment of new invasive species and to limit harm from existing invaders. We describe the existing and potential arrangements for biosecurity and make recommendations for building a more robust biosecurity system.

There are many special things about the Norfolk Island group – their cliff-ringed beauty and fascinating human history, teeming seabird colonies, and a plethora of species found nowhere else in the world. A substantial proportion of species on these islands are endemic – including 43 plants (almost a quarter of the native flora), 15 birds (species and subspecies), and hundreds of invertebrates. A few additional species, including two lizards, are restricted to the Norfolk Island and Lord Howe Island groups. Many of these endemic species have unfortunately also acquired the conservation significance of rarity, due in large part to the introduction of species from all over the world. Some are extinct. Fifty-eight Norfolk species are listed as threatened under Australia's national environmental law: 46 plants, five birds (four land birds and one seabird), two reptiles and five land snails.

Invasive species

Indigenous plant species are far outnumbered on Norfolk Island by exotic species. Some 430 exotic plant species have established, more than twice as many as the 182 known indigenous species. Without intensive management, weeds would destroy most of the remnant vegetation. Competition from weeds is a threat to all 46 nationally listed threatened plant species, and managing the woody weeds that dominate substantial areas of the national park is the major demand on park funding.

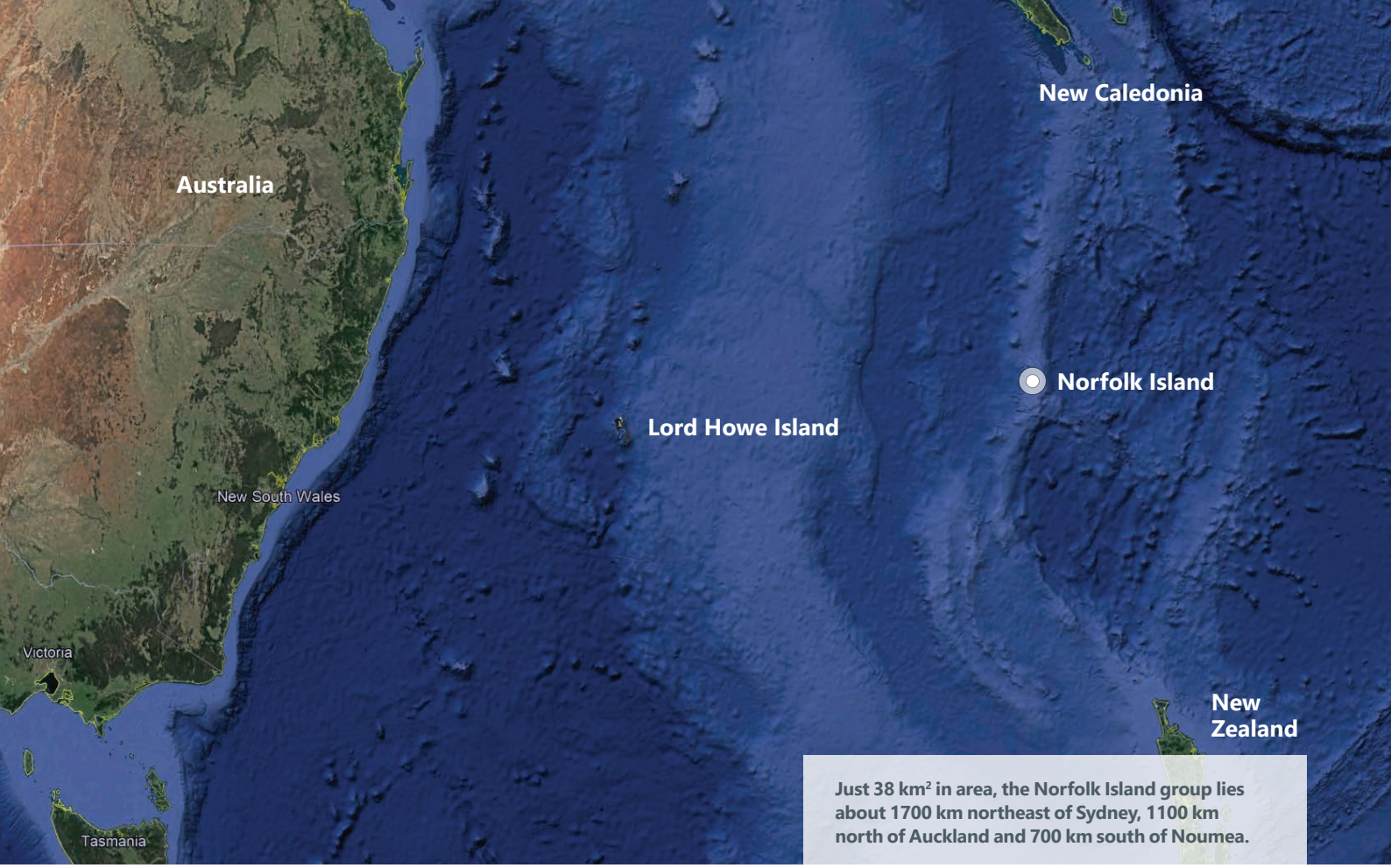
Feral cats and two rodent species (Polynesian rat and black rat) are the major threat to birds, reptiles and invertebrates on Norfolk Island. Keeping them off Phillip and Nepean Islands is a high conservation priority.

The Argentine ant, first detected in 2005 and currently being eradicated, is likely to cause serious harm to wildlife if it spreads across Norfolk Island, due to its aggression and need for protein. The local loss of other ant species would compromise ecosystem processes such as soil aeration, nutrient cycling and seed dispersal.

Biosecurity arrangements and activities

From 1979 to mid-2016, Norfolk Island was a self-governing external territory of Australia with most of the powers of a national government, including for biosecurity. When self-governance was rescinded on 1 July 2016, the federal government assumed responsibility for most pre-border and border biosecurity under the *Biosecurity Act 2015* and the *Environment Protection and Biodiversity Conservation Act 1999* (the latter for live animal imports).

The federal government intends that from 1 July 2018 NSW laws will also apply to Norfolk Island. Whether this will include NSW's *Biosecurity Act*



Previous system (prior to July 2016)	Interim system (from July 2016)	Proposed system
Norfolk Island laws	**Federal laws + Norfolk Island laws**	**Federal laws + NSW laws**
• Animals (Importation) Act 1983 • Plant and Fruit Diseases Act 1959 • Noxious Weeds Act 1916	• Biosecurity Act 2015 • Environment Protection and Biodiversity Conservation Act 1999 (live animal imports)	• Biosecurity Act 2015 (federal) • Environment Protection and Biodiversity Conservation Act 1999 (federal re. live animal imports)
Administered by Norfolk Island Government	Administered by Department of Agriculture and Water Resources	Administered by Department of Agriculture and Water Resources
	• Animals (Importation) Act 1983 • Plant and Fruit Diseases Act 1959 • Noxious Weeds Act 1916	• Biosecurity Act 2015 (NSW)
	Administered by Norfolk Island Regional Council	Administration arrangements unknown but likely major role for Norfolk Island Regional Council.

Table 1. Biosecurity arrangements for Norfolk Island – past, present and as proposed by the federal government.

2015 is not clear and will depend on agreement by the NSW government and funding from the federal government. If NSW's biosecurity laws do apply, it is likely that NSW authorities would have limited involvement with the island and that many powers under the act would be delegated to local authorities. In the interim, the Norfolk Island biosecurity laws still apply and are mostly administered by the Norfolk Island Regional Council, although the extent of their application for pre-border and border biosecurity appears to be limited.

We should expect the new biosecurity regime on Norfolk Island under Australian laws to provide exemplary protection – given the modern laws and resources of the new regulator, and the high values on the island requiring protection. Stronger biosecurity is certainly needed, as demonstrated by recent detections of the Argentine ant (2005), Asian house gecko (2005), potato/tomato psyllid and South African mantis (these two species were among many previously unrecorded exotic species detected during a quarantine survey, 2012-2014), myrtle rust (2016) and palm seed borer (2016). The island does not yet have a comprehensive risk-based biosecurity system, particularly for environmental risks.

In recognition of the 'unique animal and plant pest and disease status of Norfolk Island', the Australian government has established a legal instrument –

the *Biosecurity (Prohibited and Conditionally Non-Prohibited Goods—Norfolk Island) Determination 2016* – which lists prohibited imports and the conditions for importing goods where they differ from conditions for importing goods to the mainland. However, the legal instrument contains few prohibitions and conditions specific for Norfolk Island's conservation values. Apart from a few exceptions, it allows the importation of seeds on Australia's permitted list or seeds whose origins are Australia, whether or not they are potentially weedy. The importation of live animals requires an import permit, but we do not know whether risks for indigenous wildlife are taken into account when applications are assessed, for risk assessments and import decisions are not published.

The biosecurity agency is reviewing conditions for seed imports but this will take 'a considerable amount of time'. It is also working with the Department of Environment and Energy regarding the regulation of biosecurity risks for the environment on Norfolk Island. The implication is that until these processes are complete and relevant biosecurity measures are implemented, some biosecurity risks for Norfolk Island are unacceptably high, particularly for seed imports.

Protecting Norfolk Island's unique wildlife requires intensive management of invasive species. Much of this occurs in the national park and botanic garden, funded by Parks Australia. It includes weed management (the major demand on funding), trapping and removing cats and subsidising a desexing program, killing rats, and protecting threatened species from invasive species (eg. rat-proofing the breeding sites of birds).

Outside the national park, a major effort is being made to eradicate Argentine ants. There has been considerable success in containing the ants and eliminating them over small areas. A 2017 CSIRO review recommended a two year program, currently under way, to demonstrate the feasibility of methods for treating larger and logistically difficult areas, as well as for surveying previously treated areas to confirm eradication of the ant. Once these challenges have been met, eradication is likely to require about $2 million over five years.

Biosecurity challenges and opportunities

Deficient harmonisation: So far, harmonisation between federal and Norfolk Island officials appears to be deficient under the interim biosecurity arrangements. The lack of a state level participant in Norfolk Island biosecurity and the apparent reluctance of the federal agency to integrate federal and local priorities could be impediments to effective biosecurity.

Underwhelming environmental focus: The current arrangements for Norfolk Island indicate insufficient priority is accorded to environmental biosecurity, particularly evident with the limited restrictions on seed imports from Australia. The federal biosecurity agency's review of seed imports and identification of environmental risks should be expedited. Protecting Norfolk's unique wildlife is important for economic as well as environmental reasons, with nature tourism offering the potential to boost the local economy.

Growing biosecurity risks: The continued global spread of invasive species, including to mainland Australia and New Zealand, heightens the risks of new incursions to Norfolk Island, exemplified by the arrival of myrtle rust on the island just six years after being detected in Australia. With the intended increase in trade for Norfolk Island will inevitably come greater biosecurity risks, including new pathways for invasive species. Risks may also increase due to new port arrangements allowing vessels to moor near land.

Out of sight, out of mind: With a small population far from mainland Australia, the Norfolk Island community has a major challenge to ensure

sufficient attention from the mainland is directed to island priorities. There is often scant recognition in the Australian government of the special environmental values and challenges of islands.

Limited resources: Although not a problem unique to Norfolk Island, one of the greatest impediments to managing invasive species has been a lack of resources. The small population and rate base have greatly restricted funding available for management. One benefit of the integration of Norfolk Island into Australia is the potential to gain greater access to national funding and grants programs.

Eradication opportunities: Eradications offer the exciting potential on Norfolk Island to reverse the declines of many threatened endemic species and save on the large amounts of funding needed to conserve threatened species. They would also improve the island's appeal as a nature tourism destination. Recent achievements on islands elsewhere indicate that eradication of rats and feral cats from the 35km^2 Norfolk Island is achievable.

Creating an exemplar: The transition in biosecurity arrangements offers an excellent opportunity to create an exemplary biosecurity system for Norfolk Island – to demonstrate the value of the new federal and NSW biosecurity laws for island conservation and the commitment of the federal government to protect the special values of the Norfolk Island group.

Recommendations

Harmonise biosecurity arrangements

Effective biosecurity on Norfolk Island can only be achieved through strong cooperation between the managers of biosecurity at different levels to achieve a strong pre-border, at-border and post-border biosecurity continuum.

1. Negotiate an agreement for NSW's Biosecurity Act 2015 to apply on Norfolk Island.
2. Establish a Norfolk Island biosecurity committee with representation from the different levels of government, including biosecurity and environmental agencies, to formulate biosecurity policies and priorities for Norfolk Island and to foster harmonisation.
3. Develop a memorandum of understanding between the levels of governments to facilitate cooperation, designate roles and responsibilities, and specify funding commitments.
4. Create mechanisms for engaging industry, environmental and community stakeholders in developing and implementing biosecurity laws, policies and programs.
5. While local laws still apply, strengthen the protection they afford for environmental values, including by requiring that decisions be guided by assessments of risks for the environment as well as the economy and human health and that a precautionary approach be applied.

Conduct risks and pathways analysis

Consistent with accepted biosecurity practice, the biosecurity arrangements and priorities for Norfolk Island should be informed by a comprehensive analysis of risks – for the environment, economy and human wellbeing.

6. Commission an independent analysis of biosecurity risks and pathways: Identify the values to be protected and the known and potential biosecurity risks to these values. Prioritise risks and identify the pathways of medium to high priority risks. Recommend risk prevention, emergency response measures and mitigation strategies.
7. Make this risk analysis publicly available and update it as new information becomes available. Review and update the risk and pathway analysis every five years.

Develop a Norfolk Island biosecurity strategy

A strategy is needed to guide the development of a strong biosecurity system for Norfolk Island based on the risks and pathways analysis recommended above.

8. Commission an independent expert to develop a biosecurity strategy for Norfolk Island in close consultation with all levels of government; community, industry and environmental stakeholders; and biosecurity and ecological experts.
9. Focus the strategy on the highest priority risks and threats. Identify impediments to effective biosecurity. Develop strategies, with approximate costings, for preventing and mitigating biosecurity risks and overcoming impediments. Identify the best legislative and policy tools to achieve those outcomes.
10. Commit adequate resources and skills to implement the strategy.
11. Publicly release the final strategy and report annually on implementation. Review and update the biosecurity strategy following the update of the risk and pathway analysis every five years.

Declare Norfolk Island a biosecurity zone

Modern biosecurity laws offer flexible tools that can be moulded to meet the specific biosecurity challenges of islands. One option to facilitate island-specific biosecurity measures is to declare Norfolk Island a biosecurity zone under NSW's Biosecurity Act and develop regulations and policies to help implement the island's biosecurity strategy.

12. Declare the Norfolk Island group a biosecurity zone under NSW's Biosecurity Act 2015.
13. Develop zone-specific regulations and policies to optimise biosecurity for the Norfolk Island group and to implement the biosecurity strategy. This would include, for example, additional import restrictions and conditions, powers and protocols to facilitate rapid responses to new incursions and eradications, and measures to limit the risks of organisms being spread between islands of the Norfolk group.

Secure commitment from all biosecurity participants

Effective biosecurity is increasingly recognised as a shared responsibility of all participants. A new principle encoded in NSW's Biosecurity Act – the general biosecurity duty – offers a way of legally requiring people to take responsibility for biosecurity. It should be used to embed good biosecurity practices within the Norfolk community and those who interact with the island, such as transport company staff.

14. Develop and communicate a clear understanding of what the general biosecurity duty requires of Norfolk Island residents, visitors and transport operators. Operationalise this understanding through agreements, codes of practice and awareness-raising programs.
15. Develop a behavioural change strategy that uses principles of social science to motivate responsible biosecurity behaviours. Engage with local schools to foster biosecurity awareness.
16. Provide training for people who participate in activities with high levels of biosecurity risk or those who contribute to risk or threat mitigation.

Prepare for new incursions

Most of the effort to prevent new invaders should go to the pre-border and border work of limiting the risks of deliberate or accidental introduction of harmful new organisms, but preparations also need to be made to respond if they arrive on the island.

17. Develop contingency plans for responding to incursions of the potentially harmful organisms identified in the risks and pathways analysis.
18. Develop a biosecurity plan for activation during

emergency responses such as for ship wrecks and cyclones, when biosecurity is commonly neglected and risks are high.

19. Implement surveillance for high-risk arrivals. Use detector dogs for both surveillance and deterrence. Establish sentinel sites for high risk invasive species around areas such as the airport, wharves and cargo depots. Support and train a network of motivated community members willing to regularly conduct surveillance activities.

Undertake eradications

Eradicating the most harmful invasive animals from Norfolk Island – rats, cats and Argentine ants – would create a more secure future for wildlife, bring economic benefits for the tourism industry and reduce the need for government funding for management. There may also be the potential to eradicate some invasive plant species before they become serious weeds. It is essential that any eradication program is developed and implemented in close cooperation with the community.

20. Continue to pursue eradication of Argentine ants as outlined in the CSIRO 2017-2018 plan.

21. Identify and pursue opportunities to eradicate invasive animal and plant species on Norfolk Island where it is socially acceptable and feasible, in cooperation with the local community. The black rat, Polynesian rat, feral cat, Asian house gecko, and crimson rosella, as well as emerging weed species, are potential targets for eradication.

Establish Norfolk Island as an NRM region

Securing a future for many threatened and endemic species on Norfolk and surrounding islands requires ongoing management of invasive species. To help locals address the major biosecurity challenges on Norfolk Island, the island group should be established as an NRM region of Australia. This would facilitate greater access to expertise and funding, and trigger the development of a natural resources management plan.

22. Establish the Norfolk Island group as an NRM region of Australia and develop an NRM plan for the islands.

23. Seek funding for NRM priorities, including weed and invasive animal management.

Develop partnerships with other island managers

Because of the shared biosecurity challenges faced by island inhabitants, it could be beneficial for island environmental and biosecurity managers (including community representatives) to share strategies and expertise and to jointly work for greater mainland support for their biosecurity responsibilities. Also needed, because of the particular challenges and opportunities of island biosecurity, is an islands unit within government to develop and advance policies for island biosecurity. There would be mutual synergies in involving New Zealand, given their strong track record of island eradications and commitment to island biosecurity, and the Pacific Island Learning Network (PILN) that is operated by the Pacific intergovernmental environment agency SPREP.

24. Island managers (including from Australia and New Zealand) establish formal and informal partnerships to work together on island biosecurity issues and share expertise.

25. Establish an islands unit within government, involving federal, state and local biosecurity and environmental agencies, to develop and advance policies for island biosecurity.

1. Introduction

Some 3 million years ago a volcano erupted in the southern Pacific Ocean on a ridge of the largely submerged continent of Zealandia.[1] The larva that flowed from multiple eruptions over the next 700,000 or so years built up into a mountain that emerged from the sea.[2] Thus was born land far from any other land mass.

Mount Bates and Mount Pitt on Norfolk Island are thought to be eroded cone remnants near the central vent area of that volcano.[3] Phillip Island is what remains of a smaller volcanic centre that erupted on the slopes of the large volcano. The Norfolk Island group are the only terrestrial parts of the Norfolk Ridge, which extends from New Zealand to New Caledonia.

Currently just 38km^2 in area, these islands lie about 1700 km northeast of Sydney, 1100 km north of Auckland and 700 km south of Noumea. The largest – Norfolk Island, 35km^2 – has about 1400 human residents, supplemented by up to 600 tourists at a time.[4] Phillip Island (190 hectares), the limestone Nepean Island (10 hectares) and other small islets in the group are not inhabited by people.

The geographic isolation of Norfolk Island also means biological, social and political isolation. As with islands elsewhere, this biological isolation has given rise to a highly endemic flora and fauna, whose species are highly susceptible to decline when that isolation is breached by humans and human-introduced species.

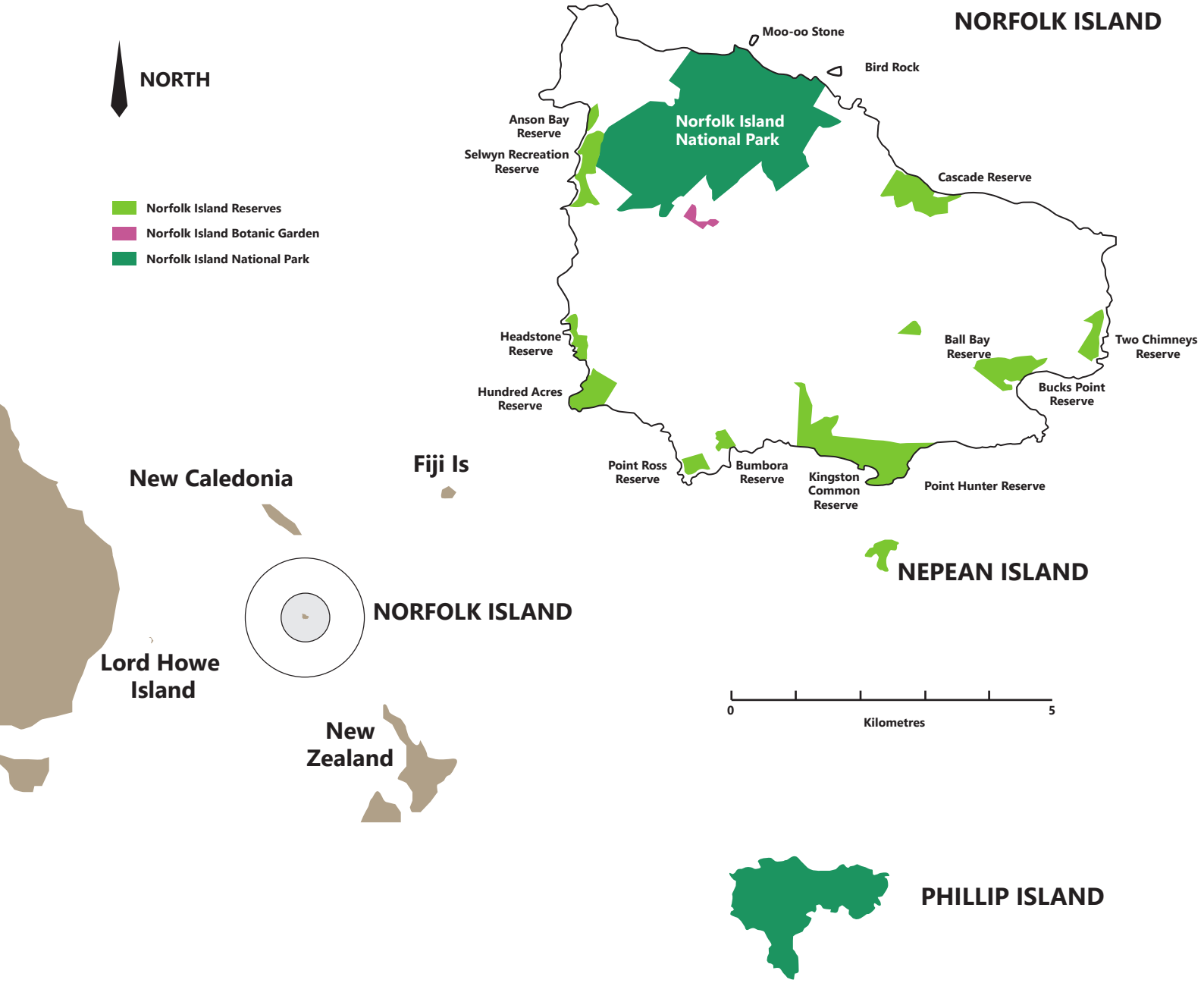
The earliest human inhabitants of Norfolk Island were Polynesians, who arrived perhaps 800 years ago but abandoned the island long before the arrival of Europeans.[5] The history of European occupation is as old as that of mainland Australia. A party of convicts and settlers under the command of Philip Gidley King was dispatched from Port Jackson (Sydney) to harvest pines and cultivate flax and food for the new colony, and to prevent French colonisation.[6] The tumultuous history of convicts, mutineers and settlers since then, which we won't go into, has had a massive impact on the biology of these islands, mainly due to extensive clearing and the introduction of species from other parts of the world. For much of the islands' recent history there has been a major effort to repair the damage and protect the much depleted populations of indigenous wildlife.

There is a strong awareness on Norfolk Island that protecting the island's values requires rigorous biosecurity – keeping out new invasive species and controlling weeds and exotic predators that threaten indigenous species. The importance has been highlighted by recent breaches of quarantine resulting in the establishment of new harmful species such as the Argentine ant, now the focus of an eradication program.

One of many changes resulting from the revocation of self-governance on Norfolk Island in July 2016 is with arrangements for biosecurity. Responsibility for border regulation has passed to Australia's federal biosecurity agency in the Department of Agriculture and Water Resources, while some aspects of the local biosecurity laws also still apply, probably as a temporary measure. Future biosecurity arrangements have not been finalised, but are likely to include application of NSW's biosecurity laws.

This report was prepared to highlight the considerable conservation values of the Norfolk Island group and the importance of rigorous biosecurity to prevent the establishment

The geographic isolation of Norfolk Island also means biological, social and political isolation.



of new invasive species and to limit harm from existing invaders. We briefly outline the environmental values of the Norfolk Island group, the invasive species that threaten those values and the biosecurity risks that need to be managed. We describe the existing and potential arrangements for biosecurity and conclude with recommendations for building a more robust biosecurity system.

We use the term 'biosecurity' broadly to encompass pre-border, border and post-border regulations, policies and activities intended to prevent, eradicate or manage harmful non-indigenous organisms. Our focus is environmental, but effective biosecurity is essential also to protect human health and economic assets.

The transition in governance arrangements for Norfolk Island offers Australia the opportunity to establish an exemplary island biosecurity system. This is very much needed, for islands are hotspots of extinction due to invasive species, including two of three animal extinctions in Australia during the past decade.[7] Protecting rare and iconic species is also of immense importance for developing Norfolk Island's attraction as a nature tourism destination and fostering climate change resilience.

2. Environmental values

There are many special things about the Norfolk Island group – their cliff-ringed beauty and fascinating human history, teeming seabird colonies, and a plethora of species found nowhere else in the world. These endemic species have evolved due to the islands' isolation, with the closest land mass currently 680 km away. Many of them have unfortunately also acquired the conservation significance of rarity since human colonisation, due to habitat destruction and the introduction of exotic species from all over the world.

Of course, these islands only have indigenous wildlife because their isolation has been repeatedly breached by species arriving in the 2.5 or so million years since Norfolk rose from the sea. Birds and insects flew or blew; seeds and spores floated, blew or hitchhiked with birds; and other species swam or drifted on logs or fragments of other lands to colonise the fertile new islands. Some colonising species evolved and diversified into new forms as they adapted to the pressures and opportunities on the islands.

Species indigenous to the islands include about 180 plants, 50 macrofungi, 50 birds (an additional 70 or so are vagrants or non-breeding migrants), and several hundred invertebrate species, including more than 60 land snails.[8] Apart from birds, vertebrate animals were rare colonists: just two bat species, two lizards and two freshwater eels are indigenous.[9] There are also many lichens and bryophytes.

The natural process of colonisation still goes on. Recent bird arrivals include two woodswallow and three petrel species.[10] A 13-year moth survey found that almost 40% of the species on Norfolk Island were non-residents, most having come (presumably blown) from Australia.[11] However, the rate of new species' arrival has dramatically escalated, with most of the hundreds of new species establishing in the past 230 years having been brought by or hitchhiked with humans. Some of these are causing a great deal of damage, by preying on or competing with native wildlife or degrading their habitat (discussed in section 3).

2.1 Endemic and rare species

A substantial proportion of the indigenous species on Norfolk and Phillip Islands are endemic – 43 plants (almost a quarter of the native flora), 15 birds (species and subspecies), 3 marine fishes, and hundreds of invertebrates (including 60+ land snails, 65 beetles, 30 moths, 12 thrips, 11 booklice, 3 katydids, springtails, and a cricket, cicada, centipede and ant).[12] A few additional species, including two lizards, are restricted to the Norfolk Island and Lord Howe Island groups.

When Europeans arrived in 1788, Norfolk and Phillip Islands were densely forested, with the endemic Norfolk Island pine (*Araucaria heterophylla*) dominant in the canopy. Now less than 10% of the original forest survives, mostly within the national park on Mt Pitt and Mt Bates.[13] The bald rolling hills of Norfolk are densely covered in kikuyu grass (an introduced species), and the Norfolk Island pine is threatened.[14]

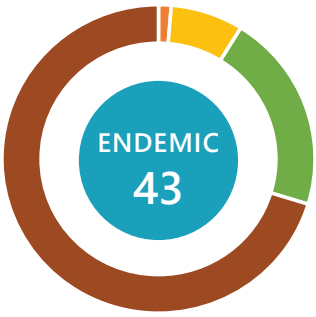
When Europeans arrived in 1788, Norfolk and Phillip Islands were densely forested, with the endemic Norfolk Island pine (Araucaria heterophylla) dominant in the canopy. Now less than 10% of the original forest survives...

The critically endangered Norfolk Island green parrot (or parakeet) has the 'dubious honour of having to be rescued from the brink of extinction not once, but twice'.[37] In 1988 the population was reduced to 32 birds due to predation by rats and cats and competition from crimson rosellas and starlings. Numbers rebounded to about 200 in 2008 due to a recovery program, but by late 2013 they had sunk again to no more than 100, including just 11 breeding-age females. A rescue effort since then has involved setting up rodent-proof nesting sites and spreading chicks among parents to improve survival rates.[38] A project is under way to establish an insurance population on Phillip Island. Photo: Luis Ortiz-Catedral

PLANTS

- *Extinct: 8
- Threatened: 46
- Introduced: 430
- Other native: 128
- Total native: 182

* 6 locally extinct & 2 globally extinct.



Land clearing, hunting and invasive species have led to the loss and decline of many native species. Among the globally extinct species are two plants, seven birds and six land snails (table 2). Now, Norfolk Island's major challenge is to keep other native and endemic species from also disappearing. Fifty-eight Norfolk species are listed as threatened under Australia's national environmental law (*Environment Protection and Biodiversity Conservation Act 1999* [EPBC Act]): 46 plants, five birds (four land birds and one seabird), two reptiles and five land snails.

2.2 Plants

Of the 46 plant species listed as threatened under the EPBC Act, 30 are endemic, two are shared with the Lord Howe Island group, and one is known beyond Norfolk Island from a single individual.[18] Two entire genera are unique to the islands, each represented by a single species, although one is recently extinct (Phillip Island glory pea, *Streblorrhiza speciosa*) and the other (Norfolk Island bastard oak, *Ungeria floribunda*) is threatened.

Globally extinct taxa	Likely major causes
Bridal flower (*Solanum bauerianum*)	Unknown, but probably clearing and rabbits. The species was previously also known from Lord Howe Island.
Phillip Island glory pea (*Streblorrhiza speciosa*)	Grazing by rabbits, goats and pigs.
Norfolk Island pigeon (*Hemiphaga novaeseelandiae spadicea*)	Overhunting, predation by feral cats.
Norfolk Island long-tailed triller (*Lalage leucopyga leucopyga*)	Predation by black rats.
Norfolk Island kaka (*Nestor productus*)	Overhunting.
Grey-headed blackbird (*Turdus poliocephalus poliocephalus*)	Predation by black rats.
White-chested white-eye (*Zosterops albogularis*)	Predation by black rats and clearing.
Norfolk Island starling (*Aplonis fusca fusca*)	Predation by black rats.
Norfolk Island ground dove (*Alopecoenas norfolkensis*)	Predation by feral cats, overhunting.
Stoddart's helicarionid land snail (*Quintalia stoddartii*)	Predation by rats.
Campbell's helicarionid land snail (*Advena campbellii*)	Predation by rats.
Posticobia norfolkensis	Predation by rats.
Quintalia flosculus	Predation by rats.
Nancibella quintalia	Predation by rats.
Panulena perrugosa	Predation by rats.

Table 2. Extinct plants and animals, Norfolk Island group.[15] Right, the now extinct Phillip Island glory pea (*Streblorrhiza speciosa*) was once cultivated in Europe.

2.3 Animals

Norfolk and Nepean Islands are listed by Birdlife Australia as an Important Bird Area (among Earth's most exceptional places for birds) for supporting the entire populations of the white-chested white-eye (*Zosterops albogularis*), slender-billed white-eye (*Zosterops tenuirostris*), green parrot (*Cyanoramphus cookii*) and Norfolk gerygone (*Gerygone modesta*), as well as over 1% of the world populations of wedge-tailed shearwater and red-tailed tropicbird.[20] Phillip Island is separately designated as an Important Bird Area for supporting populations of the globally threatened providence and white-necked petrels and more than 1% of the world's population of the grey ternlet.

Of the 15 species or subspecies of endemic land birds known from Norfolk Island at the time of European settlement, six are listed as extinct under the EPBC Act, two are listed as critically endangered and two as vulnerable. The main causes of extinction and decline have been extensive forest loss and introduced predators and competitors.

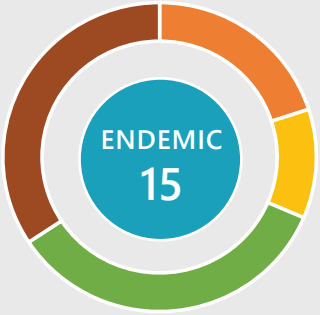
As the only land in a vast area of ocean, the Norfolk Island group offers important breeding and roosting sites for seabirds. Twenty-two birds listed as migratory or marine under the EPBC Act occur on the islands.[21] This includes a threatened subspecies of Kermadec petrel (*Pterodroma neglecta neglecta*), for which Phillip Island is one of two Australian breeding sites. Phillip Island, Nepean Island and other islets are particularly important sanctuaries, for they are free of the rats and cats that have decimated seabird colonies on Norfolk Island.

The only two native mammals known from Norfolk Island – Gould's wattled bat (*Chalinolobus gouldii*) and the eastern freetail bat (*Mormopterus norfolkensis*) – are thought to be locally extinct, due

LAND & FRESHWATER BIRDS*

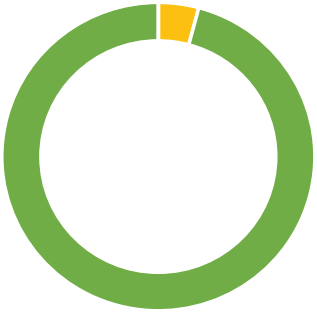
Extinct: 7
Threatened: 4
Other native: 12
Introduced: 12
Total native: 23

* Resident species only.



SEABIRDS

Threatened: 1
Other native: 23



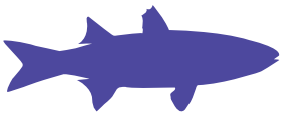
MAMMALS

Extinct: 2*
Introduced: 4

* Locally extinct.

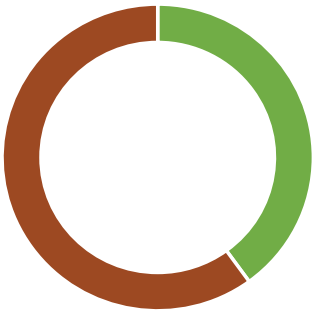
LIZARDS

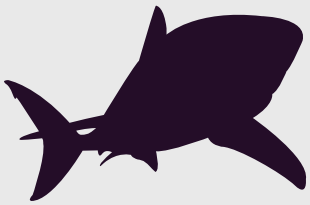
Threatened: 2
Introduced: 1



FRESHWATER FISHES

Native: 2 Introduced: 3



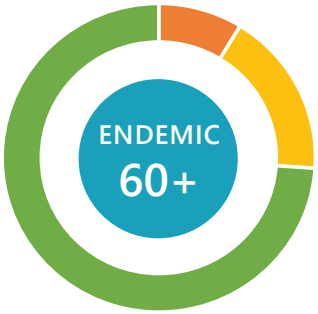


MARINE FISHES

Threatened: 1 Other native: 217

SNAILS

Extinct: 6 Threatened: 12 Other native: 51
Total native: 69



to habitat loss and predation by rats and cats.[22] These species exist in Australia.

The Lord Howe Island skink (*Oligosoma lichenigera*) and the Lord Howe Island gecko (*Christinus guentheri*), restricted to the Norfolk and Lord Howe Island groups, have both been lost from Norfolk Island, probably due to Polynesian rat.[23] The skink survives on Phillip Island (and Lord Howe islands), and the gecko on Phillip and Nepean Islands and small islets (as well as the Lord Howe Island group).

Just two freshwater fish species occur on Norfolk Island – two eels, which also exist in Australia and on other Pacific islands.[24] No frogs have colonised Norfolk Island.

The main threatened invertebrates on Norfolk Island are land and freshwater snails. Of the 69 recorded species, almost all endemic, six are presumed extinct on the IUCN Red List and 12 are threatened.[25] The main threats are environmental degradation and exotic predators.

As one of three subtropical island groups in the south-west Pacific Ocean (along with the Lord Howe Island group to the west and the Kermadec Islands to the east) the Norfolk Island group provides important feeding and breeding grounds for marine species. The alternating influence of warm and cool currents creates a transition

Like most other endemic birds on Norfolk Island, the Norfolk Island golden whistler (*Pachycephala pectoralis xanthoprocta*), listed as vulnerable, is threatened by rats and cats. These introduced predators also prevent most seabird species nesting on Norfolk Island. White terns (*Gygis alba*) gain some protection by nesting high in trees. The chick shown here has hatched from an egg laid in a depression on a tree branch.

zone resulting in an unusual mix of tropical and temperate species. The inshore waters support one of the southern-most coral assemblages in the world, and one of the few known transitional algal and coral assemblages.[26]

With Norfolk Island in the path of the East Australian current, most of the 220 marine fish species (85%) in the area are also in Australian mainland waters.[27] Whales, dolphins, sharks and turtles also inhabit Norfolk Island waters.

2.4 Protected areas

Much of Norfolk Island's remnant vegetation is protected in the Norfolk Island National Park, managed by Parks Australia. This park consists of 460 hectares on the mainland and 190 hectares on Phillip Island.[35] The Norfolk Island Botanic Garden, also managed by Parks Australia, covers 5.5 hectares. Other public reserves, managed by the local Conservator of Public Reserves, include the 10 hectare Nepean Island.

The vegetation remnants protected in the national park include palm and tree fern forest, hardwood forest, and Norfolk pine-dominated forest. The botanic garden contains a small remnant of the subtropical viney hardwood forest which once covered the island foothills.[36] Their small size renders these remnants very sensitive to disturbance.

Little is known about the invertebrate fauna of Norfolk Island. Five years ago, just three species of thrips had been recorded on Norfolk Island.[39] The quarantine survey from 2012 to 2014 added an additional 63 species to the inventory.[40] A dozen species (about 20%) are endemic or presumed endemic. About 30% are probably native to Norfolk as well as other lands, but the largest proportion – almost 50% – are widespread invasive species which feed on horticultural and vegetable crops.

Photo: Laurence Mound, CSIRO

3. Invasive species

Island wildlife can be highly susceptible to harm from invasive species. Evolving with fewer competitors, predators and parasites than wildlife on continents, island species often have poor defences against invaders. Species introduced by or arriving with humans are often very different to indigenous island species and could not travel across oceans under natural conditions. They can thrive on islands due to fewer predators, competitors and pathogens than in their land of origin, and vacant ecological niches.[41] As a result, invasive species on islands have been responsible for a great proportion of global extinctions over the past few centuries. Three-quarters of the recorded extinctions of terrestrial vertebrate animals have occurred on islands, mostly caused by invasive species.[42]

Norfolk and Phillip islands exemplify the vulnerability of island species to invasive species. As shown in the graph on page 21, invasive species – particularly weeds, rats and feral cats – constitute the major threat to the islands' wildlife. For example, the threats go beyond predation and competition. By decimating seabird colonies on Norfolk Island, rats and cats have seriously compromised ecological processes, due to the reduction in phosphorous previously deposited in the guano of millions of seabirds.[43]

The story of Phillip Island exemplifies the habitat devastation that can be wrought by invasive species. Goats, pigs and rabbits almost completely denuded the island, resulting in severe erosion, with the loss of probably some two metres of soil in most places.[44] Since the eradication of pigs and goats in the early 1900s and rabbits in 1986, some vegetation has regenerated, mainly in the gullies. The island's flora now consists of 42 indigenous species and 60 exotic species, including some serious weeds.[45]

3.1 Weeds

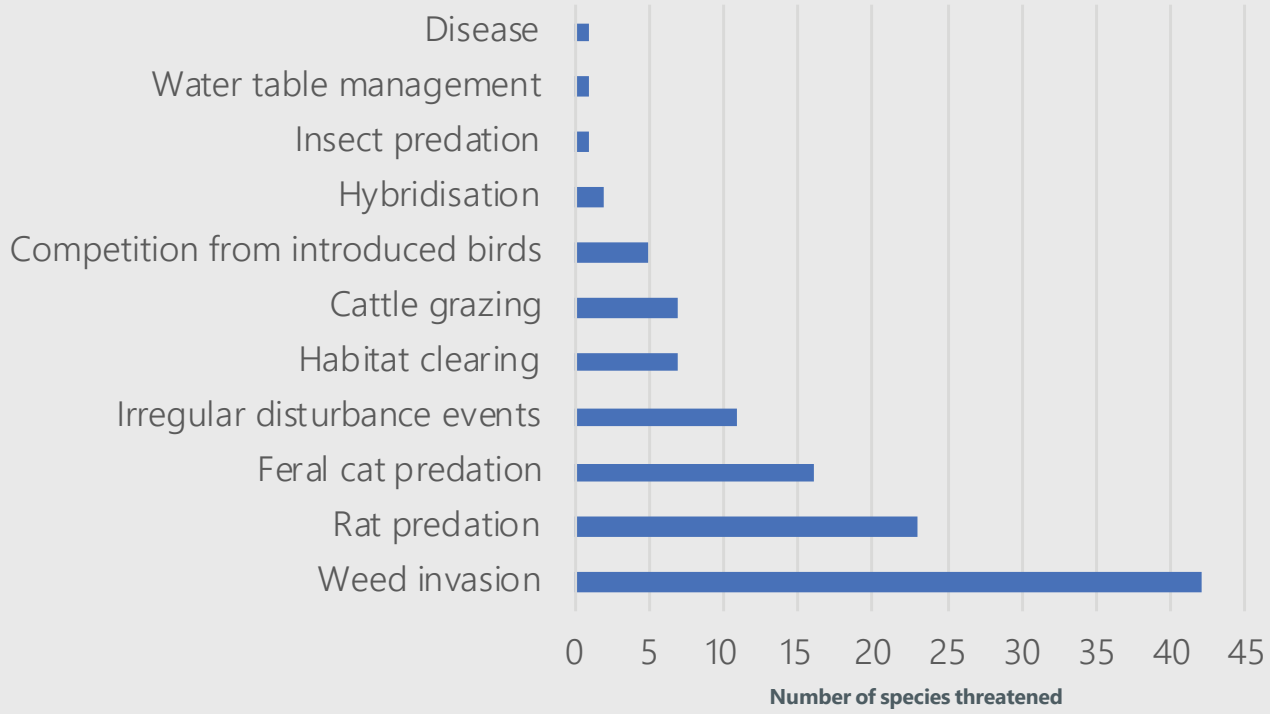
Indigenous plant species are far outnumbered on the Norfolk Island group by exotic species. Some 430 exotic plant species have established, more than twice as many as the 182 known indigenous species.[47] More than 50 were recorded for the first time during a quarantine survey in 2012-2014.[48] The situation could get worse if new species continue to be introduced from mainland Australia without being assessed for weed risk, for, as noted in the quarantine survey report, many mainland weed species are absent from Norfolk Island.

Weeds have transformed many ecological communities on Norfolk and Phillip Islands – suppressing and eliminating native plants, altering the structure of the vegetation and depriving animals of essential habitat elements.[49] For example, by changing the forest structure, weeds have reduced the number of nesting hollows available for boobook/morepork owls and green parrots.[50] Areas with dense stands of red guava or African olive tend to have lower surface soil moisture, resulting in the death of mature Norfolk Island pines due to competition for moisture.

Weeds have transformed many ecological communities on Norfolk and Phillip Islands – suppressing and eliminating native plants, altering the structure of the vegetation and depriving animals of essential habitat elements.

A wall of red guava (*Psidium cattleianum*) – one of Norfolk Island's worst weeds – backs a recently treated area, where native plants are now regenerating. In the background are Norfolk Island pines. Photo: Kevin Mills

MAJOR THREATS TO NORFOLK ISLAND GROUP SPECIES



Source: Norfolk Island Region Threatened Species Recovery Plan.

Without intensive management, weeds 'would destroy most park and botanic garden values', says the national park management plan.[51] Managing the woody weeds that dominate substantial areas of the park – red guava, African olive and Brazilian pepper – is the major demand on park funding. Competition from weeds is a threat to all 46 listed threatened plant species, most of which are endemic.[52]

Red guava (*Psidium cattleianum*):[53] Introduced for its edible fruit, this weed forms dense thickets with mats of feeder roots that make it difficult for other species to grow. It dominates the understorey in parts of the national park. The fruit is a food source for birds such as the green parrot as well as rats. When the fruits decompose they can alter soil chemistry.

African olive (*Olea europaea* subsp. *cuspidata*): This weed established on Norfolk Island soon after settlement and has created dense forests that dominate parts of the national park, particularly the drier aspects. It inhibits native plant germination and growth. It established on Phillip Island after the removal of rabbits and is now the main woody weed on the island and a threat to rare plants. However, it also helps mitigate soil erosion, and on Norfolk provides a year round source of food for birds such as the green parrot.

Brazilian pepper/Hawaiian holly (*Schinus terebinthifolius*): Introduced as a garden plant, this weed can displace native species in undisturbed sites. It prevents the re-establishment of other species due to the release of allelopathic substances. The fruits have been implicated in bird intoxication and death. It is difficult to manage as the sap can cause allergic reactions and skin lesions.

Lantana (*Lantana camara*): Introduced as a garden plant, this is an aggressive weed of open areas that suppresses regeneration of native species.

Mist flower/William Taylor (*Ageratina riparia*): Introduced as a garden plant, this weed of open areas shades out small native plants. It dominates the understorey in parts of the national park.

Kikuyu grass (*Cenchrus clandestinus*): Introduced for pasture and erosion control, kikuyu severely restricts regeneration of native plants by forming a thick sward that can rarely be penetrated by seedlings of other species. It has the potential to degrade habitat for ground nesting seabirds. The grass chokes burrows and has been reported to strangle birds on Lord Howe Island.

Madeira vine (*Anredera cordifolia*): This fleshy climber invades the margins of rainforests smothering small trees and shrubs. It is difficult to control.

Coast morning glory (*Ipomoea cairica*): This twining plant rapidly invades open areas where trees have fallen or woody weeds have been removed.

Formosan lily (*Lilium formosanum*): This vigorous, shade tolerant species produces large numbers of seeds and is difficult to remove. It often grows in disturbed sites.

The regional threatened species recovery plan has identified several additional species on Norfolk Island that have the potential to become serious weeds, including African boxthorn (*Lycium ferocissimum*), asparagus fern (*Protasparagus aethiopicus*), coral berry (*Rivina humilis*) and honeysuckle (*Lonicera japonica*).[54] Others of great concern are cotoneaster (*Cotoneaster glaucophyllus*) and ochna (*Ochna serrulata*).

3.2 Invasive vertebrates

Most animal extinctions and declines on the Norfolk Island group have been caused by introduced predators – two rat species and the domestic cat.[55] The Polynesian rat was introduced by Polynesian explorers probably some 800 years

The black rat (*Rattus rattus*) shown in this photo, taken in New Zealand, is preying on a fantail while it sits on its nest. Photo: © Nga Manu Images

Rats are considered to be the most destructive predator on Norfolk Island, responsible for the loss of several endemic bird species and the two lizard species, which are no longer present on the main island.

ago, the black rat may have come ashore from a shipwreck in 1942, and the cat was brought by early European settlers. Other vertebrates that have caused great damage in the past are rabbits, goats and pigs, all eradicated from Phillip Island.

Polynesian rat (*Rattus exulans*), **black rat** (*Rattus rattus*): These two rat species prey on land birds and seabirds (including eggs and nestlings), reptiles, and invertebrates, including land snails. They are considered to be the most destructive predator on Norfolk Island, responsible for the loss of several endemic bird species and the two lizard species, which are no longer present on the main island. Rats threaten the endemic golden whistler, Norfolk Island robin, green parrot, gerygone, slender-billed white-eye, fantail, most nesting seabirds and land snails. The black rat threatens some plants by eating their seeds and fruits, which compromises regeneration. It is vital that Phillip and Nepean Islands are kept rat-free as they provide refuges for many species threatened by rats and could become refuges for other species at risk on the main island such as the green parrot. There is a third invasive rodent present on Norfolk Island – the house mouse (*Mus musculus*) – but its impacts are unknown.[56]

Feral cat (*Felis catus*): Common throughout Norfolk Island, this predator is a threat to the boobook/morepork owl, green parrot, golden whistler, Norfolk Island robin, and most nesting seabirds. Keeping cats off Phillip and Nepean Islands is a high conservation priority.

Feral chicken/fowl (*Gallus gallus*): Scratching of leaf litter and removal of soil invertebrates by feral chickens disturbs the natural nutrient cycle on Norfolk Island, and their removal of seedlings compromises the regeneration of endangered native plants. They feed on native invertebrates, including endangered land snails, and are a reliable food source for cats and rats. Keeping them off Phillip Island is vital.

Crimson rosella (*Platycercus elegans*), **European starling** (*Sturnus vulgaris*): The use of nest hollows by these introduced birds threatens endangered native birds. They fill hollows with nesting material, preventing use by the boobook/morepork owl and green parrot. Crimson rosellas also compete with green parrots for food, destroy their eggs and evict them from nesting hollows.

Asian house gecko (*Hemidactylus frenatus*): Detected on Norfolk Island in 2005, this species could threaten the indigenous gecko if it became established on Phillip or Nepean Islands.

3.3 Invasive invertebrates

Close to 1200 invertebrate taxa were recorded on Norfolk Island by the 2012-2014 quarantine survey, which focused mainly on species associated with crop, amenity and introduced plants.[57] The survey recorded 421 species not previously known for Norfolk Island. It's not clear from the survey report how many of the invertebrates on Norfolk are exotic or invasive, and it can often be difficult to tell. The impacts of exotic invertebrate species are also often hard to tell. Concerns have been expressed about the European wasp (*Vespula germanica*) and Asian paper wasp (*Polistes chinensis*), for example, but their impacts have not been studied.[58]

A new arrival on Norfolk is the palm seed borer (*Coccotrypes dactyliperda*), an invasive 1.5-2.5 mm beetle that breeds in palm seeds, compromising plant reproduction. It is considered a serious pest of the date palm industry and could potentially impact on the island's kentia palm industry, but the likely impacts on Norfolk's one indigenous palm species (*Rhopalostylis baueri*, found also on the Kermadec Islands), are unknown.[59]

Argentine ant (*Linepithema humile*): First detected in 2005, this invasive ant is likely to cause serious harm to Norfolk Island's wildlife if not eradicated (see section 4). The species has invaded many countries, including the Australian mainland, where it forms super-colonies and competitively displaces most other ant species.[60] On Norfolk Island, the diversity and abundance of other ant species has been noticeably reduced around Argentine ant colonies. The local loss of other ants can compromise ecosystem processes such as soil aeration, nutrient cycling and seed dispersal.

It is thought that the Argentine ant could threaten a substantial proportion of Norfolk Island's vertebrates and invertebrates due to its aggression and need for protein.[61] Ground-nesting seabirds and rare species such as the green parrot and Norfolk Island robin are at greatest risk. Other species such as the two indigenous lizards would be at great risk if the Argentine ant spread to Phillip Island.

European honey bee (*Apis mellifera*): Colonies of honey bees often occupy tree hollows, a resource in short supply for the green parrot and other bird species.[62] Hives are removed from the national park where practicable.

American cockroach (*Periplaneta americana*): This cockroach may have eliminated an endemic cricket on Norfolk Island through competition and is considered a potential threat to the native cockroach on Phillip Island should it establish there.[63]

3.4 Pathogens

The two main pathogens of conservation concern on Norfolk Island – psittacine circovirus disease and root rot fungus – may occur naturally there, as they do in Australia, but their incidence is exacerbated by environmental factors. Other pathogens of native plants and animals on the islands are poorly known.[64] A serious fungal disease of plants in the Myrtaceae family – myrtle rust (*Puccinia psidii*) – has recently arrived on Norfolk Island, detected in 2016. There are no Myrtaceae plants indigenous to Norfolk Island, but its arrival highlights the risks of new disease introductions and it could become a source for transmission to other locations.[65]

Psittacine circovirus disease: This virus is known to infect more than 60 parrot species, including Norfolk Island's critically endangered green parrot.[66] Also known as parrot beak and feather

disease, the virus kills feather and beak cells and is often fatal. It is thought to have been responsible for an epidemic that killed many green parrots on Norfolk Island during the 1970s.[67]

Root rot fungus (*Phellinus noxius*): This is the main pathogen causing dieback of Norfolk Island pines.[68] It attacks tree roots, causing decay and cutting off water and nutrient supply to the crown, resulting in tree death.[69] The fungus is a natural component of rainforests in many countries, but its impacts are exacerbated by low levels of soil phosphorous, highlighting the link between seabirds and the island's ecosystem.[70]

3.5 Marine organisms

No information could be found regarding exotic marine organisms in Norfolk waters and no surveys have been publicly reported.

3.6 Future risks

The recent arrivals of the Argentine ant, Asian house gecko, myrtle rust and palm seed borer on Norfolk Island by unknown means exemplify the risks of new invasive species being introduced. The *Norfolk Island Region Threatened Species Recovery Plan* emphasises the great risks of new disease introductions, particularly of 'extremely dangerous plant pathogens' and bird diseases.[71] The catastrophe that can result was demonstrated in Hawaii when avian malaria, which arrived with an accidentally introduced mosquito species, led to extinction of almost the entire endemic bird fauna below 600 metres altitude. Other high risk groups with the potential to severely impact on island values include well known invaders such as the yellow crazy ant (*Anoplolepis gracilipes*), big-headed ant (*Pheidole megacephala*) and cane toad (*Rhinella marina*).[72] But given the unpredictability of impacts and the susceptibility of island species, many other species not recognised as invasive – including those indigenous to Australia or New Zealand – could cause harm.

The quarantine survey report notes that once a species is introduced to Norfolk Island, a lack of biological barriers almost guarantees it will spread rapidly across the entire island. This was demonstrated recently by tomato/potato psyllid (*Bactericera cockerelli*), which was found during the survey. The psyllid carries a bacterium that causes disease in a wide range of vegetable crops. It was initially found at extremely low levels, implying it had arrived only recently and potentially could be eradicated. By the survey's end, the population had 'increased exponentially' and eradication was no longer possible.[73]

Vital for the survival of several species is the ocean barrier between Norfolk Island and the other islands and rock stacks serving as refuges for several species wiped out on Norfolk. A major conservation priority must be to keep these islands free of invasive species found on the main island, particularly the black rat, Polynesian rat, feral cat, Asian house gecko and Argentine ant.

4. Biosecurity arrangements for Norfolk Island

From 1979 to mid-2016, Norfolk Island was a self-governing external territory of Australia with most of the powers of a national government, including for biosecurity.[74] The Norfolk Island government regulated biosecurity under the *Animals (Importation) Act 1983*, *Plant and Fruit Diseases Act 1959* and *Noxious Weeds Act 1916*.

When self-governance was rescinded on 1 July 2016, the Australian government assumed responsibility for most pre-border and border biosecurity on Norfolk Island under the federal *Biosecurity Act 2015* and the *Environment Protection and Biodiversity Conservation Act 1999* (the latter for live animal imports). The federal government intends that from 1 July 2018 NSW laws will also apply to Norfolk Island, and several already do so.[75] Whether this will also include NSW's *Biosecurity Act 2015* is not clear and will depend on agreement by the NSW government and funding from the federal government.[76] The proposed starting date of July 2018 is probably unrealistic. If NSW's biosecurity laws do apply, it is likely that NSW authorities would have limited involvement with the island and that many powers under the act would be delegated to local authorities.

In the interim, the Norfolk Island biosecurity laws listed above still apply and are administered by the Norfolk Island Regional Council, although the extent of their application for pre-border and border biosecurity appears to be limited. They will be repealed if NSW's Biosecurity Act is applied.

In this section we describe biosecurity arrangements and activities on Norfolk Island and consider some biosecurity challenges and opportunities.

4.1 Pre-border and border biosecurity (quarantine)

Keeping Norfolk Island safe from harmful new invasive species requires assessing the risks associated with imported goods and travellers, restricting goods that present unacceptable risks and applying import conditions to prevent accidental introductions. Working with transport companies and undertaking border inspections are important to limit the risks of accidental or illegal introductions.

We should expect the new biosecurity regime on Norfolk Island under Australian laws to provide exemplary protection – given the modern laws and resources of the new regulator, and the high values on the island requiring protection. Stronger biosecurity is certainly needed, as demonstrated by recent detections of the Argentine ant (2005), Asian house gecko (2005), potato/tomato psyllid and South African mantis (*Miomantis caffra*) (these two species were among many previously unrecorded exotic species detected during the quarantine survey, 2012-2014), myrtle rust (2016) and palm seed borer (2016). The island does not yet have a comprehensive risk-based biosecurity system, particularly for environmental risks.

The first step in the transition arrangements was an intensive survey of species on Norfolk Island – the Norfolk Island Quarantine Survey – conducted by the federal agriculture department from 2012 to 2014. This was to provide baseline information for formulating options for future biosecurity arrangements for Norfolk Island and to identify pests and diseases of potential quarantine significance for mainland Australia. The survey

Working with transport companies and undertaking border inspections are important to limit the risks of accidental or illegal introductions.

Cruise ships are one of several pathways by which new invasive species can reach Norfolk Island. Photo: Thomas Huxley | CC BY-ND 2.0

BIOSECURITY ARRANGEMENTS FOR NORFOLK ISLAND

Previous system (prior to July 2016)	Interim system (from July 2016)	Proposed system
Norfolk Island laws	**Federal laws + Norfolk Island laws**	**Federal laws + NSW laws**
• Animals (Importation) Act 1983 • Plant and Fruit Diseases Act 1959 • Noxious Weeds Act 1916	• Biosecurity Act 2015 • Environment Protection and Biodiversity Conservation Act 1999 (live animal imports)	• Biosecurity Act 2015 (federal) • Environment Protection and Biodiversity Conservation Act 1999 (federal re. live animal imports)
Administered by Norfolk Island Government	Administered by Department of Agriculture and Water Resources	Administered by Department of Agriculture and Water Resources
	• Animals (Importation) Act 1983 • Plant and Fruit Diseases Act 1959 • Noxious Weeds Act 1916	• Biosecurity Act 2015 (NSW)
	Administered by Norfolk Island Regional Council	Administration arrangements unknown but likely major role for Norfolk Island Regional Council.

Table 3. Biosecurity arrangements for Norfolk Island – past, present and as proposed by the federal government.

found more than 140 invertebrate and pathogen species on Norfolk Island not known from mainland Australia (with more to be taxonomically described). Seven species known to attack crops were described as of 'significant quarantine concern' and another 10 of 'some quarantine concern'.[77] The survey report noted there are a large number of species on mainland Australia not found on Norfolk Island, including many weeds and bacterial and fungal plant pathogens. The report was focused mainly on agricultural risks, presumably in part due to limited knowledge of environmental risks. It also reflects the dominance of agricultural pests and diseases in Australia's national biosecurity focus.[78]

In recognition of the 'unique animal and plant pest and disease status of Norfolk Island', the Australian government has established a legal instrument – the *Biosecurity (Prohibited and Conditionally Non-Prohibited Goods—Norfolk Island) Determination 2016* – which lists prohibited imports and the conditions for importing goods where they differ from conditions for importing goods to the mainland.[79] The biosecurity agency says it has strengthened conditions for some imports, including livestock, some agricultural supplies such as stockfeed, and poultry products from New Zealand.[80] These are intended in large part to protect primary industries on Norfolk Island and mainland Australia from risks originating from New Zealand, from where all sea cargo enters Norfolk Island.[81]

The legal instrument contains few prohibitions and conditions specific for Norfolk Island's conservation values. Apart from a few exceptions, for example, it allows the importation of seeds on Australia's permitted list or seeds whose origins are Australia. This means that the seeds of potential new weed species from Australia can be imported under this instrument (provided their botanical name is listed).[82]

A federal permit is required for importing live animals to Norfolk Island, but the criteria applied in assessing import applications are unknown. Because risk assessments and import decisions are not published, we do not know if the specific risks for Norfolk Island, such as the potential for imported animals to establish on the island or bring new diseases, are assessed, or if – as with seed imports – the general approach is to permit on Norfolk Island the species that are permitted in Australia.[83] One concern is that permitting the importation to Norfolk Island of parrots as pets (which has not been allowed for the past 30 years) would increase disease risks for the critically endangered green parrot. Not all risks can be effectively mitigated. For example, the diagnostic tests for avian bornoviruses, which cause an often fatal disease that has been recorded in pet parrots in Australia, are not sensitive enough to detect all cases.

The biosecurity agency is reviewing conditions for seed imports to 'ensure the permitted seeds list is appropriate and adapted for Norfolk Island', but the review process (being undertaken in parallel with the development of conditions for other plants and plant products) 'will take a considerable amount of time to be completed'.[84] The agency is also working with the Department of Environment and Energy regarding the regulation of biosecurity risks for the environment on Norfolk Island (particularly for live animals and pest species).[85]

The implication is that until these reviews are complete and relevant biosecurity measures are implemented, some biosecurity risks for Norfolk Island are unacceptably high, particularly for seed imports. While the Australian government evidently has a strong commitment to preventing new diseases or pests arriving on the mainland from Norfolk Island, we question whether there is a similarly strong commitment to preventing potential new weeds and other environmental invaders arriving on Norfolk Island. As noted above, the Norfolk Island quarantine survey found that the island is free of many invasive species inhabiting Australia.

Under the interim arrangements, with the local Norfolk Island laws still applying, the importation of certain plants and animals may also require approval by the Norfolk Island Regional Council.[86] These laws could be used to keep out harmful species not covered by the federal regime. Under the Animals (Importation) Act, a permit must be granted by the Norfolk Island Regional Council for any imports of live animals, in addition to the permit required from federal authorities. According to the council's website, its role is 'to assess the appropriateness of certain dog breeds and animal species that are imported to the island.'[87] The council's authority for assessing these imports has been delegated from the Australian Minister for Local Government and Territories.[88] Under the Plant and Fruit Diseases Act, any plant or animal can be declared a pest, and thus be prohibited from importation.[89] Powers under this act have been delegated to various federal officers and regional council staff.[90] However, there is no mention on the council's website or any other Australian government websites of any biosecurity requirements under the Plant and Fruit Diseases Act.

There is no clear linkage between the permitting processes of the federal biosecurity agency and the regional council, and the federal Department of Agriculture and Water Resources does not appear to fully recognise the council's role or publicly communicate the need for council approval of some imports.[91]

The Norfolk Island biosecurity laws provide for a great deal of discretion by decision-makers about which products can be permitted or denied entry. The Animals (Importation) Act permits but does not require the administrator to take environmental considerations into account and the Plant and Fruit Diseases Act does not mention any environmental considerations. If the local laws are retained, they need strengthening to require that decisions be guided by consideration of risks for the environment,

as well as other factors. The import procedures under these local laws should be integrated with arrangements under the federal laws.

The Department of Agriculture and Water Resources has placed biosecurity officers on Norfolk Island and bolstered some quarantine capabilities, for example by providing a detector dog.[92] One difference in biosecurity practices that has generated concern by islanders is there are no longer routine inspections of vessels arriving at Norfolk Island. The Norfolk Island Plant and Fruit Diseases Act requires that 'Immediately upon the arrival of a vessel or aircraft at Norfolk Island, an Inspector shall board the vessel or aircraft and shall search and inspect the vessel or aircraft for the purpose of ascertaining whether any plants, fruit or goods are infected or whether any disease or pest exists on the vessel or aircraft.' This no longer occurs. Federal biosecurity officers 'only board vessels arriving at Norfolk Island if there is a biosecurity imperative to do so' – if, for example, there are any concerns raised by the pre-arrival report.[93] There is now much greater reliance on port operators, shipping agents and stevedores taking responsibility for biosecurity. This reflects the process that occurs on mainland Australia. However, federal biosecurity officers do undertake surveillance of cargo when it is offloaded onto the Norfolk Island wharf. According to the biosecurity agency, this level of surveillance on goods 'is in excess to what would normally occur on the Australian mainland'.[94]

4.2 Post-border biosecurity

Protecting Norfolk Island's unique wildlife requires intensive management of invasive species. Much of this occurs in the national park and botanic garden, funded by Parks Australia. According to the 2008-2018 management plan for the national park and botanic garden, protecting their values 'depends fundamentally on reducing or managing adverse impacts of plants, animals and pathogens …, rehabilitating natural ecosystems … and rigorous quarantine measures'.[95] Priority is given to improving the conservation status of threatened species. This includes weed management (the major demand on management resources), trapping and removing cats and subsidising a desexing program, killing rats, and protecting threatened species from invasive species (eg. rat-proofing the breeding sites of birds and removing starling nesting material from boobook/morepork nest boxes). There is also considerable effort on revegetating denuded areas and areas cleared of weeds. The management plan emphasises the importance of improving quarantine to prevent new weeds, predators, competitors and pathogens from entering Norfolk Island or from crossing to Phillip Island (which remains free of rats, cats and fowl/chickens).

Outside the park, a major effort is being made to eradicate Argentine ants. There has been considerable success in containing the ants and eliminating them over small areas. A 2017 CSIRO review reported a 'consensus between Norfolk Island residents and people globally involved in ant eradications that eradication … is achievable'.[96] It recommended a two year program, currently underway, to demonstrate the feasibility of methods for treating larger and logistically difficult areas, as well as for surveying previously treated areas to confirm eradication of the ant (using a detector dog). Once these challenges have been met, eradication is likely to require about $2 million over five years. The current program will be reviewed in June 2018.

If the eradication program was to be abandoned, Argentine ants would eventually spread over the entire island, with many adverse consequences for wildlife and horticulture.[97] Argentine ants are established in many sites on mainland Australia and in New Zealand, so there is an ongoing biosecurity challenge to ensure the species is not transported to Norfolk Island again.

There is also work outside the national park to control rats. At Anson Bay, adjacent to the national park in the north-west corner of Norfolk Island, local landholders have installed a network of rat bait stations. Locals volunteer their time to make, install and bait the stations, with materials supplied by Wild Mob and the Invasive Species Council.

4.3 Risks, challenges and opportunities

Here we briefly summarise some of the biosecurity challenges and opportunities for the Norfolk Island group which should be addressed as the new biosecurity system is developed.

Deficient harmonisation: There has recently been a strong emphasis in Australian biosecurity on the importance of harmonising arrangements between different levels of government to achieve a seamless system. The new federal regime was established around the recommendations of the 2008 Beale review, with this theme of harmonisation reflected in the title of the final report, *One Biosecurity: A Working Partnership*.[98] So far, harmonisation between federal and Norfolk Island officials appears to be deficient under the interim arrangements (as exemplified above for animal imports). The lack of a state level participant in Norfolk Island biosecurity and the apparent reluctance of the federal agency to integrate federal and local priorities could be impediments to effective biosecurity.

Underwhelming environmental focus: The current arrangements for Norfolk Island indicate insufficient priority accorded to environmental biosecurity, particularly evident with the limited restrictions on seed imports from Australia. The species of quarantine concern highlighted in the report of the quarantine survey of 2012-2014 were mostly those of agricultural concern, and there does not appear to be any list of environmental risks for Norfolk Island to inform quarantine priorities. The federal department responsible for biosecurity has indicated the intention to review seed imports and identify environmental risks, but this needs to be accorded a higher priority. Safeguarding the island's wildlife from new (and established) invasive species should also be a high priority for economic reasons – for example, by providing a more secure future for nature-based tourism and limiting the costs of managing the impacts of invasive species on natural values (costs mostly borne by Parks Australia).[99]

Growing biosecurity risks: The continued global spread of invasive species, including to mainland Australia and New Zealand, heightens the risks of new incursions to Norfolk Island, exemplified by the arrival of myrtle rust on the island just six years after it was first detected in Australia. With the intended increase in trade for Norfolk Island will inevitably come greater biosecurity risks, including new pathways for invasive species.[100] Risks may also increase due to new port arrangements that will allow vessels to moor near land.[101] Currently, vessels moor about 100 metres from the island and cargo is brought ashore by smaller watercraft. This limits the risk of hitchhiker organisms on ships making it to shore, although insects such as the burnt pine longicorn beetle (Arhopalus ferus) could fly to land while a vessel is anchored offshore.[102]

Biosecurity for Norfolk Island is aided by the limited pathways by which species can be introduced, some of which are listed in Table 4. Apart from mail, almost all goods entering Norfolk Island originate from mainland Australia or New Zealand. However, these two lands have many thousands of species not found on Norfolk Island, including a plethora of potential invaders. Two cargo vessels service Norfolk Island, each arriving at six weekly intervals from Auckland.[103] Goods from Australia are first shipped to New Zealand. The quarantine survey report noted several poorly managed risks in the transit area at Auckland, where cargo can be held for several weeks before loading and which lack quarantine isolation. There is no quarantine inspection of in-transit cargo.[104]

Out of sight, out of mind: With a small population

TABLE 4: EXAMPLES OF POTENTIAL INVASION PATHWAY

Group	Pathways
Weeds	Permitted introductions of garden seeds.
	Illegal importation of garden plants or seeds.
	Accidental introduction of weed seeds, eg. attached to travellers boots and gear or imported goods.
	Spread of weeds from Norfolk to Phillip or Nepean Island, eg via birds.
Pathogens	Accidental introduction of pathogens with imported goods or with travellers and baggage.
	Illegal introductions of plant material.
Invasive animals	Accidental introductions of animals with imported goods, travellers, and from ships, yachts and aircraft.
	Natural introductions, eg. through flying, floating, blowing, attachment to birds. (This is not a preventable risk, but eradication can be feasible if new species are detected in time.)
	Permitted or illegal introductions of pets or domestic animals.
Marine species	Hull fouling is the major risk.

far from mainland Australia, the Norfolk Island community has a major challenge to ensure sufficient attention from the mainland is directed to island priorities. There is often scant recognition in the Australian government of the special environmental values and challenges of islands.[105] There would be benefits in island managers working with each other and with mainland groups to generate more focus on island priorities.

Limited resources: Although not a problem unique to Norfolk Island, one of the greatest impediments to managing invasive species has been a lack of resources, including funding and technical expertise. The small population and rate base has greatly restricted funding available for management. One benefit of the integration of Norfolk Island into Australia is the potential to gain greater access to national funding and grants programs. There is need to strengthen local capacity for surveillance and identifying new incursions as well as participating in biosecurity programs. Ideally, there would be a local conservation group and education centre to foster expertise and participation.

Eradication opportunities: Being small and isolated can also be advantageous for biosecurity – by limiting pathways for invasive species and making eradications much more feasible than on the mainland. Eradications offer the exciting potential on Norfolk Island to reverse the declines of many threatened endemic species and save on the large amounts of funding needed to conserve threatened species. They would also improve the island's appeal as a nature tourism destination.[106]

Much progress has been made on eradication techniques, including for Norfolk Island's most harmful species – rats and cats. Globally, there have been more than a thousand eradications of invasive species (mostly mammals) on islands.[107] Australia and New Zealand have been at the forefront of this effort, with each achieving more than 200 successful eradications on islands.[108] New Zealand has declared a goal of eliminating all invasive vertebrate predators from the country by 2050.[109] Australia has recently eliminated cats from the 630km^2 Dirk Hartog Island, the largest ever cat eradication.[110] Such experience indicates that eradication of rats and cats from the 35km^2 Norfolk Island is probably achievable. Eradications can be more complicated on inhabited than on uninhabited islands and will require commitment and support from locals.

Creating an exemplar: The transition in biosecurity arrangements offers an excellent opportunity to create an exemplary biosecurity system for Norfolk Island – to demonstrate the value of the new federal and NSW biosecurity laws island conservation and the commitment of the federal government to protect the special values of the Norfolk Island group.

5. Recommendations

Protecting the high conservation values of Norfolk Island demands a high level of biosecurity.[74] Australia should apply optimal methods and tools to achieve this and establish Norfolk Island as an exemplar of island biosecurity. For this, it will be vital to engender strong local engagement.

We presume (and support), as flagged in the proposed legislative arrangements for Norfolk Island, that NSW's Biosecurity Act 2015 will eventually apply in addition to the federal Biosecurity Act 2015. If this occurs, there will presumably be considerable delegation of powers under the state law to local authorities, which will need to be well funded to supplement the island's limited local capacity. Whatever the legislative arrangements, the approach should be to identify the desired biosecurity outcomes and then apply the best legislative and policy tools to achieve them. Modern biosecurity laws are flexible enough to allow for this.

5.1 Harmonise biosecurity arrangements

Effective biosecurity on Norfolk Island can only be achieved through strong cooperation between the managers of biosecurity at federal and local levels – and also at a state level if NSW's laws are applied – and by harmonising arrangements to achieve a strong pre-border, at-border and post-border biosecurity continuum. As discussed in section 4, there appear to be gaps in the current regime with the federal focus mainly on preventing pests and diseases that would be new to mainland Australia and a lack of integration with or full application of the temporarily retained local laws.

Recommendations

1. Negotiate an agreement for NSW's Biosecurity Act 2015 to apply on Norfolk Island.
2. Establish a Norfolk Island biosecurity committee with representation from the different levels of government, including biosecurity and environmental agencies, to formulate biosecurity policies and priorities for Norfolk Island and to foster harmonisation.
3. Develop a memorandum of understanding between the levels of governments to facilitate cooperation, designate roles and responsibilities, and specify funding commitments.
4. Create mechanisms for engaging industry, environmental and community stakeholders in developing and implementing biosecurity laws, policies and programs.
5. While local laws still apply, strengthen the protection they afford for environmental values, including by requiring that decisions be guided by assessments of risks for the environment as well as the economy and human health and that a precautionary approach be applied.

5.2 Conduct risks and pathways analysis

Consistent with accepted biosecurity practice, the biosecurity arrangements and priorities for Norfolk

Whatever the legislative arrangements, the approach should be to identify the desired biosecurity outcomes and then apply the best legislative and policy tools to achieve them.

All goods shipped to Norfolk Island are unloaded offshore and brought ashore by a smaller boat. This provides some protection against hitchhiker organisms on ships making it to shore. A new wharf is being built that will allow ships to moor alongside – one of many ways in which biosecurity risks are changing on Norfolk Island. Photo: thinboyfatter | Flickr | CC BY 2.0

Island should be informed by a comprehensive analysis of risks – for the environment, economy and human wellbeing.

Recommendations

6. Commission an independent analysis of biosecurity risks and pathways: Identify the values to be protected and the known and potential biosecurity risks to these values. Prioritise risks and identify the pathways of medium to high priority risks. Recommend risk prevention, emergency response measures and mitigation strategies.

7. Make this risk analysis publicly available and update it as new information becomes available. Review and update the risk and pathway analysis every five years.

5.3 Develop a Norfolk Island biosecurity strategy

A strategy is needed to guide the development of a strong biosecurity system for Norfolk Island based on the risks and pathways analysis recommended above.

Recommendations

8. Commission an independent expert to develop a biosecurity strategy for Norfolk Island in close consultation with all levels of government; community, industry and environmental stakeholders; and biosecurity and ecological experts.

9. Focus the strategy on the highest priority risks and threats. Identify impediments to effective biosecurity. Develop strategies, with approximate costings, for preventing and mitigating biosecurity risks and overcoming impediments. Identify the best legislative and policy tools to achieve those outcomes.

10. Commit adequate resources and skills to implement the strategy.

11. Publicly release the final strategy and report annually on implementation. Review and update the biosecurity strategy following the update of the risk and pathway analysis every five years.

5.4 Declare Norfolk Island a biosecurity zone

Modern biosecurity laws offer flexible tools that can be moulded to meet the specific biosecurity challenges of islands. One option to facilitate island-specific biosecurity measures is to declare Norfolk Island a biosecurity zone under NSW's Biosecurity Act and develop regulations to help implement the island's biosecurity strategy. The memorandum of understanding recommended above would need to include a commitment by federal authorities to assist in seamlessly implementing the state-level measures that intersect with their pre-border and border responsibilities.

Recommendations

12. Declare the Norfolk Island group a biosecurity

zone under NSW's Biosecurity Act 2015.

13. Develop zone-specific regulations and policies to optimise biosecurity for the Norfolk Island group and to implement the biosecurity strategy. This would include, for example, additional import restrictions and conditions, powers and protocols to facilitate rapid responses to new incursions and eradications, and measures to limit the risks of organisms being spread between islands of the Norfolk group.

5.5 Secure commitment from all biosecurity participants

Not all biosecurity actions can be mandated by specific laws. Effective biosecurity is increasingly recognised as a shared responsibility of all participants. This requires people to be aware of the specific biosecurity risks of their activities and to take responsibility for mitigating them. Particularly on islands, where biosecurity officers and experts are scarce, effective biosecurity requires citizens to be vigilant – reporting unusual sightings, for example – and to participate in surveillance and management. A new principle encoded in NSW's Biosecurity Act – the general biosecurity duty – offers a way of legally requiring people to take responsibility for biosecurity.[111] It should be used to embed good biosecurity practices within the Norfolk community and those who interact with the island, such as transport company staff.

Recommendations

14. Develop and communicate a clear understanding of what the general biosecurity duty requires of Norfolk Island residents, visitors and transport operators. Operationalise this understanding through agreements, codes of practice and awareness-raising programs.

15. Develop a behavioural change strategy that uses principles of social science to motivate responsible biosecurity behaviours. Engage with local schools to foster biosecurity awareness.

16. Provide training for people who participate in activities with high levels of biosecurity risk or those who contribute to risk or threat mitigation.

5.6 Prepare for new incursions

Most of the effort to prevent new invaders should go to the pre-border and border work of limiting the risks of deliberate or accidental introduction of harmful new organisms, but preparations also need to be made to respond if they arrive on the island. This means developing contingency plans and conducting surveillance for high risk organisms.

Recommendations

17. Develop contingency plans for responding to incursions of the potentially harmful organisms identified in the risks and pathways analysis.

18. Develop a biosecurity plan for activation during emergency responses such as for ship wrecks and cyclones, when biosecurity is commonly neglected and risks are high.

19. Implement surveillance for high-risk arrivals. Use detector dogs for both surveillance and deterrence. Establish sentinel sites for high risk invasive species around areas such as the airport, wharves and cargo depots. Support and train a network of motivated community members willing to regularly conduct surveillance activities.

5.7 Undertake eradications

As discussed in section 4.3, it is potentially feasible (based on experience elsewhere) to eradicate the most harmful invasive animals from Norfolk Island – rats, cats and Argentine ants. This would create a more secure future for wildlife, bring economic

benefits for the tourism industry and reduce the need for government funding for management. The benefits of eradication have been amply demonstrated by the eradication of pigs, goats and rabbits from Phillip Island. There may also be the potential to eradicate some invasive plant species before they become serious weeds (e.g. species mentioned in section 3.1.) As the experience with the planned eradication of rodents on Lord Howe Island demonstrates, it is essential that any eradication program is developed and implemented in close cooperation with the community.[112]

Recommendations

20. Continue to pursue eradication of Argentine ants as outlined in the CSIRO 2017-2018 plan.

21. Identify and pursue opportunities to eradicate invasive animal and plant species on Norfolk Island where it is socially acceptable and feasible, in cooperation with the local community. The black rat, Polynesian rat, feral cat, Asian house gecko, and crimson rosella, as well as emerging weed species, are potential targets for eradication.

5.8 Establish Norfolk Island as an NRM region

Securing a future for many threatened and endemic species on Norfolk and surrounding islands requires ongoing management of invasive species. To help locals address the major biosecurity challenges on Norfolk Island, the island group should be established as an NRM region of Australia. This would facilitate greater access to expertise and funding, and trigger the development of a natural resource management plan. A draft NRM plan was developed in 2009 but never implemented.[113]

Recommendations

22. Establish the Norfolk Island group as an NRM region of Australia and develop an NRM plan for the islands.

23. Seek funding for NRM priorities, including weed and invasive animal management.

5.9 Develop partnerships with other island managers

Because of the shared biosecurity challenges faced by island inhabitants, it could be beneficial for island environmental and biosecurity managers (including community representatives) to share strategies and expertise and to jointly work for greater mainland support for their biosecurity responsibilities. Given the challenges shared by Norfolk Island and Lord Howe Island, their geographical and botanical similarities and their potential links under NSW law, it could be particularly beneficial for these islands' managers to work together. Also needed, because of the particular challenges and opportunities of island biosecurity, is an islands unit within government to develop and advance policies for island biosecurity. There would be mutual synergies in involving New Zealand given their strong track record of island eradications and commitment to island biosecurity. Another opportunity for learning, capacity building and information exchange is provided by the Pacific Island Learning Network (PILN) that is operated by the Pacific intergovernmental environment agency SPREP.[114]

Recommendations

24. Island managers (including from Australia, New Zealand and PILN) establish formal and informal partnerships to work together on island biosecurity issues and share expertise.

25. Establish an islands unit within government, involving federal, state and local biosecurity and environmental agencies, to develop and advance policies for island biosecurity.

Endnotes

1 Mortimer et al. (2017).
2 Jones & McDougall (1973).
3 Green (1973).
4 Norfolk Online News (2016).
5 Anderson et al. (2001).
6 Gill (1975).
7 We refer to the Christmas Island pipistrelle (Pipistrellus murrayi) and the Christmas Island forest skink (Emoia nativitatis). The third extinction, of the Bramble Cay melomys (Melomys rubicola), was probably due to rising sea levels.
8 Department of the Environment and Energy (nd), Director of National Parks (2008), Director of National Parks (2010), Mills (2009b), Mills (2012), Ponder (1997), Smithers (1998).
9 Department of the Environment and Energy (nd).
10 Christian (nd), Coyne (2009).
11 Holloway (1990).
12 Bray (nd) (a&b), Department of the Environment and Energy (nd), Director of National Parks (2008), Director of National Parks (2010), Mills (2009b), Møller & Schwarzhans (2006), Mound & Wells (2015), Ponder (1997).
13 Director of National Parks (2008).
14 The species is listed as vulnerable in the IUCN Red List (Thomas 2011).
15 Cornell Lab of Ornithology (2017), Department of the Environment (2009), Department of the Environment and Energy (nd), IUCN Red List, Mills (2009b). Not all these species are recognised as extinct under the EPBC Act.
16 There are also locally extinct species such as two bat and six plant species.
17 This species, known only from a painting, is not recognised under the EPBC Act, but a global database of bird species managed by the Cornell Lab of Ornithology says it is now 'widely accepted' as a valid species (Cornell Lab of Ornithology 2017).
18 Director of National Parks (2010).
19 Department of Agriculture (2015), Director of National Parks (2010), Mills (2009b), Mills (2013).
20 Birds Australia & Birdlife International (2011).
21 Director of National Parks (2010).
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23 Cogger et al. (2006), Department of the Environment and Energy (nd).
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26 Parsons Brinckerhoff Australia Pty Ltd (2009), citing Kuster (2001).
27 Parsons Brinckerhoff Australia Pty Ltd (2009), citing Mosley (2001).
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30 Director of National Parks (2010).
31 Cogger et al. (2006), Director of National Parks (2010).
32 Department of the Environment and Energy (nd), McCormack & Coughran (2009).
33 Bray (nd) (a&b), Møller & Schwarzhans (2006), Parsons Brinckerhoff Australia Pty Ltd (2009).
34 Director of National Parks (2010), Ponder (1997).
35 Director of National Parks (2008).
36 Director of National Parks (2008).
37 Nias (2015).
38 Jeffery (2017).
39 Mound & Wells (2015).
40 Department of Agriculture (2015).
41 Convention on Biological Diversity (nd).
42 McCreless et al. (2016).
43 Nias & Saunders (2012).
44 Mills (2009a).
45 Mills (2009a).
46 Director of National Parks (2010).
47 Department of Agriculture (2015).
48 Department of Agriculture (2015).
49 Director of National Parks (2008).
50 Director of National Parks (2010).
51 Director of National Parks (2008).
52 Director of National Parks (2010).
53 Information about this and the other weed species comes mainly from the national park management plan (Director of National Parks 2008).
54 Director of National Parks (2010).
55 Director of National Parks (2010).
56 Most of the information in these profiles of invasive animals comes from the regional threatened species recovery plan (Director of National Parks 2010).
57 Department of Agriculture (2015).
58 Director of National Parks (2010).
59 Blumberg & Kehat (1982).
60 Hoffman (2017).
61 Hoffmann (2017).
62 Director of National Parks (2008).
63 Coyne (2009).
64 Director of National Parks (2008).
65 One indirect consequence of myrtle rust could be less food for endangered birds that rely on the fruit of cherry guava (Psidium cattleianum), an exotic Myrtaceae and widespread weed on Norfolk Island. Environmental managers remove such weeds gradually and replace them with suitable native plants so as not to suddenly deprive birds of an important food source.
66 Department of the Environment and Heritage (2004).
67 Director of National Parks (2010).
68 Director of National Parks (2008).

69 NZ Ministry for Primary Industries (2011).

70 Nias & Sanders (2012).

71 Director of National Parks (2010).

72 Yellow crazy ants had been intercepted a number of times on cargo (Director of National Parks 2010).

73 Department of Agriculture (2015).

74 Madden (2015).

75 Norfolk Island Applied Laws Ordinance 2016.

76 According to the Department of Infrastructure and Regional Development, agreement between the federal and NSW governments on application of the NSW Biosecurity Act 2015 is yet to be achieved (B. Woodruff personal communication 24 July 2017).

77 Department of Agriculture (2015).

78 Craik et al. (2017).

79 Department of Agriculture and Water Resources (2017). For example, section 24 of the Biosecurity Determination 2016 stipulates for imported seeds that they '(i) are brought or imported from a part of Australian territory (other than Christmas Island or Cocos (Keeling) Islands); or (ii) are listed permitted seeds.' They must be labelled with their botanical name, not be genetically modified, and meet Australian standards for seed contaminants and tolerances. See https://www.legislation.gov.au/Details/F2016L01061 for the determination.

80 Department of Agriculture and Water Resources (2017).

81 The quarantine survey report noted that 'New Zealand has a number of significant pests that are of concern to mainland Australia and that are not yet found on Norfolk Island, so if that pathway is not well controlled then the Australian mainland could be exposed to these risks; for example, varroa mite and bovine tuberculosis.'

82 Biosecurity (Prohibited and Conditionally Non-Prohibited Goods—Norfolk Island) Determination 2016.

83 In response to questions from the Invasive Species Council, the Department of Agriculture and Water Resources says: 'Upon receipt of import permit applications, the department undertakes a scientific assessment of the biosecurity risks associated with the proposed import in accordance with the Biosecurity Act 2015. Information about the criteria related to animal risk analysis can be found on the department's website: www.agriculture.gov.au/biosecurity/risk-analysis/animal. In undertaking biosecurity risk assessments for the importation of live animals for Norfolk Island, the department considers both the results from the Norfolk Island Quarantine Survey 2012–2014 and risk assessments already undertaken for Australia in assessing biosecurity risks and applicability for importation into Norfolk Island.' (Email 20 September 2017).

84 Department of Agriculture and Water Resources (2017).

85 The biosecurity agency is reviewing the import conditions for honey and bee products 'in order to further protect the pest and disease status of Norfolk Island bees' (Department of Agriculture and Water Resources 2017). But this is to protect European honeybees, which are invasive on the island and a likely threat to some bird species (Director of National Parks 2010).

86 For example, in April 2017 an application to import a cockatiel, peacock, galah and emu was being considered by the regional council (NIRC staff, personal communication, 26 April 2017).

87 See information at norfolkisland.gov.nf/services/environment-and-health/animal-importation.

88 Minister's Norfolk Island Delegation Instrument 2017 (No. 1). See https://tinyurl.com/yclmpp6x.

89 Under section 4, Plant and Fruit Diseases Act, 'The Minister may, by notice published in the Gazette … (b) declare any member of the animal or plant kingdom in any stage of development to be a pest for the purposes of this Act.'

90 Officers authorised under the Plant and Fruit Disease Act include various regional council officers and federal customs and border force officers.

91 According to a briefing by Department of Agriculture and Water Resources (2017), 'The NIRC does not have responsibility for the regulation of biosecurity on Norfolk Island—the Biosecurity Act is the primary legislation for management of biosecurity risks.'

92 Department of Agriculture (2015).

93 Department of Agriculture and Water Resources (2017).

94 Department of Agriculture and Water Resources (2017).

95 Director of National Parks (2008).

96 Hoffmann (2017).

97 Davis (2008).

98 Beale et al. (2008).

99 Tourism is the main economic activity on the island (SGS Economics and Planning Pty Ltd 2015).

100 Action 16.1 in the economic strategy for Norfolk Island is 'to implement new quarantine provisions that will facilitate the importing of seeds and animals for breeding, and the export of food to the mainland and beyond' (SGS Economics and Planning Pty Ltd 2015).

101 Department of Agriculture (2015).

102 Department of Agriculture (2015).

103 Department of Agriculture (2015).

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105 Nias et al. (2010).

106 Increasing nature tourism is one of the goals of the economic strategy for Norfolk Island (SGS Economics and Planning Pty Ltd 2015).

107 Owen (2017).

108 Island Conservation (nd).

109 Owen (2017).

110 Dawson (2017).

111 The general biosecurity duty (section 22 of the NSW Biosecurity Act 2015): 'Any person who deals with biosecurity matter or a carrier and who knows, or ought reasonably to know, the biosecurity risk posed or likely to be posed by the biosecurity matter, carrier or dealing has a biosecurity duty to ensure that, so far as is reasonably practicable, the biosecurity risk is prevented, eliminated or minimised.'

112 Slezak (2016).

113 Parsons Brinckerhoff Australia Pty Ltd (2009).

114 See http://www.sprep.org/piln

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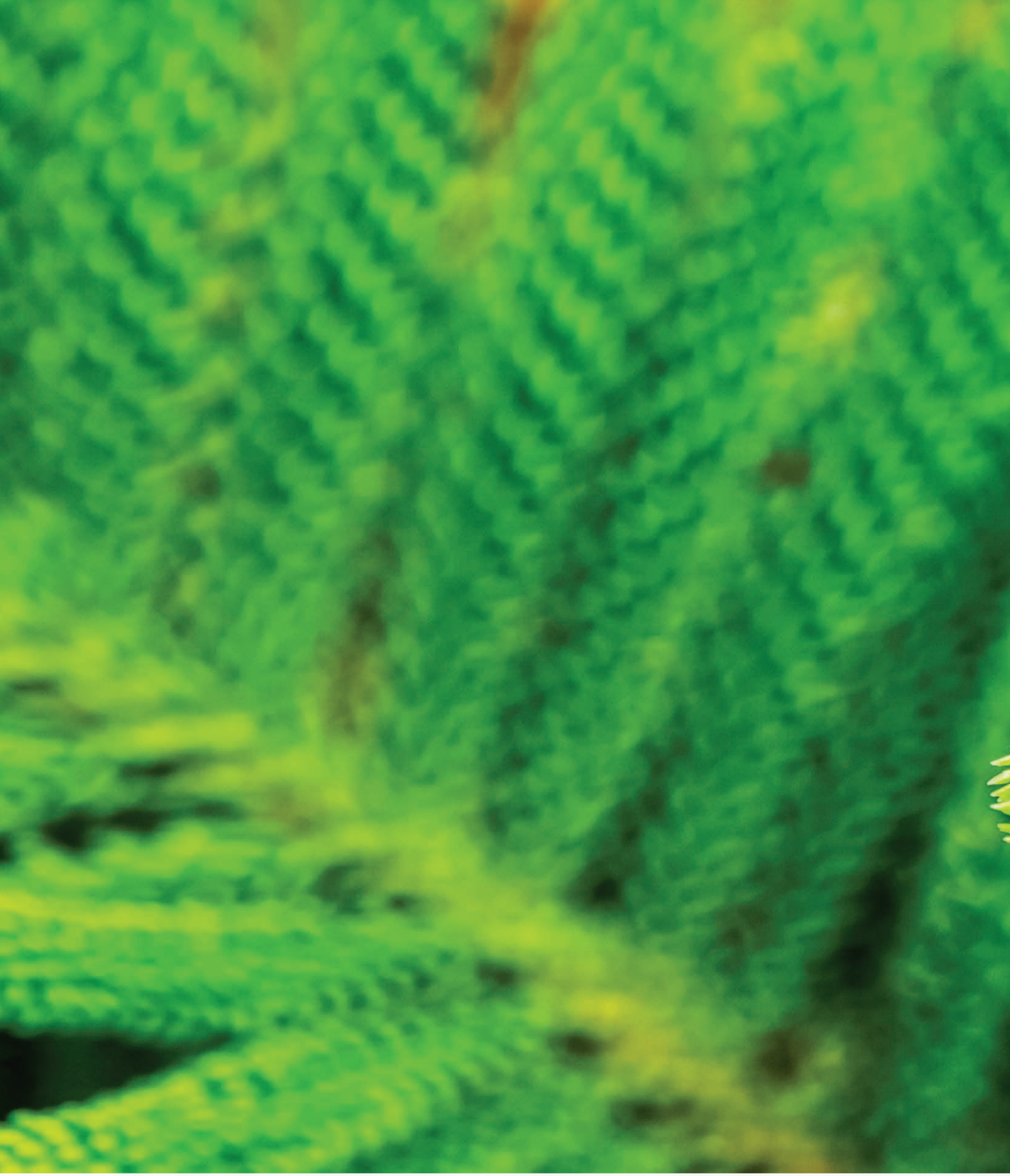

ISLAND CONSERVATION
Preventing Extinctions

islandconservation.org
info@islandconservation.org
facebook.com/preventingextinctions
@NoExtinctions

invasive species council

invasives.org.au
contact@invasives.org.au
facebook.com/invasivespeciescouncil
@ISCAustralia

LEARNING FROM LOSS

Ecologists **John Woinarski**, **Stephen Garnett**, **David Lindenmayer** and **Sarah Legge** conduct an unoffical inquest into three recent extinctions.

A speeding train leaves its rails and crashes into a car park, with many casualties. Five recent cases of an obscure cancer are clustered around a chemical factory. While waiting for medical attention a child dies in the emergency ward of a hospital. A wildfire ignited by a fallen powerline kills two people. Governments respond to such tragedies – and the community expects them to respond – with a formal public inquiry, typically by a coroner, to identify the causes and contributing factors, and the regulatory or policy shortcomings that allowed them to occur. These inquiries are not only for establishing culpability but, more importantly, for recommending reforms that make it less likely they will recur. They also provide a forum for affected parties with differing views to debate and conciliate.

We think there should be similar public inquiries whenever a species goes extinct – to identify what went wrong, and how laws, policies and practices can be improved to reduce the likelihood of future extinctions.

Australia has an appalling record of extinctions, losing more plants and mammals over the past 200 years than any other country. Extinction trends suggest that we have learnt little from these losses, for they are occurring still. Just in the past decade two more mammals and a reptile have gone: the Christmas Island pipistrelle (on 26 August 2009), the Bramble Cay melomys (between 2009 and 2014), and the Christmas Island forest skink (on 31 May 2014).

Currently, governments are mute in response to extinctions. There is no obligation for review or to apportion culpability. In such absence, we conducted an unofficial inquiry into the three recent extinctions, with our review published in the journal *Conservation Biology*. We followed the steps typical of coronial inquiries – detailing the circumstances of the 'deceased' and their 'deaths', identifying causal or contributory factors, and recommending reforms. Most conservation biologists who examine extinctions focus on ecological causes, such as habitat destruction or introduced predators. We took a broader perspective, by considering also the legal, policy and management failings.

The deceased

All three species were endemic to islands, two to Christmas Island and one to Bramble Cay. This is no aberration. Islands (those smaller than Tasmania) comprise less than 0.5% of Australia's land area, but island species have accounted for at least 24% of Australia's extinctions. It is a world-wide characteristic: islands are a crucible for radiation of species, but also such risky places that they readily become biodiversity graveyards. With small populations and low genetic variability, island species may have little resistance to new diseases, the plants may have few defences against introduced herbivores and the animals may be naive to new predators.

The Christmas Island pipistrelle was a tiny bat common in its small range until about the 1980s, after which it declined at a more or less constant rate, as was well documented by monitoring. The main extinction driver was likely to be an introduced predator (the giant centipede or wolf snake), but this is conjectural. Although there was a recovery plan, which was partly implemented, the plan did not have trigger points for an emergency response (such as captive breeding) or specify what the response should be. Without a predefined process, governments dithered in response to the predicted extinction.

The fate of the Christmas Island forest skink was similar, although there was little monitoring and its imperilled status was not officially recognised until far too late. It was listed as threatened (critically endangered) only four months before its extinction, about 15 years after a substantial decline was first recorded. The ecological causes of its demise are unknown, but probably involved one or more introduced predators.

The Bramble Cay melomys was a small rodent known only from a 5 hectare low-lying island in Torres Strait. Like the pipistrelle, its recovery plan lacked consideration of an emergency response. Almost certainly what delivered its extinction were one or more periods of inundation of the island due to storms and a gradual rise in sea level, probably resulting from global climate change.

Christmas Island forest skink (*Emoia nativitatis*). *Photo: Hal Cogger*

Bramble Cay melomys (*Melomys rubicola*). *Photo: Ian Bell*

Christmas Island pipistrelle (*Pipistrellus murrayi*). *Photo: Lindy Lumsden*

Legal and policy shortcomings

We found several legal shortcomings, particularly of Australia's main environmental legislation, the *Environment Protection and Biodiversity Conservation Act* 1999, that contributed to the extinctions.

First, it is not an offence under that act to cause, contribute to, or fail to take reasonable actions to prevent an extinction. We found some evidence that actions or lack of actions by agencies or individuals contributed to the extinctions. When bureaucrats refused to include an option for captive breeding in the recovery plan of the melomys and a nomination to list the forest skink as threatened was blocked, these officers operated with legal impunity.

Second, the power of the act pivots narrowly on a small set of 'matters of national environmental significance'. Biodiversity-rich islands are not specifically included in this set, even though they make a distinctive contribution to Australia's biodiversity and island endemics are highly susceptible to extinction. The powers under the act to protect threatened species also operate far better (although suboptimally) for cases where impacts are acutely defined (such as proposals for major developments) than for cases where threatened species face more pervasive, diffuse and chronic threats, such as introduced predators (the likely primary cause of two of these extinctions).

Third, accountability is very poorly described in the act, such that extinctions can occur without it clearly being the responsibility of any minister, government, department, landholder or official.

Fourth – and the trigger for our assessment – there is no obligation to formally and publicly inquire into extinction events: they simply happen and we move on.

Finally, there are no legal obligations for the national listing of threatened species to be comprehensive or regularly reviewed, for all threatened species to have recovery plans, or for recovery plans to be implemented. The long interval between when substantial decline of the forest skink was recorded and when it was listed as threatened meant it was not afforded, until far too late, any priority for research or management. And despite the melomys having a recovery plan, we found no record of any activity devoted to its conservation.

Shortcomings in national policy also contributed to the extinctions. Our principal conservation policy, *Australia's Biodiversity Conservation Strategy* 2010-2030, is tepid about biodiversity loss. The United Nations 2015 sustainable development goals require countries to 'take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species', but there is no such target in our biodiversity strategy – indeed, extinction is barely mentioned. This deficiency has been partly addressed with the recent (2015) development of Australia's first Threatened Species Strategy, which has an explicit commitment to avert extinctions.

A second policy failing is lack of funding, with the Australian government spending markedly less on the environment, relative to its assets and needs, than most other developed countries. Current trends are for further declines in this meagre tithe. The money spent on trying to save the three species was miserly. Applications to fund management-focused research for the pipistrelle and melomys were rejected under the Caring for Our Country program, Australia's then-premier funding arrangement for conservation.

Third, policy at the time was influenced by the concept of conservation triage, that the available funding for conservation should be prioritised for species perceived to be particularly valuable (evolutionarily distinctive, charismatic or useful) and not frittered away on apparently hopeless cases with little perceived value. Our three victims were all fairly nondescript species with little evolutionary distinctiveness and could be considered to be of no use for humans. The extinction of such species is likely to be an inevitable consequence of the triage approach.

Fourth, although we are an island nation and so should be attuned to the need for strong biosecurity, quarantine for most Australian islands is woeful. Many invasive species harmful for the distinctive native species have been and continue to be introduced, including to Christmas Island.

Finally, our national approach to greenhouse gas emissions is decidedly suboptimal, and insufficient to constrain climate change, which will ratchet up the loss of Australian biodiversity or the difficulty of maintaining it. The melomys may have been the first species to go extinct due to rising sea levels associated with human-caused global climate change.

Cartoon: Edd Cross (eddcrossillustrator.com)

Management and advocacy shortcomings

There was very little effort to save the three species or manage the putative threats. Nor was there much attempt to measure the success of, and then to refine, the limited actions taken.

Part of the problem was shortcomings in research. Researchers mainly contribute to species recovery by identifying the ecological drivers of decline, and providing advice on how to manage threats most effectively. This did not happen for the three species, mainly because of very limited and episodic funding for research. Identifying drivers was particularly challenging for the Christmas Island species, for there were many possible threats that defied ready elucidation, and the species' rapid decline allowed little time for thorough, staged investigations. Because researchers could not provide a clear, evidence-based focus for allaying threats, managers were left impotent.

Another concerning feature was the almost complete lack of public reporting of research and monitoring results, limited though they were. These were assembled mostly in unpublished reports to government and not readily available to the public or researchers.

Because the information was scarce, the public had little basis for concern and advocacy. This meant that little pressure was exerted on politicians and government agencies to save the three species, or – in a vicious cycle – for them to invest in the research that would demonstrate the imminence of extinction. This is a recurring pitfall for threatened species with the misfortune of inhabiting areas remote from most people, or that lack charisma or evolutionary distinctiveness.

One other notable feature, for which the evidence is obscured in the intricate internal mechanics of government agencies, is that individual bureaucrats may have contributed to these extinctions by their action or inaction. Governance standards should be sufficiently robust that the fate of species does not hang so capriciously on the foibles of individuals who occupy pivotal roles in environmental agencies.

Remedies

We concluded there was no single cause for any of the extinctions, but that a range of shortcomings in law, policy, management, research, monitoring and advocacy collectively and idiosyncratically led to the losses. Remedying any one of these failings may have allowed the species to survive. Remedying them now will make future comparable extinctions less likely.

Hindsight renders the shortcomings far more apparent than they may have been at the time. Such retrospective assessment is instructive, and all of those who have some responsibility for protecting our biodiversity should learn from these lessons.

We think there is support in our community, within government departments and among politicians for avoiding extinctions. Public inquests into extinctions would help build this support and ensure that losses are not totally in vain. ■

READING: Woinarski JCZ, Garnett ST, Legge SM, Lindenmeyer DB. 2017. The contribution of policy, law, management, research, and advocacy failings to the recent extinctions of 3 Australian vertebrate species. *Conservation Biology* 31(1):13–23

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PROFESSOR JOHN WOINARSKI has been involved in research, management and policy relating to Australia's threatened species for more than 30 years. He works with the Threatened Species Recovery Hub of the National Environmental Science Program at the Research Institute for the Environment and Livelihoods of Charles Darwin University.

PROFESSOR STEPHEN GARNETT is with Charles Darwin University and part of the Threatened Species Recovery Hub of the National Environmental Science Program. He has worked with threatened species, particularly birds, for 40 years, particularly in tropical Australia.

PROFESSOR DAVID LINDENMAYER is at the Fenner School of Environment and Society at the Australian National University and part of the Threatened Species Recovery Hub of the National Environmental Science Program. He has worked on threatened species in forest, woodland and heathland environments for more than 30 years.

DR SARAH LEGGE is based at the Australian National University and the University of Queensland, and works in the Threatened Species Recovery Hub of the National Environmental Science Program. Her background was first in evolutionary ecology, and more recently (the past 15 years) in applied research for threat management and threatened species recovery.