

Continental-level biodiversity collapse

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Biodiversity loss is a global phenomenon (1), with Woinarski et al. (2) providing a sobering review of the demise of the Australian native terrestrial mammal fauna. The authors' focus is on the loss of >10% of endemic terrestrial native mammal fauna since European settlement in 1788. The extent of mammal loss is highlighted by the contrast with mainland North America, with just one mammal species extinction in the equivalent ~200-y period. Woinarski et al. (2) make key points about conservation policies and practices, some of which have global implications.

Woinarski et al. (2) provide convincing evidence for predation by the feral cat (*Felis catus*) and red fox (*Vulpes vulpes*) as a primary driver of mammal decline (Fig. 1A). The authors also contend that altered fire regimes, in part through the loss of indigenous land custodians, are an important contributor to Australian mammal decline, particularly through promoting hunting efficiency by feral predators.

Direct interventions must be taken to safeguard the most imperiled Australian mammal species. New approaches within unfenced areas,

such as improved poison baits, are urgently required to control feral animals (particularly the feral cat). An expanded network of feral predator-free fenced areas is needed on the Australian mainland. Woinarski et al. (2) discuss how such initiatives can be highly successful. However, they can sometimes be so successful that other problems arise, such as overabundant populations of prey species (e.g., macropods) (3) and highly unexpected cascading extinctions of native mammal species of conservation concern (4). For example, intensive poison baiting in Booderee National Park in southeastern Australia resulted in significant suppression of red fox populations. However, at the same time, the tree-dwelling marsupial greater glider (*Petauroides volans*) (Fig. 1B) became regionally extinct and others, including the common ringtail possum (*Pseudocheirus peregrinus*), are in steep decline (4). Such "ecological surprises" underscore the critical need for careful monitoring of management interventions, including feral predator control.

Although concerted action is essential to reduce populations of feral animals in many

parts of Australia, it will be critical not to lose sight of the need to tackle other key drivers of biodiversity decline. This is because predation by feral animals (and its interaction with altered fire regimes) is not the primary driver of biodiversity decline (including mammal decline) in some Australian ecosystems. Context-specific actions are therefore required to address context-specific threatening processes for particular species and ecosystems of concern. For example, industrial logging, recurrent wildfire, and long-term decline of both large old trees and stands of old-growth forest, are the well-established interacting drivers of decline of the critically endangered Leadbeater's possum in the wet forests of Victoria (5). Cessation of industrial logging is needed to prevent the extinction of this species. Moreover, a return to indigenous burning regimes is not a valid strategy in these forests, because there is little evidence of pre-European Aboriginal presence in these ecosystems. Australia's temperate woodlands provide another example. There, biodiversity decline is a result of a suite of interacting factors beyond the effects of exotic predators, such as long-term vegetation clearing [including burning of large old trees (Fig. 1D) and firewood harvesting], overgrazing by domestic livestock, and past intensive hunting and bounty programs (6). Large-scale and long-term replanting and natural regeneration programs, as well as better protection of large old trees, will be critical for restoring both temperate woodlands and many elements of the biota they support, including some mammals of conservation concern (7) and threatened bird species (8).

Woinarski et al. (2) only briefly touch on range collapse in extant Australian mammal fauna. Some species have been lost from 95–99% of their former distribution (9), with range contractions so profound that many people remain unaware of the array of native mammals that used to occupy certain areas: the widely discussed shifting-baselines concept (10). An example is the greater bilby (*Macrotis lagotis*) (Fig. 1C), an animal now associated with remote arid environments. Many Australians, including some conservation scientists, are shocked to learn that the species was once common and widely distributed across mesic environments, like woodland ecosystems close to major urban centers, such as Canberra. The local and regional extinction of this species (and a suite of other medium-sized native mammals lost from temperate woodlands) has led to the functional extinction of the key ecosystem

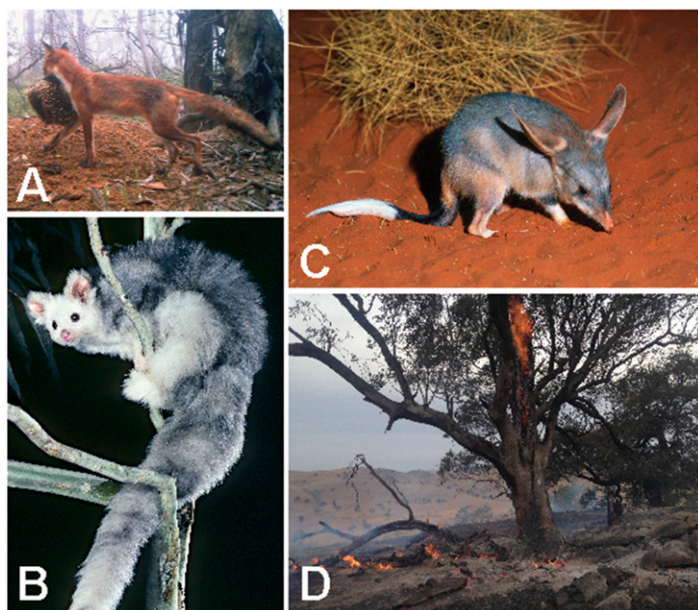


Fig. 1. (A) Red fox eating a native mammal, an example of the invasive species problem that transcends tenure (reserve-off reserve) boundaries. Photo courtesy of Georgeanna Story, Invasive Animals CRC. (B) Greater glider, a common species that is becoming rare. Photo courtesy of Esther Beaton. (C) Greater bilby, a species that was formerly widely distributed in Australia but is now lost from almost all of its former range. Photo courtesy of Esther Beaton. (D) A large old tree burning, an example of the loss of a key ecosystem structure on which many species are dependent. Photo courtesy of Mason Crane.

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processes (such as soil bioturbation) played by these animals, with knock-on ecosystem effects on rainfall penetration and plant germination (6). Thus, these losses are not simply tallies of individual species; they are indicative of, and have contributed to, broader environmental decay.

The review by Woinarski et al. (2) highlights the large number of extinct Australian mammals and the numerous threatened mammals that are at risk for extinction. However, some currently common species are also in steep decline and are rapidly becoming uncommon or rare. The greater glider (Fig. 1B) is one of many such species (4). The plight of such animals highlights why it is imperative not to be complacent about the status of taxa that presently appear to be secure. The risk of decline of common species is magnified by the rapid decline in key ecosystem structures that form critical habitat for many species. As an example, much work has been conducted on the decline of large old trees in forests, woodlands, agricultural areas, and savannas worldwide (11) (Fig. 1D). These keystone ecological structures are disproportionately valuable habitat elements for a wide range of biota, including mammals. In Australia alone, >300 species of vertebrates cannot survive without access to large old trees (12). It can take many decades, if not centuries, to recruit new cohorts of large old trees to ecosystems where they have been lost, with time-lag effects for species dependent on these trees.

What Can Be Done?

Australia should be far better placed than most nations to prevent extinctions; it is the only continent that is a single nation, it is economically wealthy, and home to some of the best conservation scientists globally (13). Knowledge needed to tackle and then reverse species and ecosystem decline is often well documented. However, Australia's poor record of mammal extinctions highlights major conservation problems. Many things need to be done.

First, urgent action must be taken to safeguard the most imperiled species through direct interventions. In those areas where feral predators are a major driver of species loss, programs based on targeted translocations into areas with predator-proof fences should be implemented. In other ecosystems, many factors operating independently or in concert with other threatening processes drive mammal decline, and species-specific and context-specific management actions will be required. In all cases, carefully implemented monitoring programs will be essential to quantify the ecological effectiveness and cost-effectiveness of management interventions. However, the record of conservation monitoring in Australia is exceptionally poor, as it is almost everywhere around the world (e.g., see ref. 14). This impedes management learning about which actions are working and which are not. In cases where some monitoring has been implemented, it has often been both poorly designed and lacking trigger points for action if populations undergo rapid decline (15). This

has led to threatened or endangered species being passively monitored until they have gone regionally or globally extinct. These problems characterize threatened and endangered species-monitoring programs in many places around the world (16). Notably, trigger points for management action are absent from the recovery plans of virtually all of the Australia's threatened mammals (16). Moreover, there is currently a lack of accountability and blurring of responsibility, in that no agency or individual in Australia has ever been held culpable for any extinction event.

Second, far better biodiversity management and monitoring must extend to protected areas. Many authors stress the importance of reserves for conserving biodiversity (17), but Woinarski et al. (2) note that Australia's extensive reserve system has not adequately protected some species, particularly those susceptible to pervasive threats that cross tenure boundaries. In some cases, active management of reserves will demand targeted, species-specific actions, whereas in others an ecosystem-based approach might conserve not only a particular threatened species, but also associated species and a given ecosystem per se. It is likely that overall conservation benefits will be maximized when both species-based and ecosystem-based strategies are used and integrated (18). However, key research questions remain about the effectiveness of targeted endangered species-specific management actions as a robust surrogate for the conservation of either other species or ecosystems per se (19).

Third, effective conservation actions require adequate logistical and financial support. Environmental and conservation management is chronically underfunded in Australia and the workforce needed to deliver on-the-ground management actions is rapidly being reduced at

local, regional, state, and national levels. Current downward funding and workforce trends must be reversed to prevent further extinctions.

Fourth, "short-termism" in environmental policies and programs must be addressed. Australia, in particular, has a record of environmental initiatives being instigated with much fanfare and then defunded within 3–5 y. Species loss, altered key ecosystem processes, and land degradation in Australia have resulted from >200 y of environmental mismanagement. Rectifying these problems will take far longer than short-term initiatives. Recently, the Australian government has attempted to redress this problem by establishing a 6-y Threatened Species Recovery Hub that links researchers and managers to establish practical conservation strategies in and beyond protected areas.

Finally, sobering scientific reviews, like that of Woinarski et al. (2), risk leaving the public without hope that progress toward improved conservation outcomes can be achieved. It is therefore important to provide tangible examples of successful biodiversity conservation outcomes that demonstrate what has worked, where, and why (20). This is necessary to keep governments, funders, and the public engaged in the difficult task of extinction prevention.

Conclusion

Woinarski et al. (2) underscore the rapidity with which a large part of an entire faunal group across a continent can either go extinct or be reduced to such small numbers that they contribute little to key ecological processes. Adequate resourcing for—and implementation of—informal management actions (and proper monitoring of those actions) is essential to prevent even more species being added to lists of extinct animals.

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