Fragmented

Wildlife habitats worldwide are threatened by the decline of native vegetation, which exists only as small, isolated remnants. In the first of two articles, Wayne Deeker explains how fragmentation has endangered our own native species.

Pictures: Division of Wildlife and Ecology

Habitat fragmentation has been associated with the decline of native mammals in Western Australia's wheatbelt. Affected species include the tammar wallaby (right), the banded hare wallaby (top) and the euro (above).

landscapes

Is our wildlife in danger?

Australia has a poor record when it comes to clearance of native vegetation. Europeans first perceived the continent as a huge, empty island, overflowing with exploitable natural resources. This led to massive deforestation and land-clearing campaigns designed to eradicate the native biota which was thought to impede economic 'progress'.

Colonial governments gave land freely to settlers provided it was cleared for agriculture. With hand saws and bullock teams, they cleared millions of hectares of native vegetation. But even worse clearing occurred later, with the aid of tractors and bulldozers. Australia has now lost more than 90% of its former native vegetation in agricultural areas.

Land clearance was especially severe in south-west Western Australia, in an area now known as the wheatbelt. Here, only 6.7% of native vegetation remains. Most of that exists because those areas were needed for town sites and other services. Woodlands were favoured for clearing because their soil was thought to be the most fertile. The remaining native vegetation remnants are unrepresentative of the region's former vegetation types, and many are degraded.

Short-term consequences

Remnants are often the only place some species of native animals dependant on native vegetation can exist. Yet few remnants can continue as functioning ecosystems because fragmentation causes physical changes to the remnants. This makes survival impossible for many species.

Recent work by Dr Denis Saunders and colleagues from the CSIRO Division of Wildlife and Ecology suggests that fragments may experience different solar-radiation, wind and water regimes to continuously-vegetated regions. These altered physical conditions can degrade the remnants, changing their species composition and physical structure, especially at the edges.

These effects, and the other impacts that followed clearance and settlement, have had an ongoing effect on the biota. At least 24 plant species and several animal species have become extinct in the wheatbelt and many more are rare and declining in abundance and range.

A fragmented landscape is subject to higher daytime and lower night-time temperatures than heavily vegetated land, exposing upper layers of

In the wheatbelt area of south-west Western Australia, only 6.7% of native vegetation remains. Most of these remants are degraded.

the soil to a widened daily temperature range. This can affect the nutrient-cycling process through the effect on soil micro-organisms.

Also, most trees on the edges of vegetation fragments have not matured, in the presence of strong winds. They therefore lack the structural reinforcements that enable them to resist windthrow.

When dominant trees are blown over by summer cyclonic storms, the woodland is exposed to foreign species (weeds) which change the ground-cover conditions. This adversely affects small mammals and invertebrates. Many remnants are further at risk because stock-grazing prevents tree and shrub recruitment. Most remnants consist of senescent (old) trees. When they die, there will be no young ones to take their place. This accelerates habitat degradation.

Once a woodland is opened up, its interior is exposed to hot, dry winds which can affect the gas exchange of interior plants. Loss of trees also leads to reduced evapotranspiration of the surrounding pastures, causing faster saturation of the soil by heavy rains and leading to flooding, erosion and sedimentation.

Loss of trees and other native vegetation can also cause the water table to rise. Trees and shrubs transpire more than agricultural crops, and so have greater water use. When trees are present they use a lot of water, balancing the rainfall and keeping the groundwater level well below the surface. But when the trees are removed, the groundwater level begins to rise, bringing salty water to the surface where it can affect the soil's productivity.

Weeds are a serious problem for remnants because they can inhibit the establishment of native plants. Weeds also change remnant litter conditions and fire regimes. Shrub communities are generally less vulnerable to weeds than woodlands because they have lower nutrient levels which prevent weed growth. Weed seeds are dispersed into the centre of the largest reserves, and their establishment can be extensive when nutrient addition from the surrounding agricultural land is accompanied by soil disturbance. Weed invasion is likely to be a more serious problem for many remnants in future.

Habitat fragmentation, combined with the tremendous impact of feral animals, has also been associated with the loss and/or decline of several mammal species from most fragments within the wheatbelt.

The decline of WA's mammals had already begun before the bulk of the clearing had taken place, due primarily to the rabbit and fox. Rabbits reached WA in the 1920s, quickly denuding native vegetation as they had in other parts of Australia. They competed with native animals for burrow space and food resources.

High rabbit numbers also kept fox numbers high. The foxes preyed heavily on native species which were vulnerable because their cover failed to regenerate following fire, drought or rabbits. Fragmentation exacerbated the effects of rabbits and foxes, confining animals to vegetation remnants, where they had no escape from foxes and feral cats.

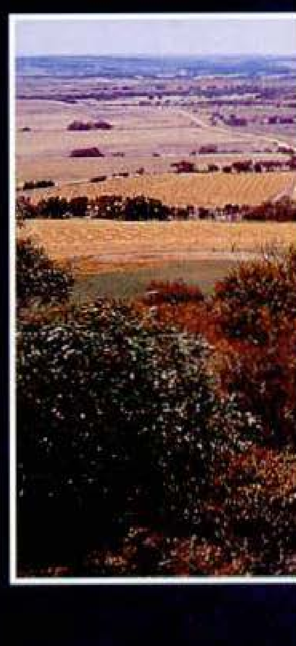
Rabbit control techniques also affected native mammals. Warren-ripping and fumigation probably also affected native burrowing animals and when myxomatosis was introduced in the 1950s, it rapidly wiped out more than 98% of the rabbits, diverting fox predation towards native fauna.

All of the impacts of settlement combined, particularly feral animals, were responsible for the decline of native mammals in the wheatbelt. Habitat fragmentation exacerbated these effects by restricting native animals to small, isolated areas, thus keeping their populations small.

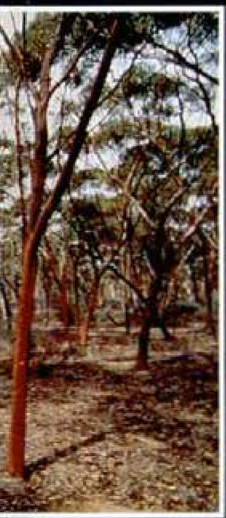
Species are still being lost from the wheatbelt. In 1976, brush tail possum were found in the CSIRO study area at Durokoppin Nature Reserve, but they had vanished only 10 years later. The western brush wallaby (*Macropus irma*) may be the next to go. Furthermore, black-footed Rock wallabies (*Petrogale lateralis*) only survive in some rocky remnants because the Western Australian Department of Conservation and Land Management (CALM) has an active fox control program. They would certainly die out without it.

Many populations of native mammals in the wheatbelt are probably not viable in the long term because their confinement in small remnants keeps their numbers low. At present, only western grey kangaroos, euros, fat-tailed dunnarts, and echidnas have secure populations in the wheatbelt, and only if further degradation does not occur.

Bird species are in better condition than the mammals, with a greater percentage of the original species remaining and in greater numbers. But the birds are showing a similar decline to the mammals. Nearly half of the bird species recorded in the wheatbelt have declined in range and/or abundance there over the last 80-90 years. Some of

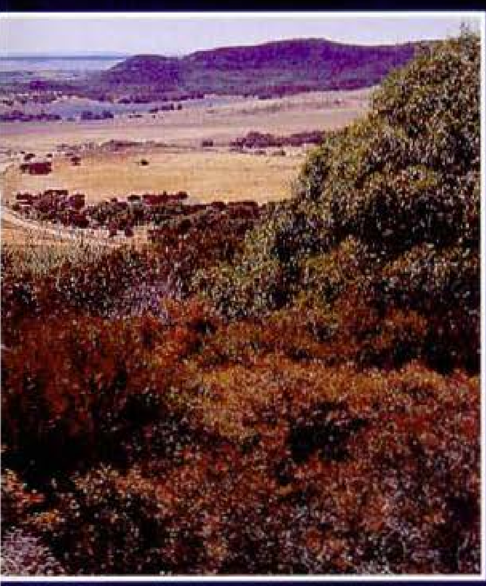


When native vegetation is removed, groundwater levels rise, bringing salty water to the surface.



A degraded remant of eucalypt woodland.

This remnant features a more diverse range of species.



those species were formerly abundant, declining in the last few years. Habitat clearing is the most important reason for the decline of some of these species: they are still common where vegetation remains intact.

Less understood, but important consequences of the loss of fauna species following fragmentation have been: an increase in seed predators following the removal of Carnaby's cockatoo (*Calyptorhynchus funereus latirostris*); non-dispersal of large-seeded species following the loss of emus; a substantial impact from agriculture on all soil fauna groups except ants and the loss of macropods from most areas of the wheatbelt, which has led to a change in nutrient cycles. It is unknown what effect fauna loss has had on pollination regimes, or how the loss of burrowing animals like the bilby and burrowing bettong has affected seedling establishment.

Remnants are also vulnerable to the equally serious longer-term consequences of fragmentation: population degradation and loss of habitat diversity.

Large scale and long-term effects

In their 1981 book *Conservation and Evolution*, former CSIRO Division of Plant Industry chief Sir Otto Frankel and Dr Michael Soulé of the University of California define conservation as 'providing for the long-term survival of species under natural conditions, allowing for their continuing evolution'. If species' evolutionary change is not considered, they say, attempts to prevent their extinction are called *preservation*. Most 'conservation' programs are but attempts at preservation, and do not have a long time scale.

Using this definition, it now appears that very few reserves are large enough for the 'conservation' of their species. In Australia, one third of all parks and reserves are less than 1000 hectares and only 15% of parks and 1% of reserves exceed 100 000 ha. Most are between 15 000 and 20 000 ha. Reserves smaller than about 500 000 ha are vulnerable to the following processes which, like physical degradation, can cause loss of species from the reserve.

Too-large disturbance area: Many species in a community only live in temporary habitats that are part of a successional stage. After an initial disturbance, the community gradually returns to its former state. The process can take many years and along the way there are several stages through which the vegetation must progress. If any successional stage disappears even temporarily from a reserve, the species that depend on that stage will be lost, as will other species that depend on those species.

If succession-dependant species were confined to a single reserve, loss of the critical successional stage could mean extinction for a large number of species. Managing a reserve so that all successional stages are maintained at all times is a difficult process, probably almost impossible in small reserves.

Sometimes an event like a fire or cyclone disturbs an area larger than the park itself, resetting the entire park to a single successional stage. If there were no sources of recolonisation, many species would be lost. It is important therefore to incorporate the largest disturbance size into the reserve design; reserves must be able to cope with the rare, but potentially devastating disturbance event, like the one-in-300-year flood. The smaller the reserve, the greater the chance that a single event will wipe out the whole lot.

Genetic deterioration: Fauna populations that become confined to small vegetation remnants begin to inbreed, (the mating of close relatives) because young individuals cannot disperse from their parents. Inbreeding causes a loss of heterozygosity in the offspring.

A heterozygous individual carries two forms (alleles) of the same gene, one inherited from each parent. Where the parents are closely related, there is a greater chance that the offspring will inherit the same alleles from both parents. Individuals heterozygous for many genes have a greater Darwinian fitness (are more likely to survive to reproduction and pass on those genes) than homozygous individuals.

Even a small amount of inbreeding can be harmful, sometimes causing an increase in the incidence of maladaptive traits in a population. This increases mortality, especially during times of environmental stress or change.

A related population effect is genetic drift, which is the random loss of alleles due to sampling. Rare alleles are only carried by a few individuals in a population, and these alleles may be lost from a population by chance alone, merely by the individuals carrying them not surviving to breed. Since each generation inherits its genes from the one previous, small populations are vulnerable to the random loss of alleles in this manner because there are fewer and fewer alleles to sample from each

Rabbits and foxes have contributed to the decline of Western Australia's mammals.

generation. This is a calamity in evolutionary terms because individuals in small populations become more and more genetically alike.

Loss of evolutionary potential: The more genetically alike members of a population are, the less able the population would be to adapt to a changing environment. Natural selection is the main agent of evolutionary change: it acts upon variety, favouring the survival of individuals exhibiting advantageous traits over those less suited to their environment. Without variety — when members of a population resemble each other too closely — natural selection has nothing to select for. No individuals will have any advantage over the others, hence they will all perish when the environment inevitably changes. This is one reason for extinction: organisms fail to adapt to altered environmental conditions. Genetic variability is directly related to evolutionary potential: more is better.

Speciation must also be accounted for in conservation-management plans, because the greatest evolutionary change takes place during speciation; once speciation has finished, most species remain relatively constant.

In 1980, Soulé empirically estimated the minimum area required for speciation from the size of an island where speciation is known to have occurred. He found that no reserve on Earth is large enough to allow for the speciation of reptiles, birds or mammals. He believes that speciation among these taxa has essentially ceased. Saunders and fellow scientist Dr Richard Hobbs, however, believe there is too much uncertainty to endorse this view.

Non-viable population sizes: The minimum viable population (MVP) size is defined as the minimum number of individuals necessary to ensure enough genetic variation so that an evolutionary capability is maintained. The issue of how to define an MVP is very complex, covering all aspects of biology.

Saunders and Hobbs say it is not possible to isolate any specific MVP. Their opinion is that no-one knows what a real MVP might be. However, many researchers believe that 50 breeding individuals is the bare minimum to ensure short-term survival. It is short term because even with 50 breeding individuals, 1% inbreeding per generation still occurs. It should be remembered that a breeding population of 50 can mean an actual population of several hundred.

Soulé, and Dr Daniel Simberloff of Florida State University, provided a more realistic, though not universally accepted, long-term population size of about 500 breeding individuals. This figure balances allele gain through mutation with alleles lost to genetic drift. For most mammals, such numbers require reserves of thousands of square kilometres, even more to maintain higher predators like tigers. Again, it seems that current reserves are far too small to sustain large mammal species for long.

In one study, 94 out of 100 computer simulations of grizzly bear populations in Yellowstone National Park using actual life-history data predicted a failure of the population in 300 years with an average time to extinction of 114 years. For these bears, 50 is far too small a population size.

Clearly, even the world's largest reserves are inadequate for conservation purposes. In fact, it is predicted that without human intervention, half of the large mammal species that now depend on reserves for their habitat will become extinct in 500 to 2000 years.

Is there hope?

Saunders and Hobbs recently organised a series of conferences to discuss the conservation of fragmented habitats and their species. The conferences were attended by representatives from the WA Departments of Conservation and Land Management (CALM) and Main Roads; the Western Australian Roadside Conservation Committee (RCC); Stanford University; and the Tammin Land Conservation District Committee. Integrated land management, including corridors, was identified as the best hope.

Corridors are strips of native vegetation that link at least two formerly-joined remnants, effectively increasing reserve sizes. They are believed to have a number of ecological functions. By far the most important of these in conservation terms is to allow the movement of biota — mainly animals — between remnants, allowing a remnant-network to function as a single large population, called a *meta*population.

Movement among patches of a metapopulation enhances gene flow, which helps prevent the genetic consequences of isolation mentioned earlier. In general, the greater the degree of connectiveness, the greater a metapopulation's chance of survival.

The second article on fragmented landscapes, to be published in next issue of *Ecos*, will examine the role and management of bush corridors, and the possibility of achieving long-term conservation in fragmented landscapes.

More about fragmented landscapes

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