

10. Threatened species of Kakadu National Park: synthesis and conclusion

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10.1. Introduction

Kakadu National Park (KNP) is one of the largest and most diverse national parks in Australia. Its objectives include obligations to deliver cultural outcomes for its traditional landowners; requirements to provide satisfying experiences, infrastructure and safety for very many visitors; and biodiversity conservation. There are many challenges to the achievement of these diverse objectives, and many specific challenges for the biodiversity objectives, relating in part to limited access for management and the substantial array and near intractability of threatening factors. These factors include legacy impacts of historic mining, current mining within the Park environs, climate change, tourism, inappropriate fire regimes, weeds, vertebrate and invertebrate pests, and diseases and pathogens. Within this complex setting, the conservation of Kakadu's very many threatened species (possibly more than any other conservation reserve in Australia) is a management priority. The size and complexity of this complement of threatened species is influenced in part by the vast extent of Kakadu, its co-occurrence with an area of particular richness for endemism, and its substantial range of environments.

The effectiveness of the management of Kakadu's threatened species is constrained by a series of factors:

(i) *Inadequacy of status assessment.* Lists of threatened species are fluid, and there may be substantial delays between when species merit listing and when they become listed. Given that Kakadu's Plans of Management may typically operate over 5–10 year cycles, this may mean that there may be critical delays between signs of a species' decline and its explicit inclusion as a management priority within Kakadu's planning process. Furthermore, as indicated in the invertebrate chapter in this volume (Andersen et al. Chapter 4), it is almost certain that many currently unknown or little known invertebrate species may merit listing as threatened, but cannot because of information deficiencies. This may also be the case for plant species, although this is less likely because Kakadu's plant species have been far more comprehensively inventoried than its invertebrate species (Cowie & Liddle Chapter 3), and because all plant (and vertebrate) species known from the Northern Territory have their conservation status scrutinised at c. 5 year intervals through the Northern Territory threatened species process.

Given fluidity in lists and delays between information acquisition and consequences for listing, there may also be some cases where currently listed species that may be management priorities in Kakadu should no longer be listed or prioritised. Based on recent assessment of conservation status, this may be the case for Red Goshawk and Northern Shrike-tit (Woinarski & Garnett Chapter 7).

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(ii) *Inadequacy of knowledge about listed threatened species.* Management will be most effective when it is based on robust and comprehensive information. For almost all of the threatened species occurring in Kakadu, there are major information gaps that currently impede good management.

These deficiencies relate to locations occupied within KNP, population size and trends, habitat (and food) requirements, life history attributes, the relative impacts of current and projected threats (i.e. which threats are most detrimental and are currently driving status change), and responses to management interventions. The extent of knowledge gaps varies appreciably amongst threatened species, with relatively more information for some terrestrial mammal and bird species, and less information for some invertebrate, plant and marine species. However, for even some terrestrial mammal species (such as the Northern Brush-tailed Phascogale *Phascogale pirata*) the information base is particularly threadbare and inadequate. Such information inadequacy compromises the ability of managers to answer such fundamental conservation questions as: In what areas should management attention be focused?; What threats are the most important to manage?; How do we best manage those threats? How do we document management effectiveness? Which species merit most immediate attention?

But there will always be some information shortcomings, and KNP has had many decades of substantial environmental research. For many species there is sufficient information to provide preliminary management advice, or at least to provide some advice that is likely to be more effective than no advice. As described in (vii) below, if resulting actions are set within an adaptive management framework, this advice can then be subject to continuing iterative testing and refinement. But some information gaps may be particularly critical; and a strategic program that focuses on research to fill these gaps may be necessary to ground management that aims to achieve adequate conservation outcomes.

(iii) *Inadequacy of knowledge about threats.* The incidence, extent and history of many factors that may affect threatened species in KNP are poorly known. This is so particularly for relatively covert threats such as disease and pathogens, but there is also very little useful information for some other threats likely to be causing major impacts, such as predation by feral cats. Furthermore, little is known about the manner in which different threats may interact, and result in potentially multiplicative impacts.

(iv) *Limited ability to control some threats.* Even in cases where the major factor affecting a threatened species is well known, it may be impossible or prohibitively expensive to eradicate or even effectively control that threat in a manner sufficient to allow the recovery of the threatened species. Many of the main threatening factors affecting threatened species in KNP may fall into this category: these may include climate change and consequential saltwater intrusion, cane toads, feral cats, feral pigs and some weeds. However, in such cases, some conservation outcomes may be achievable through captive (*ex situ*) breeding, localised intensive threat abatement activity at particular sites that are significant for the threatened species, or manipulation of the genetic or behavioural features of the threatened species to allow it to avoid or cope better with the uncontrollable threat (e.g. toad aversion training for Northern Quolls: O'Donnell et al. 2010).

(v) *Limited target-setting and specific objectives.* Management may be doomed to be ineffective and arbitrary if it is not positioned within a clear framework that provides explicit justification for actions, or is not directed strategically towards the achievement of an

explicit, realistic and worthwhile set of targets and objectives. For the conservation of threatened species in KNP, the existing Plan of Management has been criticised for this shortcoming (Parr et al. 2009). In the absence of well-defined targets, it is difficult to assess the extent of management success or failure. Furthermore, in the absence of a robust framework for management, there is little or no accountability for failure or recognition of achievement for success.

(vi) *Uncertainty about prioritisation.* As described in earlier chapters in this symposium, there are very many threatened species in KNP, many additional species of cultural or other concern, and many other issues that drive management attention and action. Without some explicit and rational justification mechanism, it is difficult to ensure that adequate resources are directed towards the most urgent and effective actions for the conservation of threatened species, to ensure that other management activities are not detrimental to threatened species, and to prioritise activities amongst different threatened species. For conservation management in KNP, an unusually explicit prioritisation factor is the responsibility mandated in the *Environment Protection and Biodiversity Conservation Act 1999* (s 269(1) that ‘the Commonwealth must implement a recovery plan or threat abatement plan to the extent to which it applies in Commonwealth areas’. Hence, such actions should be locked in as essential components of the Park’s management program.

(vii) *Limited application of monitoring and adaptive management.* As foreshadowed under (ii) above, in the absence of perfect knowledge, management may be most effective over longer periods if it is contextualised within an adaptive management framework that embeds monitoring within a cycle of performance assessment, reporting and improvement (Holling 1978). Indeed, monitoring is a particularly critical issue for threatened species, as it is instrumental for the provision of a rational prioritisation of actions within and amongst species, to measure management effectiveness, and to assess conservation status. As described in the previous chapters, there is effective and statistically powerful monitoring for only a small minority of KNP’s threatened species. Conversely, some existing more general monitoring programs in KNP are notable for describing population trends over at least several years (e.g. Edwards et al. 2003, Russell-Smith et al. 2009, Woinarski et al. 2010, 2012) and some of these programs have been useful in helping to change management practice.

(viii) *Resource constraints.* All conservation reserves have finite resources. As illustrated in the previous chapters, there are very many threatened species in KNP. Research to fill significant knowledge gaps is required for many species, and this may be expensive and long-term. Many of KNP’s threatened species may require considerable investments in management, over long time periods. It is impossible that all research and management actions that are needed to achieve conservation security for all species can be implemented within existing budgets, and implausible that these can all be implemented within any more generous but realistic budget settings. Nonetheless, there may be scope for more effective resourcing efficiencies through better integration of collaborative management of threats amongst regional stakeholders, through investments in research partnerships, through expansion of the conservation budget through competitive funding or philanthropic sources, through more tightly focused management actions, and through management frameworking that works towards threat management that is better integrated amongst threatened species affected by similar threats within the same broad landscape types.

(ix) *Off-site impacts.* KNP may have perfect conservation management for all threatened species occurring within its borders, but the status of many of those species in KNP may

still decline because of off-site impacts. These constitute three main issues: (a) species whose individuals may disperse widely such that Kakadu constitutes only a part of those individuals' range, either seasonally or in parts of their life cycle; (b) species whose habitat or individuals are detrimentally affected by pervasive factors beyond the control of Kakadu management, notably such as through the impacts of global climate change (this issue is considered in more detail in (iv) above); and (c) species that operate in a regional meta-population for which subpopulations occurring in areas around Kakadu may operate as population 'sinks', hence de-stabilising and reducing the long-term viability of subpopulations within Kakadu. This latter issue is mostly a problem in relatively small conservation reserves, but may be a minor concern for a few threatened species in Kakadu that have very large home ranges and relatively small population size (a possible such example may be Red Goshawk *Erythrotriorchis radiatus*).

Many of Kakadu's threatened animal species are not permanent residents in Kakadu, and hence their population trends in KNP may be affected significantly by factors operating outside Kakadu's borders. This is particularly the case for shorebirds (affected particularly by habitat loss and degradation along other parts of their migration route), marine turtles and sharks and sawfish (all affected particularly by targeted take or by-catch within and beyond Australia). The scale of these dispersals varies substantially, from relatively local to global (as for the shorebirds). In all cases, long-term conservation objectives are likely to be realisable only through collaborations involving stakeholders in all parts of the species' range. Nonetheless, appropriate conservation management in KNP may help contribute to the resilience of dispersive species' populations, allowing them some (limited) scope for coping with pressures elsewhere in their range.

Collectively, these factors have led to the undesired outcome that many of KNP's threatened species are now exhibiting declining trends (in some cases severely), notwithstanding some commitment to threatened species' recovery and the application of some threat management. This is a sub-optimal outcome, but one that may well be typical of other conservation reserves in the region.

10.2 The current status of threatened species in Kakadu

In most of the previous chapters the authors were requested to list all threatened species occurring (or formerly occurring) in KNP, to interpret their current status (particularly whether they were increasing, stable or decreasing in abundance), and to provide recommendations for enhanced management. In this section of the paper, we integrate the information on the assemblage of threatened species and on their population trends; in the next section we integrate recommendations for enhanced management.

A clear conclusion is that very many threatened species occur (or occurred) in KNP. The tally is a little indefinite, as it depends upon what list or lists are considered, and the extent to which one includes species for which the few and only records from the KNP area are now historic. There are four mammal species in this latter set (Northern Hopping-mouse *Notomys aquilo*, Golden-backed Tree-rat *Mesembriomys macrurus*, Water Mouse *Xeromys myoides* and Golden Bandicoot *Isodon auratus*), and these may represent local extinctions (or, more precisely, extirpations) from KNP. However, this conclusion should be qualified by noting that their loss from the area may (or may not) have preceded the establishment of the National Park, and could be qualified also by noting that it is difficult to demonstrate absence and it is just possible that they may persist in the area (with this possibility varying substantially between the 'lost' species). These

losses are more than historical marginalia, as their fate serves as a reminder that some factors threatening the Kakadu biota have operated with significant detrimental impact over many decades: that is, the current decline of many threatened species in KNP is not necessarily a new phenomenon or an indication of the sudden recent imposition of novel threats or management inadequacy.

Table 10.1 summarises the tallies of threatened species in KNP by broad taxonomic group.

Table 10.1 Tallies of threatened species (and threatened ecological communities) by taxonomic group and legislative list

Taxonomic group	No. of EPBC Act listed threatened taxa	No. of Northern Territory listed threatened taxa	No. shared between lists	Total number of different entities listed as threatened
plants	3	14	2	15
invertebrates	0	0	0	0
fish	4	4	4	4
frogs	0	0	0	0
reptiles	8	9	5	12
birds	7	16	6	17
mammals	9	12	6	15
ecological communities	1	0	0	1
<i>total entities</i>	32	55	23	64

This Table excludes species recognised internationally as threatened, but not listed as threatened under Northern Territory and Australian legislation, and excludes very many species considered Near Threatened or Data Deficient (noting that neither category is available under the *EPBC Act*). It also excludes many species (particularly invertebrates) about which too little is known to even assign a status. Setting aside such species, the tally of listed species occurring in KNP is very substantial (32 EPBC Act-listed species, and a further 32 species listed under Northern Territory legislation), and may well exceed that for any other conservation reserve in Australia. The conservation management of so many species is a formidable challenge, especially given that their threatened status implies that many may require very considerable threat abatement actions.

One question that this symposium sought to answer was: how are threatened species faring in KNP? In many of the previous chapters, the authors have struggled to answer this question: for most species, trends in KNP are not known, largely because most threatened species are not subject to specific monitoring programs. Notwithstanding the now reasonably long history of Kakadu as a national park, and of the decades of environmental research undertaken, there has generally been little robust or long-term monitoring of threatened species. There are some specific exceptions (such as the long-term monitoring program for breeding Flatback Turtle *Natator depressus* at Field Island: Kyne Chapter 5), some monitoring programs that have been established but not regularly

implemented (notably for some plant species: Cowie & Liddle Chapter 3), and some more general monitoring programs have provided information on trends for some threatened species (notably the fireplot monitoring program, that has demonstrated marked population change for several threatened mammal species: Woinarski et al. 2010).

For threatened species, the clearest picture of trends in KNP is for a set of small- to medium-sized mammal species (such as Brush-tailed Rabbit-rat *Conilurus penicillatus*, Northern Quoll *Dasyurus hallucatus*, Pale Field-rat *Rattus tunneyi*, Black-footed Tree-rat *Mesembriomys gouldii*) that have all exhibited marked decline over the last 1-2 decades. For none of the threatened species occurring in KNP is there any compelling evidence of population increase.

Most of the previous chapters sought not only to address trends in the status of KNP's threatened species, but also to consider the adequacy of knowledge for those species, the extent of conservation management directed towards those species, and the threats that are most influencing current status.

The KNP area has been subject to much research; and successive plans of management and the Kakadu Research Advisory Committee have sought to ensure that much of this research is directed as strategically as possible. However, as documented in previous chapters, there are still formidable knowledge gaps for most threatened species. In terms of conservation management objectives, these knowledge gaps mostly relate to limited information on distribution (and areas of significance for particular species), population size, ecological requirements, the relative impacts of threats, and the response to a range of management options. This is the case particularly for invertebrates (Andersen et al. Chapter 4), plants (Cowie & Liddle Chapter 3), marine species (Kyne Chapter 5) and terrestrial reptiles (Gillespie & Fisher Chapter 6), but also applies for most birds and mammals. In many cases, the inadequacy of knowledge substantially hinders or subverts the application of targeted management. Of course, there are also some notable achievements, whereby substantial research effort has been (or is being) directed at major knowledge gaps concerning threatened species. One notable such example is the current collaborative research program that is considerably advancing (from a previous very sparse base) knowledge of the status of threatened shark and sawfish species in Kakadu (Kyne Chapter 5).

Furthermore, it is likely that knowledge transfer between researchers on one hand and rangers and other park management staff on the other is imperfect, with little information on threatened species readily available on the Park's GIS and other knowledge management systems, and hence little incorporation into day-to-day Park management activities. There is also relatively little knowledge exchange concerning threatened species with the Park's traditional owners, but some of that traditional knowledge is being documented (Winderlich & O'Dea Chapter 2). Nonetheless, there are some notable initiatives in knowledge transfer. Many monitoring and other research activities in KNP are deliberately designed as collaborative exercises with Parks staff and Traditional Owners, and hence allow for on-ground sharing of knowledge. Furthermore, this symposium and its predecessors have been designed to provide a forum for such knowledge exchange, and to seek to ensure the translation of research to management advice.

Much of the Park's management is directed towards the control of fire, weeds and feral animals, and this activity undoubtedly provides some benefit to many of KNP's threatened species and its threatened ecological community. Furthermore, exclusion of

commercial fishing and constraints on recreational fishing, management of some other tourism activities, and regulation or prohibition of mining and other extractive industries also serves to provide general benefit to KNP's biodiversity. But there is relatively little management directed and tailored specifically to meet the explicit needs of threatened species, or to control the most detrimental threatening factors at the sites of most significance to particular species; and to date there has been little attempt to develop and implement a coherent, comprehensive and strategic plan for the recovery and management of any threatened species within KNP. One manifestation of this lack of management focus on threatened species is the low uptake in KNP of actions detailed in Recovery Plans for the minority of KNP's threatened species for which Recovery Plans exist, notwithstanding the legal requirement to implement these Plans on Commonwealth lands. One other manifestation is the relatively low uptake of recommendations given in the Park's two attempts at a threatened species strategy (Roeger & Russell-Smith 1995, Woinarski 2004). But, as with the discussion above concerning knowledge limitations, there are also some recognised achievements. In this regard, the development and implementation of a Stone Country fire management program (Petty et al. 2007) is particularly notable, in that it seeks to curb the threat that is of most concern to the status of very many threatened plant and animal species (and the Park's sole threatened ecological community) in one of the Park's major landscapes; and the implementation of this program appears to be resulting in some benefit to at least some of those species (Cowie & Liddle Chapter 3).

What threats are having the most impact for KNP's threatened species? As described in earlier chapters, this simple question is not necessarily easy to answer: in some cases, threats operating beyond the Park are the most detrimental; in some cases (such as for some highly restricted plant species), the population size of the threatened species may be stable and there are no particular threats; in other cases, the information is simply too insubstantial to ascribe causality or to demonstrate the relative impacts of any particular threat. Furthermore, threats vary in their intensity and impact amongst different landscapes and species. Notwithstanding these caveats, there is a compelling signal that for the Stone Country, fire is the most significant threat for a substantial set of threatened plant and animal species (and for the ecological community): the current regime is characterised by fires that are too frequent, extensive and of high intensity. The same threat is also critical for a smaller set of lowland species, mostly mammals. (As noted within most chapters, this threat is in turn influenced by some weed species, particularly invasive pasture grasses, whose large biomass fuels fires of increased severity.) The evidence is not yet compelling, but there are reasonable grounds for inferring that predation by feral cats is also a major threat for many threatened mammal species (and possibly some threatened bird and reptile species). The other notable threat that has been demonstrated to affect multiple species is poisoning by cane toads, causing recent marked population declines for some threatened mammal and reptile species.

In addition to these main considerations, the previous chapters also noted other threats to particular threatened species; and most recognised that global climate change had substantial potential to cause direct severe impacts, or to amplify some existing threats, on some threatened species, with particular concern for some threatened species occurring in coastal floodplains. Furthermore, any such substantial environmental change is likely to lead to many currently non-threatened species becoming threatened.

10.3. Research and management priorities for threatened species in Kakadu

The workshop, and papers in this symposium, recognised that the general trend for Kakadu's many threatened species is of decline, albeit with some variation amongst species (some species declining particularly severely; other species probably stable; and yet other species for which the information base is too inadequate to determine trends). Workshop participants recognised that this is not an ideal or even satisfactory state, and that substantial changes in management may be required. Most of the preceding chapters offered some recommendations towards enhancement of existing management.

In outline, such changes should include:

1. A much more explicit statement of KNP's objectives for the conservation of threatened species, with clear and measurable targets and commitment to achieving the targets.
2. An explicit prioritisation of research and management activity and investment to those threatened species for which Kakadu is of particular importance, or which may most benefit from management.
3. A strategic program of research that focuses tightly on the key knowledge gaps that most impede the design and delivery of effective conservation management.
4. Tailored monitoring programs for most threatened species, with those monitoring programs designed in such a manner that they can effectively measure population trends and responses to management intervention, are implemented in a timely manner, and are reported within a framework that allows managers to regularly gauge the impacts of their management.
5. A more spatially specific conservation management approach, with a dedicated attempt to identify sites of particular significance for priority species, with such sites providing foci for intensive management actions.
6. Further enhancement of the existing Stone Country fire management program, to seek to continue to reduce fire intensity, frequency and extent.
7. Development of a complementary lowland fire management program, that includes as a key priority and target the imposition of fire regimes that enhance habitat suitability for threatened species, in particular to increase the extent of relatively long-unburnt woodland and forest areas.
8. An integrated research and management program that seeks to implement effective control of feral cats in at least trial areas of the lowlands.
9. The establishment of ex situ conservation measures for priority threatened plant species (and potentially some animal species).
10. Consideration of the reintroduction to protected sites within KNP of some threatened mammal species that are now locally extinct in the Park.
11. The enhancement of collaborative management programs for threatened species with neighbouring land-owners.
12. The establishment of an advisory KNP threatened species Recovery Team that includes relevant researchers and stakeholders.

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