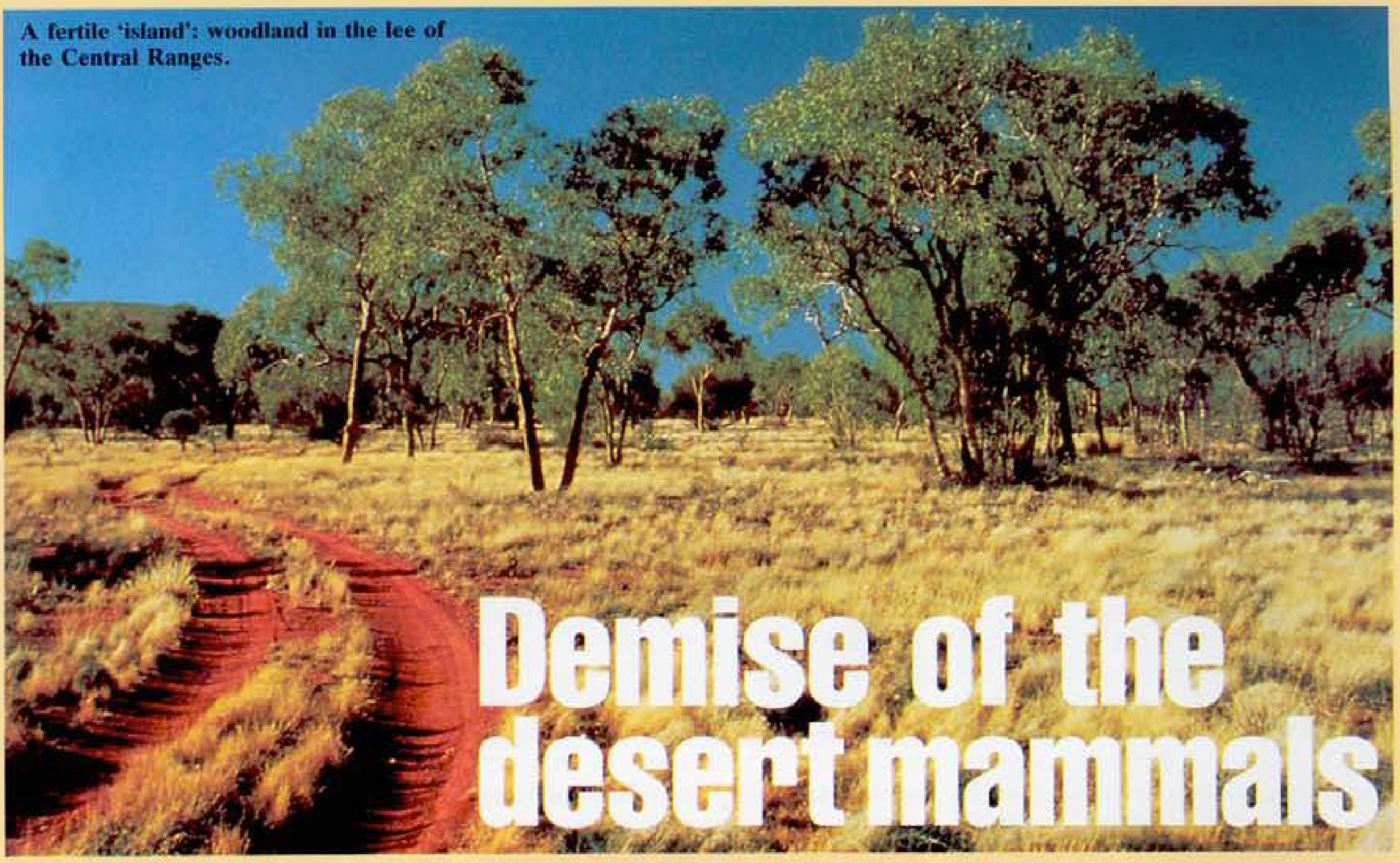


A fertile 'island': woodland in the lee of the Central Ranges.

Demise of the desert mammals

Australia's dry outback is often described as unchanging and 'timeless' — and indeed it may seem that way when standing under a ghost gum in the middle of a hot and shimmering vastness.

But in fact European occupation has wrought many irreversible changes to the region, including the greatest degree of extinction of the native mammals anywhere in this country.

Of the 72 species of mammals (excluding bats) known originally to live in our arid zone, 11 are now extinct, 5 have disappeared from the mainland and are found only on offshore islands, and 15 have declined enormously in their range, often becoming absent from the arid zone proper and persisting only in the semi-arid fringes.

The Council of Nature Conservation Ministers (CONCOM) reports that, among the 38 land-dwelling Australian mammals now considered endangered or extinct, 60% are or were present in the arid zone. But that's not because most of our mammals call the desert home; in fact, the majority (almost two-thirds) live in what is termed the mesic zone — the relatively benign, well-watered fringes of the country. Why do arid-zone mammals account for a disproportionate percentage of the species that have become extinct or endangered since European settlement?

But first, what is the arid zone; is it simply desert by another name?

A female mala and her pouch young, the first mala ever to be bred in captivity. (Photo: Ken Johnson.)

When describing the region those studying it use the word desert guardedly because this tends to invoke images of the barren Saharan sand dunes or the cactus-studded American version. Our arid zone is quite well vegetated by comparison.

It is defined as that part of Australia not suitable for cropping under natural conditions, although it may be used successfully for pastoralism. An arid area may be that way because of either low rainfall or high evaporation. In the southern part of the continent the arid zone may start where average annual rainfall is 250 mm or below. In the north, arid-zone rainfall may reach half a metre a year, but it tends to fall in the summer when the rate of evaporation is extremely high.

These annual averages mean that our arid zone is not particularly dry when considered on a global scale — the Sahara is far drier. However, the figures are misleading as the rainfall varies so much, more than in many of the world's other arid areas. Most years, our arid zone receives falls that are below the average annual values. Probably in connection with the El Niño cycles, intermittent very dry periods occur, but then occasional tropical depressions may sweep across and dump the year's average in just a few hours. Water will then flow and accumulate in some places.

Within the arid zone are areas that have been named deserts — such as the Simpson and Tanami. These are sandy and very infertile, and hence cannot support grazing. Such sandy 'deserts' may also extend outside the traditional arid zone (for example, the 'Little Desert' in Victoria).

The human population of the arid zone is minute; the mesic zone is where the vast majority of Australians live. How has our presence in such small numbers caused such an impact?

Extinctions in the arid zone have not affected all animals equally. No birds, reptiles, or amphibians are known to have disappeared completely, although the night parrot is very rare and the malleefowl has gone from much of the zone. Several other bird species are also rare, but it's difficult to determine whether they have declined since European settlement.

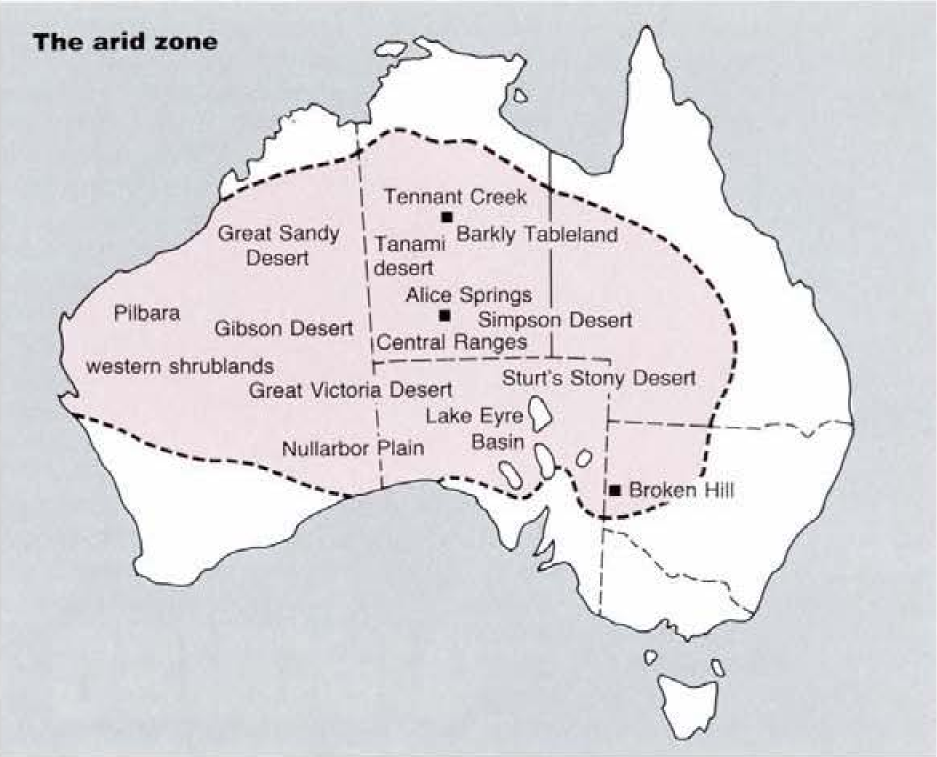
Although some reptiles are restricted to particular regions, they have all persisted despite the changes to the landscape.

Among the mammals, scientists have observed that the species most affected by European settlement are those with a weight in the range of about 35 grams to 5–6 kg. Most of these medium-sized species are or were herbivorous or omnivorous. What made them particularly vulnerable when large mammals, such as the big red kangaroo, are still thriving in much of their range?

Looking for answers to all these questions, and a framework to describe the unique ecosystems of arid Australia, is animal ecologist Dr Stephen Morton of the CSIRO Division of Wildlife and Ecology. He works in the Division's Centre for Arid Zone Research in Alice Springs, right in the heart of the region he studies.

With evidence from his own research, and from that of many others, Dr Morton has put together an explanation of how European settlement had its impact on the animals of the arid lands.

Of course, we are all aware of the various 'sins' that settlers in Australia committed that had an impact on the country. Introduced predators such as cats and foxes found their way into the arid zone, as did the biggest curse of all, the rabbit. Exotic diseases might also have taken their toll of native animals, along with the introduction of pastoralism. Mice found many parts of the region to their liking and can still erupt in large plagues. The decline in traditional Aboriginal practices of patch-burning has also affected many Australian ecosystems.



Unique environment

Dr Morton believes that each of those factors — especially the rabbit — played an important part at various times and places, but they don't provide the whole explanation for the disproportionate demise of our medium-sized arid zone mammals. His research shows that the unusual environment of arid Australia played a part, and his model starts with a consideration of that.

For much of the local flora and fauna, our arid lands' most important feature is, paradoxically, not the scarcity of rain but rather the infertility of the soil. Analysis has shown that nearly all the soil types in the zone are extremely poor in phosphorus and nitrogen. Indeed, they may contain less than half the mean levels found in regions with comparable aridity elsewhere in the world. The landscape is ancient and weathered, and over time many elements have been lost from the surface.

However, it contains areas — so-called 'run-on' zones — where water can cause an accumulation of nutrients, and other regions, notably calcareous outcrops, that may have inherently greater levels of soil nutrients. So fertile patches can exist, but in general they are islands in a sea of infertility.

All of this is important for plant production. Botanists have found that perennial plants growing on infertile soils tend to be poorly digestible because they have developed defences — either chemical or structural — against herbivores. Much of the plant material in the vast expanses of our interior is low in nutrients and high in digestion-inhibiting compounds. From the point of view of herbivorous mammals, much of inland Australia is, to use a phrase coined by ecologists Dr Jack Kinnear and Professor Bert Main, 'nutritionally hostile'.

Also, because of the uncertainty of the rainfall, plant productivity is very unpredictable. In the occasional wet years, the productive patches will expand and may even coalesce, and it can appear that the region is no desert at all. Conversely, in the long dry times the patches break up

The spinifex sandplain, in the heart of the arid zone, north-west of Alice Springs.

into smaller and smaller fragments, some of them disappearing altogether.

Another important aspect of the environment is fire. This recycles scarce nutrients, removing the established plants in an area and allowing new growth to start from the nutrient-rich ashes of the old. The microbial breakdown of plant matter is slow in the arid soils, mainly as a result of the low levels of nitrogen, and fire is a much quicker means of freeing essential nutrients.

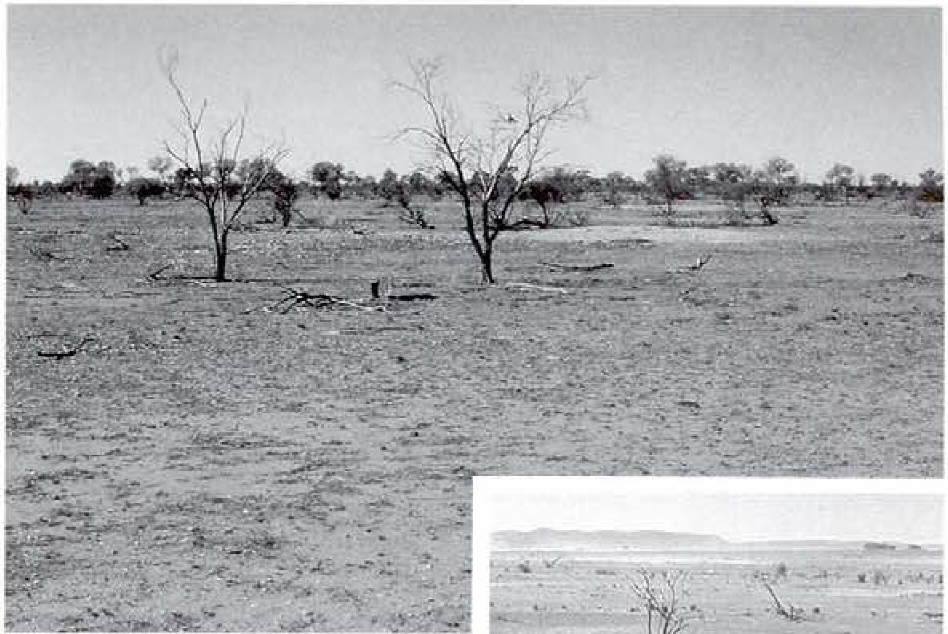
Fire can also disrupt an area of perennial plants, and allow short-lived species — persisting as seeds — to take their brief turn. In this way it increases the number of edible plant species in an area.

Animals

All animals — not just mammals — must somehow find enough nutritionally adequate food from an environment poor in nitrogen — an essential constituent of proteins and nucleic acids. However, the problem is greatest for warm-blooded creatures (called homeotherms) because they have a much higher metabolic rate, and hence greater expenditure of energy and turnover of building materials, than animals — notably reptiles — whose body temperature fluctuates with that of the environment. Also, unlike reptiles and amphibians, warm-blooded animals cannot remain inactive for long periods.

The smaller the homeotherm, the more acute the situation becomes, as small mammals require more food per gram of body weight than big ones. Being a herbivore imposes an added strain. Most plant material is neither energy- nor nutrient-dense, so living on it can be a successful strategy only for an animal that is greater than a certain size, because small mammals have much the same amount of space for digestion in relation to their volume as do large ones, but their requirements are relatively greater. (More information on animal sizes and herbivory appeared in *Ecos* 51.)

For this reason almost no herbivorous mammals weigh less than about 50 grams. Small mammals must eat insects or seeds (where energy and nutrients are concentrated), or scavenge for anything that is highly nutritious. Most medium-sized species are (or were) herbivores. To get enough food, they require relatively large patches of fertile country, as do the large herbivores, also. Unlike the latter, however, they do not have the necessary mobility to move considerable distances to another good feeding ground when one is exhausted. Small mammals cannot cover these distances; on the other hand, they need less energy per individual than larger species, and so can make do with the more numerous smaller patches of good growth. It seems that the medium-sized herbivores 'fall between two stools'.



Unfortunately, our introduced animals — if not managed correctly — can make the land look like this: *top*, land damaged by rabbits; and *lower*, cattle-degraded land.

Birds, despite their high metabolic rate, are saved because they are not herbivorous — indeed their metabolic demands are such that most could not be — and so do not need to digest such large volumes of food. Also, their flight makes them highly mobile. They can easily recolonise the expanded habitat that becomes available after major rains.

All in all, Dr Morton believes that physiological and environmental constraints made things difficult for the medium-sized herbivorous mammals in inland Australia before the arrival of European settlers. Quite probably species would frequently disappear from certain areas during 'hard times' and later recolonise them, during the infrequent periods of high plant production, from 'refuge populations' surviving in patches of good country. In this fashion the species, although their population sizes would fluctuate, had managed to survive for millennia.

How did mammals, along with reptiles and birds, manage to persist in places where free water was frequently unavailable? Dr Morton's studies have led him to conclude that food, rather than water *per se*, is the most critical factor for the survival of animal life in our deserts.

He has found that many animals avoid exposure to high temperatures by their behaviour (burrowing or only emerging at night or during the coolest parts of day); others possess physiological adaptations to enable them to produce a more concentrated urine.

However, in general, most animals obtain enough water with their food, and the real challenge is to acquire enough of that. Most of the available food is nutritionally poor, although sometimes plants may produce energy-rich nectar; but even this, while packed with carbohydrate, is low in nitrogen.

The balance tipped

Into this delicately poised but enduring state of affairs came the introduced herbivores. These depended on rich patches for their survival in hard times just as much as the native animals did. But during good years, cattle and sheep were stocked (and rabbits reproduced) to levels way above the long-term capacity of the environment to support them.

The rabbit was especially successful because here it had escaped its usual attendant parasites, predators, and com-

Lotsa lizards!

Central Australia is home to an extraordinarily large and diverse collection of lizards. A recent study by CSIRO's Dr Steve Morton and Dr Craig James of the University of Sydney found that, in the spinifex grasslands of Australia's arid zone, both the number of species in an area and the absolute abundance of individuals exceed those in North American deserts. What's more, subterranean lizards — not found at all in North America — turned out to be far more numerous here than had previously been realised.

Lizards are successful in most of the world's arid zones, presumably because their ability to use the abundant heat and sunlight to regulate their body temperature — despite their lack of physiological temperature regulation — puts them at less of a disadvantage relative to the mammals there than in cool areas. Also, their slower metabolic rate and lower requirements for food enable them to spend long periods inactive during the most stressful times. So, a variety of lizards in any desert is not too surprising; but why do they do so well in Australia?

For a start, the extreme uncertainty of rainfall means unpredictable reductions in food supplies; this creates far less difficulty for a lizard than for animals that need to maintain a consistently high metabolic rate and unvarying temperature. Their only solution is to be nomadic and move to the best areas; birds and some large mammals can do this, although at a cost in terms of energy expenditure.

But Dr Morton and Dr James argue that another factor has contributed to the success of lizards in central Australia: termites. This idea also accounts for the finding that spinifex grasslands — unappealing as they may seem to us — are the *creme de la creme* of lizard habitats.

These grasslands can accumulate quite a mass of above-ground tissue (up to 8000 kg per hectare), but the material is nutritionally poor and hence not useful to most herbivorous mammals. However, little is wasted in an ecosystem, and the spinifex litter provides food for termites, which can thrive on relatively low-nitrogen diets. Consequently, spinifex grasslands contain large termite populations and a wide range of species.

The termites, of course, are food for the lizards. Further evidence for the association comes from the observation that, as termite abundance and diversity decline — which happens in the more fertile parts of the country where other detritus-feeders compete — so too does lizard diversity.

Of course, other creatures also eat termites. The numbat likes them, but although once widespread in the arid zone it's now confined to a tiny area of Western Australia. However, animals that eat termites face a disadvantage; the mounds are generally too hard to break into. A predator must therefore collect the insects from below the ground, and harvesting such small items from mounds of sand offers a small return for a high expenditure of energy — a cost that energy-profligate mammals, on the whole, do not find worth while. What about echidnas, which have a slightly lower metabolic rate than other mammals? Dr Morton believes they may be more abundant in the Centre than was previously supposed, but the flat, sandy topography may not provide enough nesting sites and so their population remains limited.

The very arid deserts of the world, like those in Arabia, have so little rainfall that plant production is too sparse even to support many termites. Australia's arid zones can have enough moisture, yet it's sufficiently unpredictable to give lizards an advantage over mammals; couple this with the infertile soils, which indirectly favour termites over other detritus-eaters, and you have the conditions for a lizard success story.

The diversity and abundance of lizards in arid Australia: a new hypothesis. S.R. Morton and C.D. James. *The American Naturalist*, 1988, **132**, 237–56.

A sample of our arid zone's rich reptile fauna: the netted dragon and the sandswimmer, *inset above*, and striped skink, *inset left*.

A female bilby at the Arid Zone Research Institute in Alice Springs, bred from bilbies living in the Tanami desert. (Photo Ken Johnson.)

petitors. Its population would initially soar, exhausting many of the fertile islands; but the next drought would bring a dramatic decline in numbers. The attentions of rabbits and stock degraded the best areas where, in pre-European times, native mammals had found refuge during drought. And also, at the end of a drought, settlers would push their stock back out into the formerly barren regions, and the rabbits themselves would multiply and recolonise the remaining suitable areas, in direct competition with the native herbivores.

Dr Morton believes that each successive drought must have left fewer and fewer dependable refuges containing native species, and local disappearances must have been common. The rabbits' destructiveness made many areas unsuitable for themselves, and they can now no longer occupy permanently some of the places they once did.

Several extinctions took place in the sandy deserts — outside the range of stock and, it has been presumed, rabbits. However, Dr Morton believes that the rabbit might well be to blame there as well, for it might have arrived there and increased in number, using available resources in a good year and afterwards only occupying the area sporadically or not at all. He suspects that ecologists might have underestimated the initial spread of the rabbit, assuming that, because it is not found in those extreme zones now, it never was.

Another objection to the Morton theory is that we know that stock and rabbits co-existed with certain now-endangered or extinct species for some time. However, he has a potential answer for this too. The co-existence took place in the largest and most secure patches of good habitat — the very cream of the country — and Dr Morton argues that the resources were so good there that several droughts might have been necessary to wipe out the native herbivores.

Further evidence for the rabbit's guilt emerges when we match its distribution with the ranges of those mammals that have become extinct or declined. Interestingly, the spectacled hare-wallaby and the northern nailtail wallaby, both closely related to the species that have suffered so dramatically, are still surviving quite well. Dr Morton believes this is because the centre of their range lies north of the country occupied by the rabbit.

Introduced predators, such as foxes and cats, followed the rabbits, using them as food. When rabbits increased in numbers, so too did these predators and the native dingoes. But when the rabbits' numbers fell, the predator population switched to other prey, and the medium-sized mammals were the obvious choice. Of course, in time the number of predators would also fall, but only after they had exhausted any remaining native herbivore populations.

For the reasons already outlined, the medium-sized herbivorous mammals were the most sensitive to these disturbances. Dr Morton has concluded that the primary cause of their extinctions was the modification of habitat brought about by the introduced herbivores — rabbits, cattle, sheep, goats, and horses. Other factors have had demonstrable effects and are significant as immediate causes, but would not, he argues, have had such an impact were it not for the more fundamental changes wrought by the introduced herbivores.

Past and future

'Mammals both here (in the MacDonnell Ranges) and elsewhere were very difficult to obtain.' So wrote W.B. Spencer in 1896, describing the results of a scientific expedition to central Australia. He mentions only two or three colonies of burrowing bettongs — although one, within the drainage basin of Lake Amadeus, was quite populous.

In 1958, the zoologist Hedley Finlayson noted that the burrowing bettong's 'numbers fluctuate greatly and its occurrence is local and discontinuous and not uniform. Warrens housing a big population during one season may be found quite deserted the next.' These and other historical records confirm Dr Morton's idea that many of the Centre's animals were not uniformly distributed before European settlement, but were confined most of the time to a few small areas of abundance, whence they would spread out only when conditions permitted.

Dr Morton's model accounts for the fact that reptiles have suffered no extinctions, and that birds, although probably affected to some degree, are in a far better state than the mammals. It also explains why arid zone mammals suffered far more than those in the mesic zone.

All of this has an important bearing on prospects for reintroducing endangered or restricted mammals to parts of their former ranges. If Dr Morton is right, then reintroductions will only work in the long term if the animals are released into high-quality, nutritionally rich, dependable habitats, which are then monitored and carefully managed. Populations of feral animals — both grazers and predators — will also need to be managed. The right places are not common; Dr Morton and many other ecologists are trying to identify them now.

Roger Beckmann

More about the topic

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