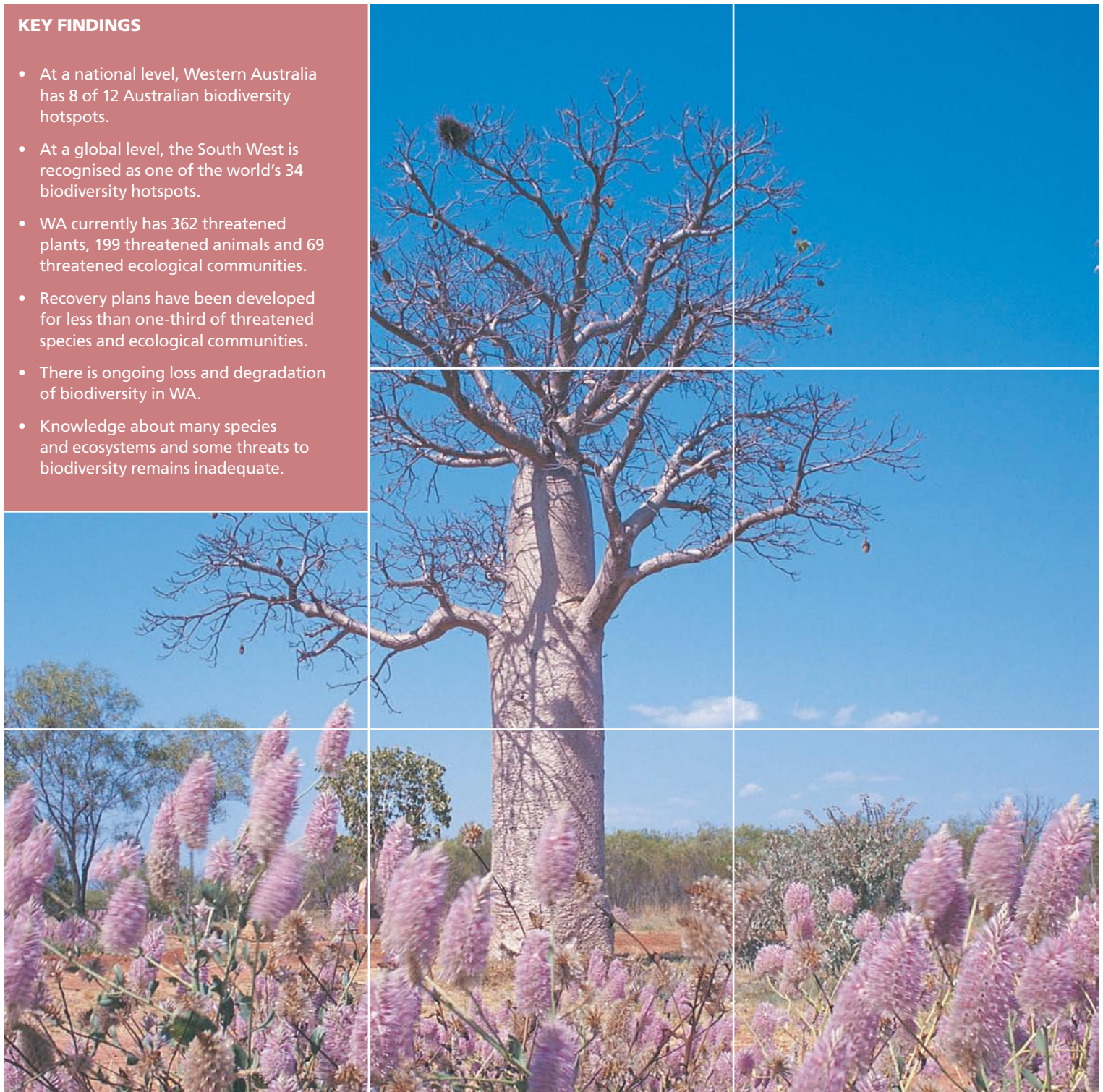


Theme 5



KEY FINDINGS

- At a national level, Western Australia has 8 of 12 Australian biodiversity hotspots.
- At a global level, the South West is recognised as one of the world's 34 biodiversity hotspots.
- WA currently has 362 threatened plants, 199 threatened animals and 69 threatened ecological communities.
- Recovery plans have been developed for less than one-third of threatened species and ecological communities.
- There is ongoing loss and degradation of biodiversity in WA.
- Knowledge about many species and ecosystems and some threats to biodiversity remains inadequate.



BIODIVERSITY



INTRODUCTION

Biodiversity is defined as the variability within and among genes, species and ecosystems. It covers marine, terrestrial, subterranean and aquatic life and implies a highly complex system of interacting entities that occur over a range of temporal and geographic (from local to global) scales (Department of Environment and Conservation, 2006a). Biodiversity at the species and ecosystem levels are well-understood compared to genetic diversity. In this report, the term 'biodiversity' refers to organisms native to WA. Introduced species are considered threats to biodiversity, and treated as an environmental issue. Western Australia's rich biodiversity can be attributed to the State's large area which spans a huge range of geographical, soil and climatic conditions. Terrestrial ecosystems range from rainforest, savanna woodlands, grasslands, shrublands, heathlands, tall forests and woodlands. Inland water environments include permanent and seasonal waterways and wetlands (see '*Inland waters*'). The marine environment is similarly diverse, including coral reefs, intertidal mangrove forests, seagrass beds, sandy beaches, coastal salt marshes, rocky shores, algal reefs and kelp forests (see '*Marine*').

Western Australia is home to some of the most unusual and unique biodiversity on Earth. This includes over 11 500 known taxa of vascular plants which include flowering plants, ferns and conifers (Department of Conservation and Land Management, 2004d). This represents about 50% of known Australian vascular plants. Western Australia has eight of the 12 national biodiversity hotspots (defined by having high numbers of endemic species coupled with significant threats), which reflects the State's richness and high endemism in biodiversity and significant threats. Western Australia also has one of the 18 tropical marine biodiversity global hotspots. Vertebrates are the best known animal group in WA with 220 mammal, 510 reptile, 3028 fish, 77 amphibian and 611 bird taxa formally described. Other groups, particularly fungi and invertebrates, are poorly understood. Marine and aquatic biodiversity is generally less well known and described than

terrestrial taxa, and the lack of knowledge remains a significant shortcoming. Western Australia has 3747 islands that are recognised as important refuges for many species (13 fauna taxa are found only on offshore islands, and five are found on both the mainland and islands). The South West part of the State is also one of the world's 34 biodiversity hotspots (Conservation International, 2006). About 80% of native plant species are endemic, meaning that they are not native to any other parts of Australia or the world (Beard et al., 2000).

The conservation of biodiversity and maintenance of wider ecological functions is essential for long-term protection of the environment and human survival. The inter-relationships between plants, animals, microorganisms and the nonliving environment are complex and not well understood. In the absence of knowledge of these interrelationships, the potential for disrupting ecological function and services is significant. Many environmental issues presented in this report can have cumulative effects on the environment, placing biodiversity under increased pressure. Threats to biodiversity not only come from biological and physical processes, but from institutional issues too. Foremost amongst these problems is the failure to adequately value biodiversity in decision-making; but this is exacerbated by shortcomings in knowledge of biodiversity and the lack of commitment and capacity to manage ongoing threats.

Objectives

- Improve understanding of biodiversity in WA.
- Where possible, reduce or eliminate key threatening processes (both systemic and environmental) to biodiversity.
- Conserve comprehensive, adequate and representative biodiversity at the genetic, species and ecosystem scales.
- Improve community capacity to understand, manage and protect biodiversity for future generations of Western Australians.

Headline indicators

There is no overall indicator of the condition of biodiversity. This is because of the complexities in measuring diversity and health at genetic, species and ecosystem scales. Reservation of ecosystems can be used as interim headline indicators as it is very important for the long-term protection of the State's biodiversity. Conservation reserves form part of the national reserves system and aim to contain comprehensive, adequate and representative (often abbreviated to CAR) examples of ecosystems (see '*Conservation*').



Indicator B1: Percentage of terrestrial biogeographical regions that meet the 15% reservation target.

The benchmark of 15% reservation has been increasingly recognised for terrestrial bioregions (Department of Conservation and Land Management, 2003b). It originates from the *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia* (ANZECC & MCFFA National Forest Policy Statement Implementation Sub-committee, 1997), but has been expanded to include other ecosystems as well as forests. The *National Objectives and Targets for Biodiversity Conservation* (Environment Australia, 2001) requires that a representative sample of each bioregion is protected within the National Reserve System, in the network of Indigenous Protected Areas, or as private land managed for conservation under a conservation agreement by 2005. No formal evaluation has yet been undertaken to assess the State's progress in meeting these targets.

As of June 2005, only 20% of the terrestrial subregions (as defined by the Interim Biogeographic Regionalisation for Australia) met the objective of 15% or more reserved and

11% of the subregions did not contain any formally reserved areas (Table B0.1). About 7% of WA's terrestrial area is currently reserved in the formal conservation estate, although other forms of informal conservation measures are present (see 'Conservation').

Indicator B2: Percentage of marine biogeographical regions that have no formal reservation.

The *National Objectives and Targets for Biodiversity Conservation* requires that progress be made towards the establishment of a comprehensive, adequate and representative system of marine protected areas. However, no specific percentage targets for marine regions or ecosystem types have been set. Most marine bioregions have a very low level of reservation and 65% of bioregions had no marine reservation as of June 2005 (Table B0.1). The Ningaloo bioregion had the highest level of reservation (82% of its area).

Table B0.1: Terrestrial subregions and marine bioregions in WA that meet various levels of reservation, as of June 2005.

Level of reservation	Number of terrestrial subregions ^a	Per cent reserved	Number of marine bioregions ^b	Per cent reserved
0%	6	11%	11	65%
0.1–5.0%	20	37%	2	12%
5.1–10.0%	9	16%	0	0%
10.1–15.0%	8	15%	0	0%
More than 15.1%	11	20%	4	23%
Total	54	100%	17	100%

Data source: Department of Conservation and Land Management [ver. 2006]. Note: (a) Includes the formal conservation reservation system only. Data from Indigenous protected areas and private land not included. (b) Marine bioregions are defined by the Interim Marine and Coastal Regionalisation of Australia.



The beautiful firewood banksia is found on sandy soils between Perth and Kalbarri (K. Strepnell)

Overall condition**Indicator B3: Extent of native vegetation remaining.**

Many WA terrestrial subregions have a high percentage of their native vegetation remaining (i.e. 41 of the 54 terrestrial subregions have 96% or more remaining) (Figure B0.1). Many South West bioregions have little native vegetation remaining (Department of Conservation and Land Management, unpublished data). For example the western Avon Wheatbelt subregion has 8.6% of its pre-European settlement vegetation remaining and the eastern Avon Wheatbelt subregion has 18.6%. Overall, about 40% of the pre-European settlement extent of native vegetation still remains in the South West.

In comparison, the rangelands retain a much higher percentage of native vegetation. The amount of native remaining vegetation is generally correlated with the amount of stress that those ecosystems are under (Figure B0.2). However, there are a number of landscape level threats (such as changed fire regimes, the impacts of introduced species and *Phytophthora dieback*) which are not directly related to the amount of remaining vegetation. In addition, the extent of fragmentation (or connectedness) of the landscape is as important as the area of vegetation cover. When small remnants of native vegetation remain but are not connected to other similar areas, they become islands of vegetation in a sea of agricultural land or urban development, and the genetic diversity and ecosystem resilience declines.

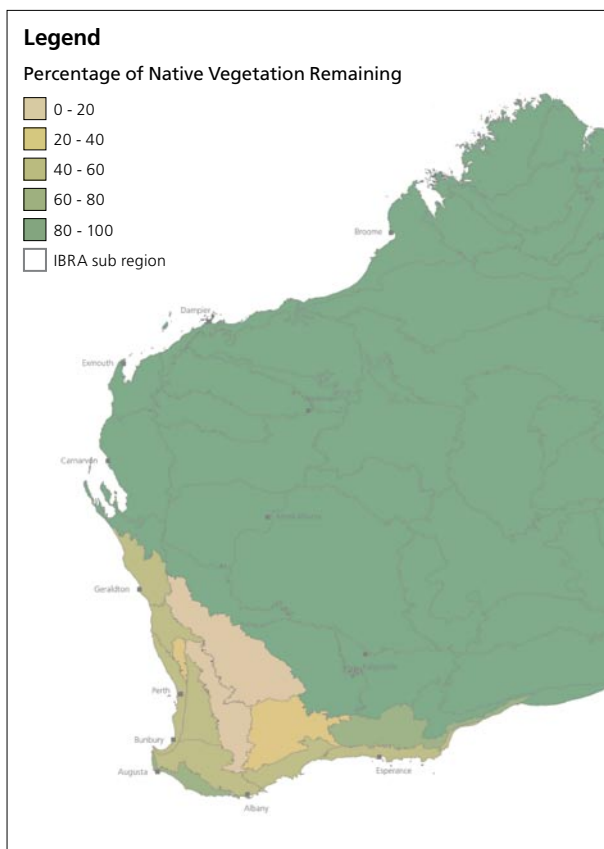


Figure B0.1: Percentage of pre-European vegetation that currently remains in terrestrial subregions.

Data source: Department of Conservation and Land Management [ver. 2005]. Analysis: Department of Agriculture; Department of Conservation and Land Management. Presentation: EPA.

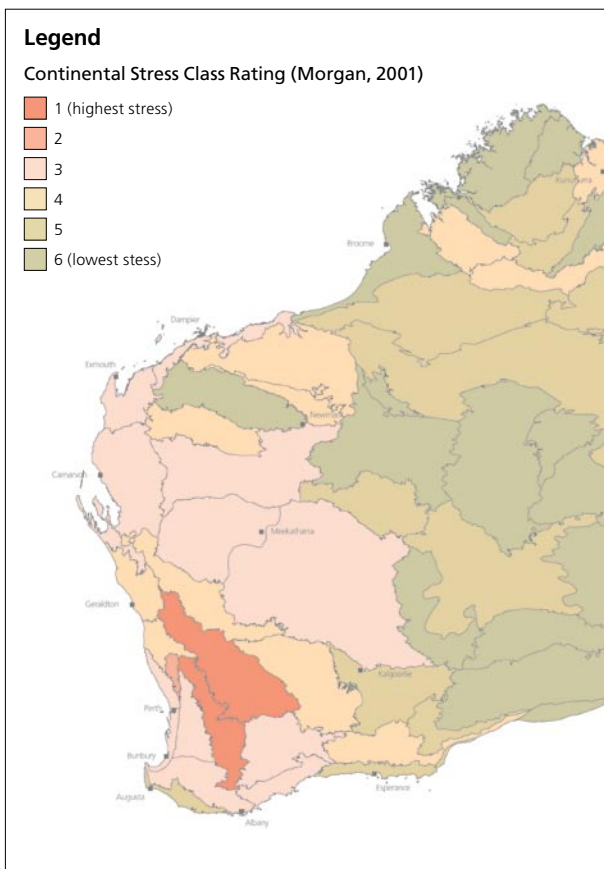


Figure B0.2: Continental stress class of Western Australia's terrestrial subregions.

Data source: Morgan (2001). Presentation: EPA.

Indicator B4: Continental stress class.

'Continental stress class' is a method of describing landscape health in Australia at bioregional scales (Morgan, 2001). Bioregions are areas defined by common natural characteristics, such as vegetation types, geology and landforms. The continental stress class is determined by a variety of factors including level of reservation, number of threatened species and communities, and number of pest and weed species. The continental stress classes have been adjusted in other publications using expert opinion (for example, see Department of Agriculture et al., 2003, and May & McKenzie, 2003).

The South West wheatbelt is the highest stress area for biodiversity in WA, due to widespread loss of native vegetation, fragmentation of habitat, land salinisation, and relatively small areas protected in the conservation estate (Figure B0.2). Other coastal parts of the South West and the Mid West also show high levels of stress on biodiversity. Land development and associated clearing and fragmentation, Phytophthora dieback and weeds are examples of pressures in these regions.

Much of the Kimberley region and the central desert areas have the lowest stress on biodiversity. It should be noted that continental stress is under-represented in some Pilbara and Kimberley subregions, especially those impacted by frequent and extensive fires, introduced species and overgrazing. Also, large areas of reserved land have skewed the assessment towards less stress than is otherwise observed on the ground. Some groups of organisms have undergone considerable decline, such as small and medium-sized mammals. However, many ecosystems in these areas have retained their pre-European vegetation and are in better condition than those in the South West.

Indicator B5: Number of threatened species and ecological communities.

Threatened plants and animals are ranked as critically endangered (CR), endangered (EN) or vulnerable (VU), using criteria set out by the World Conservation Union (formerly known as the IUCN). Several criteria for listing plants, animals and threatened ecological communities in WA include having a low number of remaining individuals, populations or occurrences; a small or highly contracted range; susceptibility to known threats; and decline in habitat quality. Listed threatened plants and animals appear in wildlife conservation notices, published annually by the Western Australian Government Gazette. Currently there are 379 threatened plants, 204 threatened animals and 66 threatened ecological communities in WA (Table B0.2). Further there are 14 plants,



The endangered dibbler is threatened by foxes, changed fire regimes and loss of habitat to Phytophthora dieback (Department of Environment and Conservation)



18 animals (mostly mammals) and 3 ecological communities that are thought to be extinct or destroyed (Table B0.2). Threatened plants are also known as Declared Rare Flora.

Listed species or communities are not necessarily the only ones in danger of extinction, and the listing process (especially for threatened ecological communities) is incomplete and is thought to under-represent the true number of threatened species and communities. In addition to threatened species and ecosystems, an additional list of 'priority' flora, fauna and ecosystems is used to reflect those which are poorly known, where special survey effort is needed, or to designate taxa that are considered naturally rare.

The number of threatened and priority flora and fauna has increased over time – a total of 2619 taxa (including 2309 flora and 310 fauna) were listed in 1998, while 3022 taxa (including 2625 flora and 397 fauna) were listed in 2006-07 (Table B0.2; Department of Conservation and Land Management, 1998 & 2006; Department of Environment and Conservation, unpublished data). This represents increases of 14% for flora

and 28% for fauna being flagged as priority or threatened since 1998. However this may reflect increases in taxonomic revision, curation of collections, improved data management and field investigations, and may not necessarily represent a change in the conservation status of the State's wildlife (Department of Conservation and Land Management, 2005a).

Some taxa may improve categories following population recovery, or as surveys reveal more populations. Threatened plants, animals and communities are found throughout WA (Figures B0.3, B0.4, B0.5) but the Swan Coastal Plain and the South West have the highest density of threatened flora, fauna and ecological communities. The Kimberley area includes a large number of threatened fauna snails which are restricted to small areas of rainforest vegetation. Barrow Island stands out as having a very high number of threatened fauna (20 taxa) because it is home to many animals that are no longer found on the mainland, including a turtle, a bird and many cave-dwelling animals (such as a fish, snake, spider and many water-dwelling crustaceans).

Table B0.2: Number of threatened flora, fauna and ecological communities.

Group	Presumed Extinct or Destroyed	Threatened (CR, EN, VU)	Total
Plants	14^a	379^b	393
Flowering plants, conifers and cycads	14	377	391
Ferns		1	1
Mosses		1	1
Animals^c	18	204	222
Mammals	11	42	53
Reptiles		23	23
Birds	2	45	47
Frogs		3	3
Fish		8	8
Worms		1	1
Spiders		18	18
Insects	1	3	4
Millipedes		5	5
Crayfish		4	4
Other crustaceans (found in underground water and caves)		18	18
Snails	4	34	38
Threatened Ecological Communities^d	3	66	69
Total plants, animals and ecological communities	35	649	684

Data source: (a) Government of Western Australia (2006), (b) Department of Environment and Conservation [ver. Feb 2007], (c) Department of Environment and Conservation [ver. Jan 2007], (d) Department of Conservation and Land Management [ver. Jan 2004] (no further communities have been endorsed since this time).

Indicator B6: Number of recovery plans and their effectiveness.

A total of 649 species and communities are listed as threatened in WA (Table B0.3). About 39% have recovery plans developed (Table B0.3). Ideally each one should have a recovery or management plan and associated actions. At present, critically endangered species and ecological communities have priority for recovery plan development and implementation, followed by those that are endangered and then vulnerable.

The degree of implementation and effectiveness of recovery plans is limited. Seventy-four interim recovery plans for critically endangered plants and 33 for threatened ecological communities were assessed to determine progress during

implementation of the plan. For plants under recovery plans, 55% improved, 32% remained stable and 12% declined. For threatened ecological communities under recovery plans, 15% improved, 57% remained stable and 27% declined (Department of Environment and Conservation, unpublished data, February 2007). Most threatened plants or communities have increased or remained stable under recovery plans but some species and communities have declined. It is possible that some of these would have become extinct or that their decline would have been much more rapid if they had not been covered by a plan. The development of a recovery plan does not guarantee the survival or improvement in condition of threatened species or ecosystems, but it does provide the best possible opportunity of doing so.

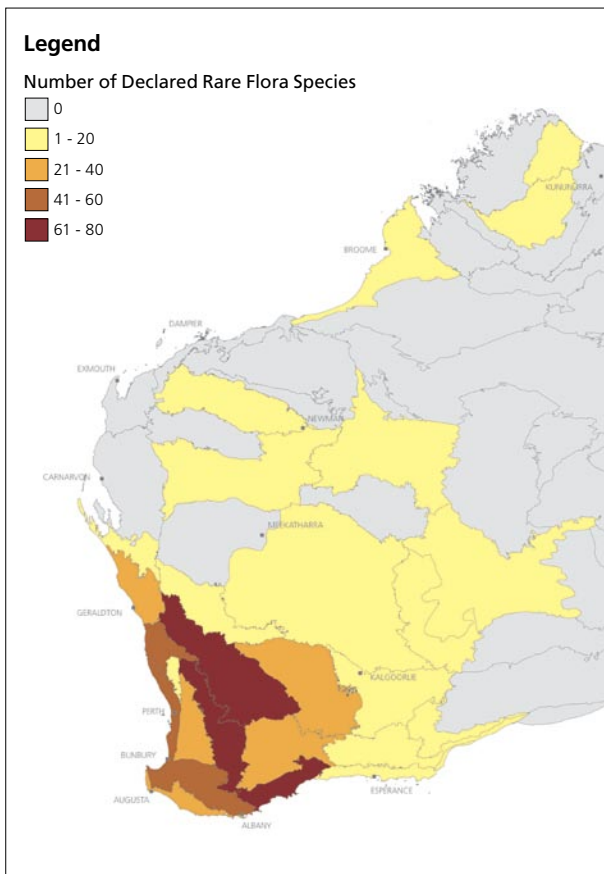


Figure B0.3: Number of declared rare flora per terrestrial subregion.

Data source: Department of Environment and Conservation [Jan 2007].
Presentation: EPA.

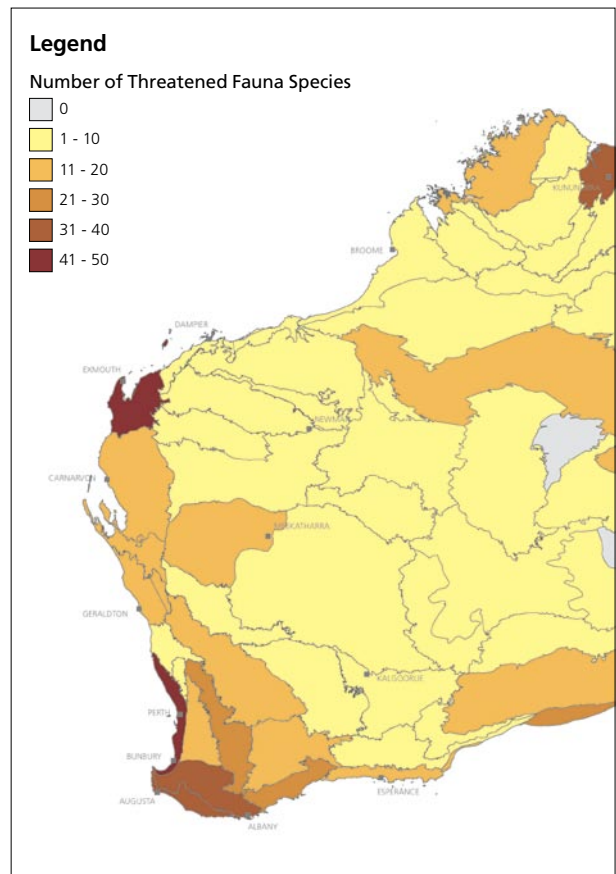


Figure B0.4: Number of threatened fauna per terrestrial subregion.

Data source: Department of Environment and Conservation [ver. Feb 2007].
Presentation: EPA.



Everlasting daisies in the Goldfields region of WA (K. Stepnell)

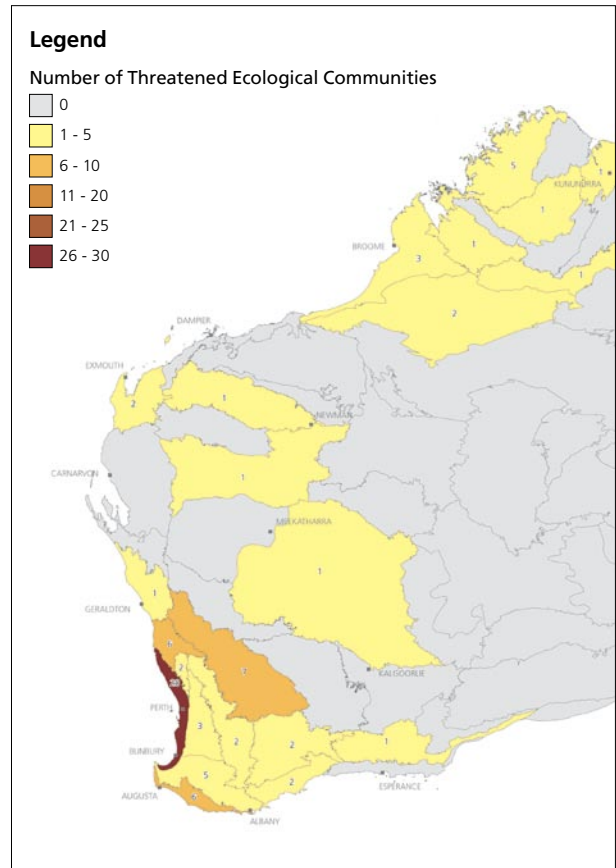


Figure B0.5: Number of threatened ecological communities per terrestrial subregion.

Data source: Department of Conservation and Land Management [ver. Jan 2004].
Presentation: EPA. Note: These data are based on limited survey work that has only partially identified the number of threatened ecological communities likely to occur in WA.



Table B0.3 Number of Western Australian species threatened and ecological communities covered by endorsed recovery plans and interim recovery plans.

Group	Critically Endangered	Endangered	Vulnerable	Other	Total covered by recovery plans	Total threatened (not including extinct or destroyed)	Per cent covered by recovery plans
Plants	119 (including 117 IRPs + 2 RPs)	22 (including 20 IRPs + 2 RPs)	14 (including 13 IRPs + 1 RP)	-	150	379	40%
Animals	34 (8 IRPs + 3 RPs)	12 (2 IRPs + 5 RPs + 2 National Plans)	20 (4 IRPs + 4 RPs + 1 National Plan)	3 (2 IRPs + 1 RP)	69	204	34%
Threatened Ecological Communities	18 (All IRPs)	7 (All IRPs)	5 (All IRPs)	1 (An IRP)	31	66	47%
Overall total					250	649	39%

Data source: Department of Environment and Conservation [ver.2007] Note: RP – Recovery plan; IRP – Interim recovery plan; Some plans have been updated and replaced; Some fauna are covered within threatened ecological community interim recovery plans; Some plans cover more than one species or threatened ecological community.

Effectiveness

Forty-eight actions for maintaining biodiversity were identified in the *1998 State of the Environment Report* (Government of Western Australia, 1998). Of these 46% remained incomplete, 33% have been completed but not evaluated, and only 21% have been completed and evaluated. Evaluating the effectiveness of programs to maintain biodiversity is very difficult. Indicators of biodiversity condition still largely do not exist and so few environmental outcomes can be quantified. In addition, the effects of on-ground actions are difficult to detect and it may take many years of monitoring before environmental outcomes are evident. Consequently, even though a large proportion of these programs are underway or complete, it has been very difficult to evaluate actual environmental outcomes and increased monitoring and evaluation effort is urgently needed. The National Action Plan for Salinity and Water Quality and the Natural Heritage Trust programs may help to improve monitoring of biodiversity issues, such as introduced animals, weeds and *Phytophthora* dieback.



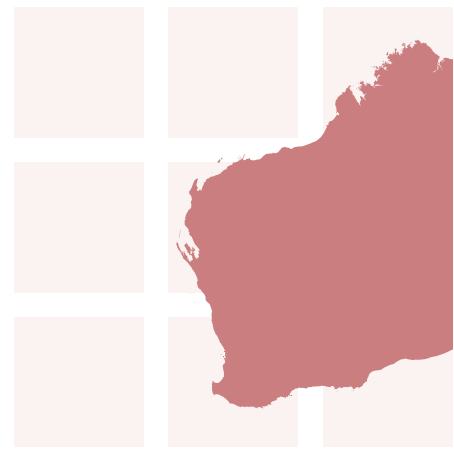
The kangaroo paw is the floral emblem of WA (Tourism WA)

SUGGESTED RESPONSES

- 5.1 Finalise and enact the Biodiversity Conservation Bill: the need for biodiversity conservation legislation is urgent as the existing legislation is outdated.
- 5.2 Finalise and implement the draft *A 100-year Biodiversity Conservation Strategy for Western Australia*. A draft version of the strategy has recently undergone public comment. The strategy will be an important complement to the proposed Biodiversity Conservation Act.
- 5.3 Ensure all potentially threatened species and communities are assessed and their status recognised within an appropriate time frame.
- 5.4 Assess the level of implementation and effectiveness of recovery plans.

See also 'Conservation':

- Accelerate establishment of the formal conservation reserve system, particularly in priority terrestrial subregions and marine regions.
- Progressively implement a protected area plan for each priority subregion and region, and provide adequate management.



INDICATIVE EXTENT OF ISSUE

PRIORITY RATING: 2

KEY FINDINGS

- Fires are contributing to a decline in biodiversity across many areas of WA.
- The Kimberley has the highest frequency and greatest extent of fires in the State.
- Appropriate fire regimes for biodiversity are not well understood.

Description

Fire is an important natural feature of the Western Australian landscape. Fires help shape the diversity of plants (Dixon & Barrett, 2003) and animals. Many native plants have evolved fire-related adaptations over time, such as fire-induced flowering or smoke-induced germination (Hopper, 2003). Without human intervention, fires are most often started naturally by lightning strikes. Natural fire regimes (or patterns) have been significantly changed following the arrival of humans. Changed fire regimes have the potential to change ecosystems and the composition of species within. Problems arise when ecosystems are burnt too often. This can lead to loss of biodiversity through inadequate recovery and reproduction times for many plants and animals, resulting in a simplification of ecosystems. Too little fire can also be a problem, limiting reproduction mechanisms for some native plants that use ash, smoke or intense heat to germinate seed.

Aboriginal people traditionally used fire for hunting, cultural and land management purposes. The arrival of Europeans brought a culture of fear of fire, with a focus on fire suppression and preserving human life and property. This is particularly apparent in the South West where prescriptive burns under controlled conditions have been introduced to try and reduce the vegetation fuel load that is available to burn in the event of fires. Fire in the rangelands has historically been used as a pasture management technique, first by the Aboriginal inhabitants and later by the pastoral industry. Fires caused by accidents and arson are also significant.

Understanding the role of fires on biodiversity is complex, and requires an understanding of the frequency (time between burns), seasonality (time of year), intensity (severity) and the extent (area) of the burn. The effect of fire on species and ecosystems varies significantly, further complicating its effect on biodiversity. Often the mosaic pattern in which naturally-occurring fires burnt the landscape has radically changed since European settlement (Dixon & Barrett, 2003).

Objectives

- To understand the role of fire in the Western Australian environment.
- To use and control fire to maintain biodiversity.
- To use scientific understanding for adaptive management of fires.

Condition

Indicator B7: Frequency and extent of fire across WA.

The extent and frequency of fires are major factors impacting on biodiversity. The Kimberley has the highest frequency of burning (Figure B1.1), with most of the landscape having been burnt over the past 15 years, and some areas burnt annually. Between 80–100% of the Kimberley has been burnt over the same period (Figure B1.2). Widespread areas of the Pilbara, the central deserts, and the South West forests have also been burnt, but much less frequently.

Native vegetation within urban areas is subject to frequent fires as a result of arson, accidental ignition, and invasion by grassy weeds which add to fuel loads. Significant efforts are made in metropolitan areas to reduce the frequency of fire in proximity to people and infrastructure. Frequent fire also poses a significant threat to remnant vegetation in the agricultural zone. Many areas of remnant vegetation are subject to invasion by weeds and fragmentation of ecosystems, and once burnt it is more difficult for recolonisation by native species.

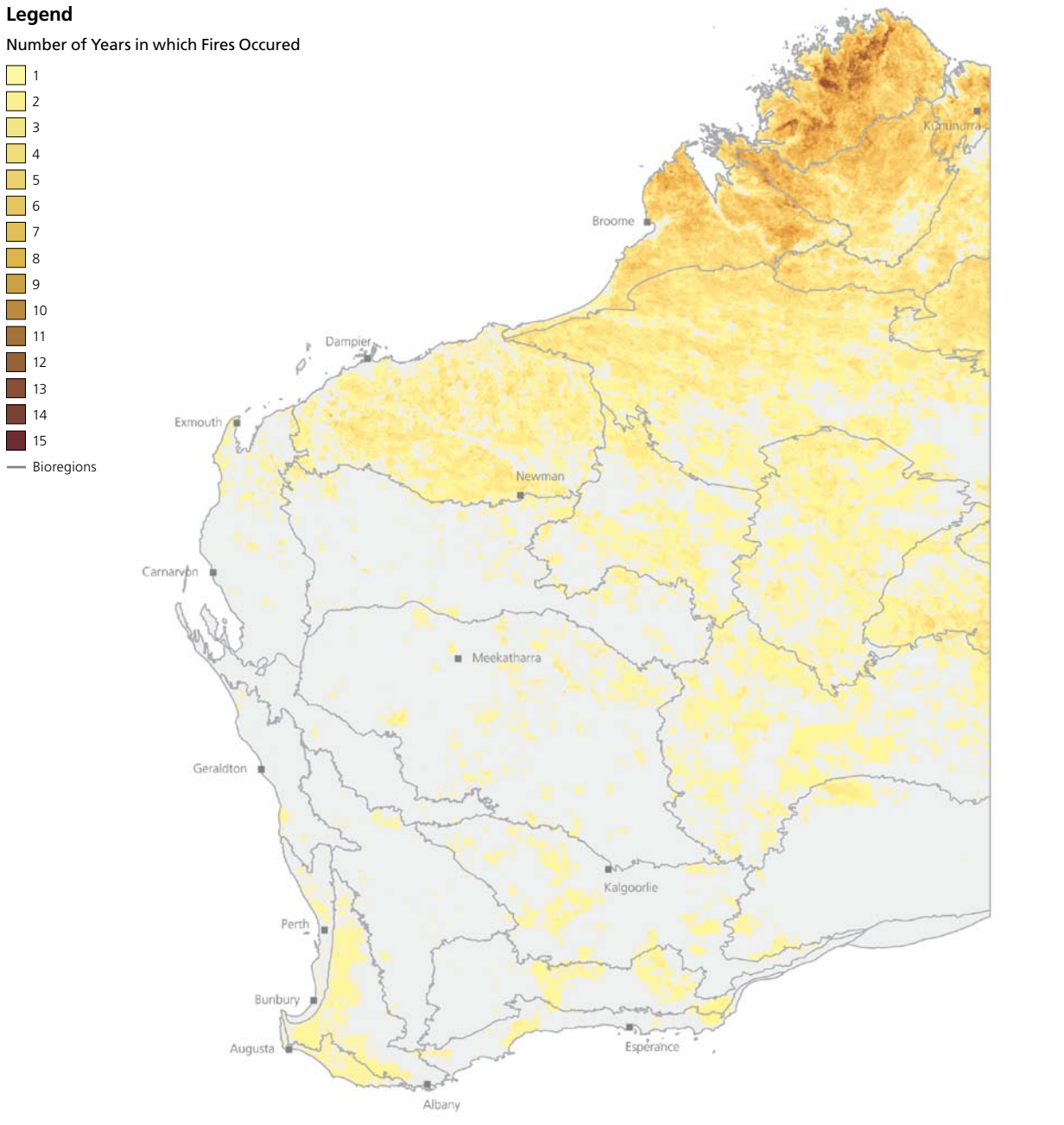


Figure B1.1: Frequency of landscape burning, 1989–2004.

Data source: Department of Land Information – Firewatch data on frequency of fires outside the South West [ver. 2005]; Department of Conservation and Land Management – bushfire and controlled burning years for the South West [ver. 2005]. Analysis: EPA. Presentation: EPA. Note: The frequency of landscape burning ranges from never burnt to burnt every year. It is possible that some areas are burnt more than once in any one-year period, but this is not distinguished in the methodology.



Controlled burn at Caraban State Forest north of Yanchep (L. Sage)

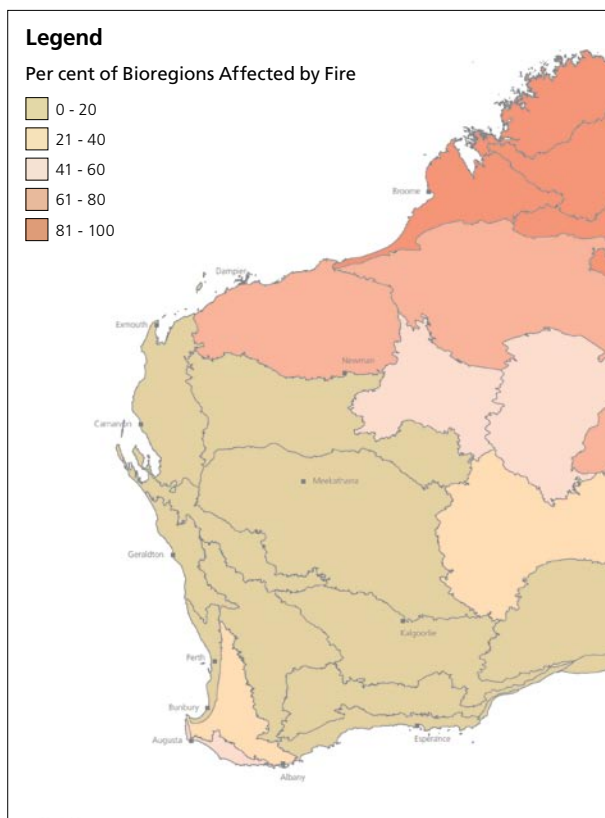


Figure B1.2: Per cent of terrestrial bioregions burnt over a 15-year period, 1989–2004.

Data source: Department of Land Information – Firewatch data on frequency of fires outside the South West [ver. 2005]; Department of Conservation and Land Management – bushfire and controlled burning years for the South West [ver. 2005]. Analysis: Department of Land Information – Firewatch data on frequency of fires outside the South West; EPA - bushfire and controlled burning years for the South West. Presentation: EPA.

Indicator B8: Effects of too much fire.

Changed fire regimes have radically changed the environment by threatening fire-sensitive species and altering floristic patterns and vegetation structure, and hence affecting the fauna that depends on that vegetation. Fire-sensitive plants include Gondwana relicts in high rainfall areas. In addition, many species that are not necessarily fire-sensitive can be burnt too frequently and not effectively recover between fires. Fire-sensitive animals are those that have limited capacity to escape, or to find alternative food sources and shelter if fire temporarily removes habitat.

Examples of ecosystems and species at serious threat from too much fire include:

- vegetation – kwongan vegetation, other heathland vegetation types, Kimberley vine thickets, Swan Coastal Plain communities and Goldfields woodlands and Mulga woodlands;
- birds – noisy scrub bird, western ground parrot, western bristlebird, Carnaby’s black-cockatoo and malleefowl;
- mammals – Gilberts potoroo, heath rat, brush-tailed phascogale, golden bandicoot, scaly-tailed possum, monjon (rock wallaby); and
- invertebrates – Stirling Range trapdoor spider and Kimberley land snails.

The Kimberley is undergoing irreversible changes to biodiversity due to fires that are too frequent, especially impacts to savanna ecosystems. The savanna region is mainly covered by fire-tolerant species, but is interspersed with some fire-sensitive species. These tend to be plants which must set seed instead of being able to reproduce vegetatively, have a maturation period of at least three years, are usually restricted to rugged

sandstone habitats, and form tropical forests and woodlands (Yates & Russell-Smith, 2003). These areas need to be managed to preserve patchiness or mosaic at a landscape level

The Arnhem cyprus pine (*Callitris intratropica*) has a distribution in savanna areas of the Kimberley region, and has been suggested as a useful bio-indicator of changes to fire regimes. This tree species is long-lived, obvious in the landscape, covers a wide range of environments, and remains visible for many years after it has died (Bowman & Panton, 1993; Graham, 2001). The Arnhem cyprus pine is very fire-sensitive at seedling and sapling stage and requires at least 12 years to mature. It has limited seed dispersal from the parent tree, and has short-term seed viability (Graham, 2001). Adult trees are killed by high intensity and frequent fires, but are undamaged by low intensity fires. Surveys between 1998 and 2000 showed that approximately 50% of all Arnhem cyprus pines examined were dead, very few showed signs of re-sprouting, and there were limited numbers of saplings (Graham, 2001). In some areas, up to 100% of the trees were dead, indicating that high intensity and frequent fires are severely impacting this species.

Frequent large, hot, late-season fires can destroy the important mosaic of growth, maturity and species composition across the landscape (T Start, Department of Conservation and Land Management, pers. comm.). One consequence of changes to extent, seasonality and patchiness of fires in the Kimberley is a change of grass species composition from perennials to annuals (Graham & McKenzie, 2004). Frequent wide scale fires apply selection pressure on the landscape, so annual grasses that grow quickly and then die off are at an evolutionary advantage. However, once this trend begins, large areas of dead grass at the end of the dry season provide ample fuel for naturally-occurring or human-induced fires to start and travel long distances. The reduction in abundance of perennial grasses has also had a large impact on trees or woodland plants, and many grain-eating animals such as finches (Graham & McKenzie, 2004).



The blackened landscape after a fire at Mt Cooke in January 2003 (N. Burrows)



Indicator B9: Effects of not enough fire

Fire prompts flowering of some native plant species, and many use ash, heat or smoke as a germination medium for seeds (sometimes known as 'fire-opportunists'). The burning of existing vegetation also allows regeneration from seeds stored in soil. Some plants thought to be extinct or rare have had significant range extensions after a fire, including the many stemmed lily (*Sowerbaea multicaulis*), the showy eremophila (*Eremophila racemosa*), *Calamphoreus inflatus* and *E. veneta* (Yates et al., 2003). Spinifex species are very flammable and are adapted to the patch burning regime used by Aboriginal people. In predominantly urban and agricultural landscapes and some conservation estate and unallocated crown land areas, fires have often become either large-scale burns or have ceased. Animals that have a competitive advantage after a fire are those that can move relatively quickly away from the fire front, and then recolonise an area to take advantage of new shoots, as the vegetation begins to return, or increased availability of prey.

Pressures

Lightning strikes are a common natural ignition source of fires. The North Kimberley has the highest number of lightning strikes in Western Australia (and also Australia), with an average of between 8 and 12 lightning strikes per square kilometre hitting the ground annually (Kuleshov et al., 2006) (Figure B1.3). Electrical storms, common in the Pilbara and Kimberley, can result in the ignition of multiple fires across a vast area at the same time. These fires are particularly difficult to control due to the vast areas of land and their inaccessibility.

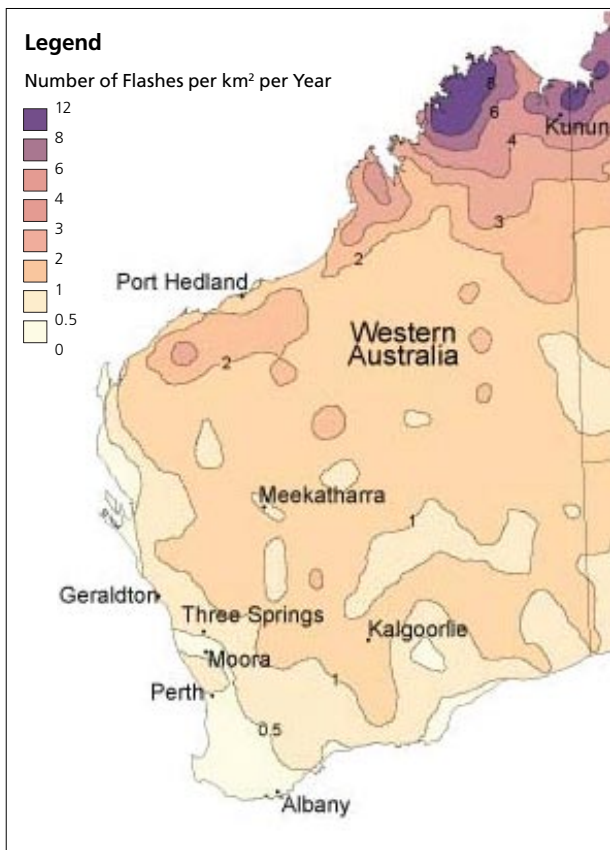


Figure B1.3: Average annual lightning ground flash density.

Data source: Kuleshov et al. (2006). Note: Analysis generated from NASA Optical Transient Detector and Lightning Imaging Sensor data (0.5 degrees grid resolution) averaged over the 8-year period 1995-2002. The satellite data were calibrated against the ground-based Lightning Flash Counter data and adjusted accordingly.

Land holders (such as pastoralists, Aboriginal people and conservation managers in the rangelands) use fire for different reasons. In 2005, 27% of pastoralists undertook a prescribed burn for management purposes (Department of Agriculture, 2005). Fire is often used as a management tool for vast and inaccessible landscapes and can act as a selection pressure for species found in an area. Fire is useful for promoting new growth in plants that is palatable for livestock, but the frequency of burning (especially in the Pilbara and Kimberley regions) is too high for the long term survival of many native species. Aboriginal people also continue to use fire for traditional hunting, cultural or land management reasons. The way in which Aboriginal people burn the landscape has changed over time, with much less of their traditional land being burnt since 1920 than occurred before that time. This is a result of past social policies (the removal of Aboriginal people from the land), and more Aboriginal people having moved into towns (spending less time in their country).

Prescribed burning practices in the South West forest region have caused conflict within government, the general public, and scientific communities. Some advocate use of controlled burns to reduce fuel loads and bushfire intensity, and to protect human life and property. Others contend that prescribed burning does not have a preventative effect for bushfires and has many negative consequences for biodiversity (such as eliminating fire-sensitive species and facilitating the spread of weeds). Prescribed burns are carried out by State Government agencies for land management purposes. Agencies have faced criticism because prescribed burns are a risk to biodiversity. This is comprehensively addressed in two recent EPA reviews (Environmental Protection Authority, 2004 & 2006). The area actually burnt is dependent on climatic and weather conditions and available agency resources (Environmental Protection Authority, 2004).

Current responses

Fire management: The Department of Environment and Conservation conducts a program of controlled burns on land which it manages in order to protect and conserve biodiversity values, human lives and community assets. Controlled burning is undertaken to reduce the occurrence and impacts of large, intense wildfires, and regenerate and protect forest ecosystems following harvesting operations or other disturbances.

Fire fighting: The Fire and Emergency Services Authority, volunteer bushfire brigades and the Department of Environment and Conservation are responsible for responding to fires and attempting to control or extinguish them. Local councils and individual landholders are responsible for maintaining firebreaks.

Environmental Protection Authority fire reviews: In 2004 the EPA undertook a review of the former Department of Conservation and Land Management's controlled burn practices in the South West forest region. A review of fire management in the Kimberley and other rangeland regions was also released for public comment in 2006.

Research: The Department of Environment and Conservation is undertaking research on the effect of fire regimes on species richness and composition in the southern jarrah forest; fire behaviour in dry eucalypt forest; the effect of fire on cave systems, fungi and short range endemic species; the interactions of landscape and fire management; the effects of fire on invertebrate biodiversity. It is also undertaking post-fire monitoring in Nuyts wilderness area (near Walpole). Some research projects are done in collaboration with the Bushfire Cooperative Research Centre. Project Vesta is a collaboration between CSIRO and the Department of

Environment and Conservation to research fire behaviour and management, specifically in dry eucalypt forests. The project is designed to establish the effect of fuel load and structure on fire behaviour and provide insight into long-term effects of prescribed burning on bushfire behaviour.

Cooperative research centres: State agencies, the Department of Environment and Conservation, the Fire and Emergency Services Authority and the University of Western Australia form part of the Bushfire Cooperative Research Centre. This centre provides research to aid management of bushfire risks to the community in an economically and ecologically sustainable way. The Cooperative Research Centre for Tropical Savannas Management includes the CSIRO, Department of Agriculture and the Department of Environment and Conservation, and conducts research on fire management and the effects of fires on vegetation and weed spread.

Firewatch: This program is run by the Department of Land Information through the Leeuwin Centre at CSIRO. It collates satellite imagery to produce accurate and up-to-date information to emergency services, land managers and land holders. It can also be used to compile long-term information such as seasonal and annual data, fire frequency and locations or areas burnt.

Implications

The implications of inappropriate fire regimes are very serious for the environment, society and the economy. Fires that occur too frequently across large areas or at an inappropriate time of year cause loss of habitat and food supply for native species, loss of landscape diversity and degradation problems for land and inland waters. Fires can also exacerbate or cause additional threatening processes to occur such as soil erosion, release of particulates to the atmosphere, weed invasion, eutrophication, salinisation, and also increase the spread of *Phytophthora dieback* through fire fighting operations.

Fires can also result in the release of greenhouse gases and reduce carbon sequestration by plants. Very intense fires which kill mature native vegetation can contribute to long-term ecological change by removing adults and leaving new seedlings vulnerable to climate stressors such as drought. Further loss of species and the simplification of ecosystems are likely if inappropriate fire regimes persist. Changed fire regimes are an emotive issue and causes frequent debate amongst local communities. In urban areas, there is significant effort to reduce the frequency of fires so as to prevent loss of life and damage to housing and associated infrastructure. In agricultural and pastoral areas, fires can cause significant productivity loss and damage to crops, plantations, feedstock, water supplies, farm infrastructure and livestock. The decisions made to protect humans and infrastructure that are made on economic and social grounds have important effects on biodiversity.

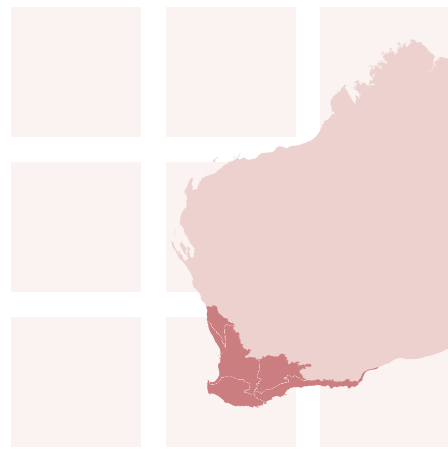
SUGGESTED RESPONSES

- 5.5 Establish a comprehensive condition monitoring program to determine trends in biodiversity as a result of changed fire regimes.
- 5.6 Implement the EPA's *Review of the Fire Policies and Management Practices of the Department of Conservation and Land Management* (now Department of Environment and Conservation).
- 5.7 Implement the recommendations of the EPA's *Fire Management of the Kimberley and Other Rangeland Regions of Western Australia*.



Department of Environment and Conservation attending to a fire (Department of Environment and Conservation)





INDICATIVE EXTENT OF ISSUE

PRIORITY RATING: 2

KEY FINDINGS

- Loss and degradation of native vegetation continues to negatively affect biodiversity in WA.
- The agricultural Wheatbelt zone is the most highly cleared area in WA due to past land clearing. Some local government areas have less than 5% of original native vegetation remaining.
- Nearly 900 ha of native vegetation was cleared each year in the Perth metropolitan region (equivalent to more than 1 football oval per day) between 1998 and 2004.
- About 7000 and 8000 hectares were approved for clearing in 2005 and 2006 respectively under the clearing provisions of the *Environmental Protection Act 1986* (which equates to about 10 football ovals per day).
- There is a need for a consolidated and accurate record of the total amount of native vegetation being cleared in WA every year.

Description

Removal of native vegetation, both historic and current, is a major threatening process affecting biodiversity in WA. It includes the traditional concept of clearing, but also involves other substantial damage to native vegetation (e.g. burning, overgrazing and draining or flooding of land) which results in the removal of at least some native vegetation, and can result in degradation or loss of whole ecosystems. The loss of habitat area through clearing is currently the primary cause of declines in species and populations worldwide (Millennium Ecosystem Assessment, 2005).

Historic clearing commenced with the arrival of Europeans and settlement in WA. A strong development culture and aggressive agricultural expansion resulted in broadscale clearing of vast areas of the South West between 1945 and 1982 (Commonwealth of Australia, 2000). During the 1960s, 'a million acres a year' was released for agriculture, much of it in areas prone to land salinisation. Clearing rates slowed significantly in the 1970s, but widespread recognition of

the growing salinity problem did not occur until the 1980s, when clearing controls were enforced. Broadscale clearing for intensive agriculture has now largely ceased, but it has left a legacy of environmental problems. Widespread clearing has also occurred along coastal zones of the South West, in particular the Perth metropolitan area, to accommodate a growing population and developing industries. Although clearing for cropping and grazing is generally not allowed in the rangelands, clearing for agriculture has occurred in the Ord River Irrigation Scheme and Fitzroy River catchments. Native vegetation in some pastoral areas is also under pressure from overgrazing (including pastoral livestock, introduced and native animals) and frequent extensive fires. More recently, most clearing occurs in small pockets of the South West for urban development and in other regional locations for mining. Clearing of native vegetation across the State is now regulated under the *Environmental Protection Act 1986* unless exemptions apply.

Removal of large areas of native vegetation fragments the landscape, leaving behind small and unconnected remnants. Many flora, fauna and communities are threatened, often resulting in diminished biodiversity and extinctions in some areas. Clearing in the South West has resulted in other environmental issues including salinisation of land and inland waters, enhanced spread of weed species and exacerbated soil erosion, and has also contributed to reduced carbon stores of greenhouse gases. It is also believed that broadscale clearing in the South West may be responsible for reduced rainfall in cleared areas (due to a change in the land's surface and a reduced ability to form moisture-carrying clouds) (Lyons, 2002).

Objectives

- Minimising the impacts of loss and degradation of native vegetation on biodiversity.
- Protecting or conserving native vegetation remnants that are important for biodiversity reasons or to prevent further land and inland water degradation.
- Prohibiting further clearing of areas that have already been extensively cleared.

Condition

Indicator B10: Percentage of native vegetation remaining in subregions and local government areas.

Many Western Australian terrestrial subregions have a high percentage of their native vegetation remaining (i.e. 41 of the 54 terrestrial subregions have 96% or more remaining), with most in the rangelands (Figure B0.1). The most extensively cleared subregions in WA are both the Avon Wheatbelt (AW2 and AW1), the Dandaragan Plateau (SWA1), the Western Mallee (MAL2), the Lesueur Sandplain (GS2), the Swan Coastal Plain (SWA2), Geraldton Hills (GS1) and the Recherche (ESP2) subregions (Table B2.1). These areas have diminished biodiversity and have a higher proportion of threatened flora and ecological communities (Table

B2.1). Vegetation types that inhabit valley floors and lower slopes in the landscape are more than 90% cleared in the agricultural Wheatbelt zone, and comprise about one-third of all vegetation types in the Avon Wheatbelt and Western Mallee subregions (McKenzie et al., 2003). After broadscale clearing for agriculture, the whole agricultural Wheatbelt zone (including upper catchment areas) retains only 7% of its native vegetated area (Beecham, 2004). The Perth subregion (SWA2) (bound by Jurien Bay, Dunsborough and the Darling Scarp) contains 42% of the known threatened ecological communities, and this is certainly due to the clearing and fragmentation of native vegetation, but may also be influenced by a disproportionately high number of research studies in the area.

Table B2.1: Subregions with more than 50% of native vegetation cleared, and percentages of Declared Rare Flora and Threatened Ecological Communities.

Subregion name	Per cent native vegetation remaining in 2006	Per cent of total Declared Rare Flora found in subregion	Per cent of total Threatened Ecological Communities found in subregion
Avon Wheatbelt 2 (AW2)	8.6%	17.2%	3.0%
Avon Wheatbelt 1 (AW1)	18.6%	20.3%	10.6%
Dandaragan Plateau (SWA1)	28.9%	4.2%	3.0%
Western Mallee (MAL2)	32.8%	9.2%	3.0%
Lesueur Sandplain (GS2)	40.9%	13.2%	9.1%
Perth (SWA2)	41.2%	12.9%	42.4%
Geraldton Hills (GS1)	43.0%	6.1%	1.5%
Recherche (ESP2)	48.0%	2.4%	0.0%

Data source: Department of Conservation and Land Management [ver. 2006] - percentage native vegetation remaining; Department of Environment and Conservation [ver. Feb 2007] - declared rare flora; Department of Conservation and Land Management [ver. Jan 2004] - threatened ecological communities (no further communities have been endorsed since this time).

Some local government areas in the Wheatbelt retain very small amounts of native vegetation (Table B2.2). This is a good gauge of the present and future loss of biodiversity (and other environmental problems), but it does not represent the current areas of concern for ongoing loss of native

vegetation (namely areas subject to urban development and mining). Further, 33 (40%) of the 83 non-metropolitan local governments in the South West have less than 15% vegetation remaining (Shepherd et al., 2001).

Table B2.2: Top 10 most cleared local government areas in the South West.

	Local government area	Per cent native vegetation remaining in 2001
1	Cunderdin	1.8%
2	Quairading	3.6%
3	Dowerin	4.3%
4	Goomalling	4.6%
5	Corrigin	4.9%
5	Wyalkatchem	4.9%
7	Wongan-Ballidu	5.2%
8	Tammin	5.5%
9	Mingenew	6.6%
10	Bruce Rock	7.1%

Source: Shepherd et al. (2001).



Indicator B11: Rate of loss of in native vegetation cover over time.

The change in native vegetation cover for the Perth metropolitan region has been assessed for the period 1998 to 2004 (Figure B2.1). Large areas in outer Perth suburbs have been cleared. Between 1998 and 2004 a total of 5974 ha were cleared in the Perth metropolitan region - an average rate of 853 ha per year. 1998 and 2004 a total of 5974 ha were cleared in the Perth metropolitan region - an average rate of 853 ha per year (Western Australian Local Government Association Perth Biodiversity Project, unpublished data, 2007). Two-thirds of the total area cleared has occurred since 2001, with an average rate of nearly 1000 ha per year between 2001 and 2004. Over 2% of the total native vegetation that was present in 1998 was cleared by the end of 2004. This is over one football oval per day being cleared in the Perth metropolitan region. The total area of native vegetation within the Perth metropolitan region includes large areas of State Forest, national parks

and other vegetated areas in the Darling Scarp, and it is clear that the vegetation of the Swan Coastal Plain suffered the most clearing. The rate of clearing in Perth is likely to have continued (or possibly accelerated) with the economic boom and increased demand for housing in the past 3 years.

It should be noted that there are limitations of 2001 and 2004 data, including

- the preferential mapping of landscapes with trees, leading to some mapping of areas that are parkland (but basically cleared of native vegetation) or completely degraded;
- the inclusion of areas that are approved for clearing through development approvals and/or clearing permits;
- some areas have been cleared since the time of the aerial photography; and
- Carnac, Penguin, Garden and Rottne Islands, Kings Park and the Wilbinga extension to the Perth Metropolitan Region Scheme are not included in these data.

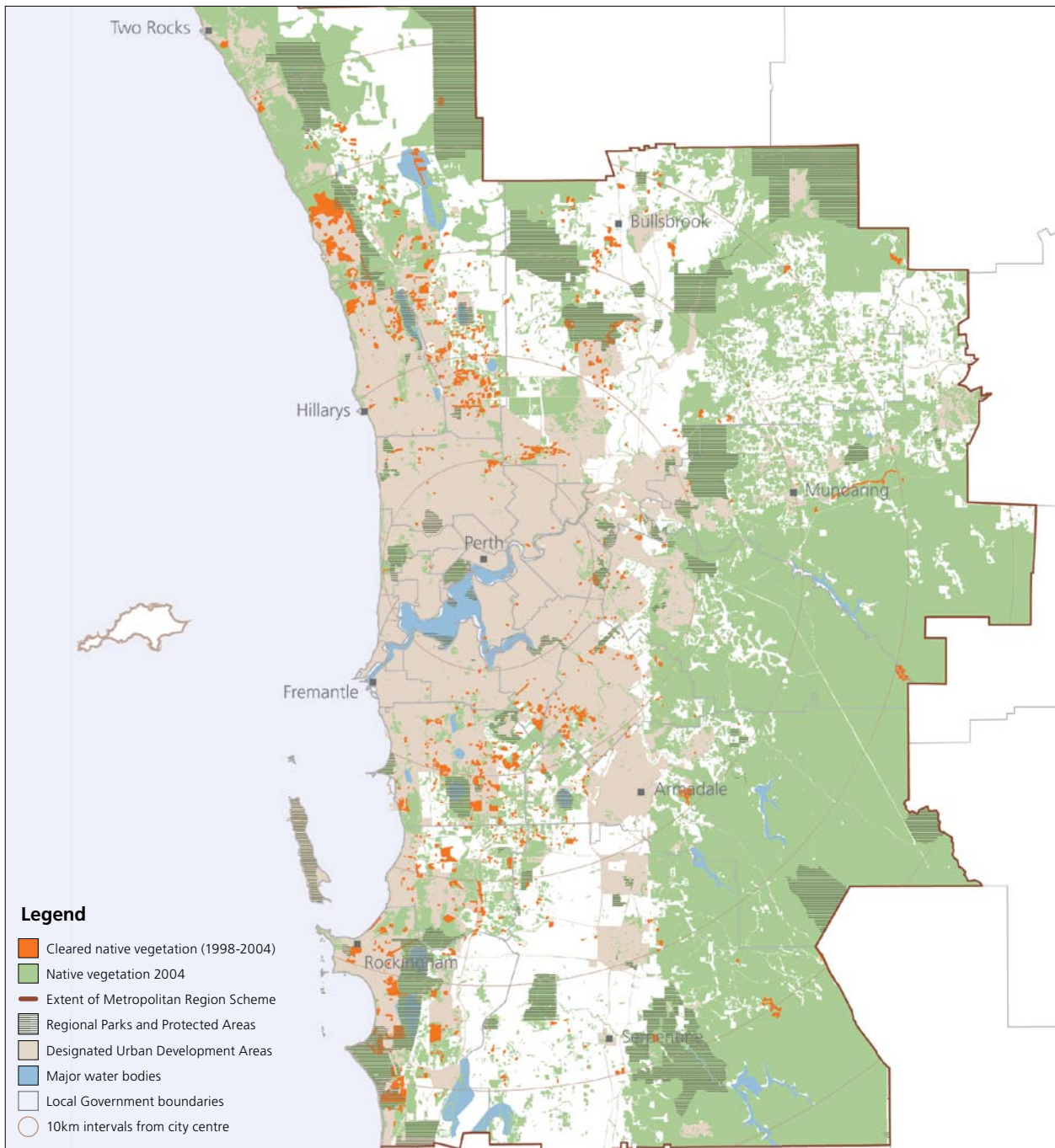


Figure B2.1: Clearing in the Perth metropolitan region, 1998–2004.

Data source: Department of Agriculture and Food [ver. 2007]. Data analysis: Department of Agriculture and Food and EPA; Presentation: EPA. Note: Carnac, Penguin, Garden and Rottne Islands, Kings Park and the Wilbinga extension to the Perth Metropolitan Region Scheme are not included in these data.

Most recent clearing between 2001 and 2004 was concentrated in the outer Perth suburbs. The cities of Wanneroo and Rockingham have the highest areas of native vegetation cleared (over 1100 and 800 ha respectively) as a result of housing and infrastructure development (Table

B2.3). Similarly, the cities of Joondalup and Bayswater have undergone the largest percentage decreases (17% and 12% respectively) in the area of native vegetation remaining over this timeframe (Table B2.3).

Table B2.3: Top 10 local governments by area of land cleared (total number of hectares and percentage of remaining vegetation), 2001-04.

	Local government area	Total number of hectares	Annual clearing rate from 2001–04 (ha/year)	Local government area	Total per cent change	Annual per cent clearing rate from 2001–04 (%/year)
1	Wanneroo	-1158	-296.5	Joondalup	-16.9%	-4.23%
2	Rockingham	-805	-289.5	South Perth ^a	-12.7%	-3.18%
3	Swan	-529	-132.3	Bayswater	-11.9%	-2.98%
4	Cockburn	-445	-111.3	Stirling	-11.3%	-2.83%
5	Joondalup	-272	-68.0	Canning	-10.7%	-2.68%
6	Kwinana	-223	-55.8	Rockingham	-10.5%	-2.63%
7	Mundaring	-122	-30.5	Cockburn	-9.7%	-2.43%
8	Gosnells	-102	-25.5	Belmont	-7%	-1.75%
9	Armadale	-95	-23.8	Kwinana	-4.6%	-1.15%
10	Stirling	-78	-19.5	Gosnells	-2.7%	-0.68%

Data source: Western Australian Local Government Association Perth Biodiversity Project unpublished data [ver. 2007], based on data provided by the Department of Agriculture and Food [ver. 2006]. (a) City of South Perth results are likely to have been due to differences in mapping of vegetation in the two time periods.

Two local governments (towns of Bassendean and Cambridge) slightly increased the amounts of vegetation found in their areas, probably as a result of replanting and/or landscaping works. Some local governments have very small areas of native vegetation remaining (e.g. South Perth), and so changes in vegetation were probably due to methodology rather than loss of native vegetation. Local governments with less than 20 ha of native vegetation remaining and excluded from this analysis were Claremont, East Fremantle, Fremantle, Mosman Park, Peppermint Grove, Perth, Subiaco, Victoria Park and Vincent. The amount of legal or long term protection given to remnants of native vegetation varies according to local government area and land tenure. The condition on native vegetation was not addressed in these data sets (Western Australian Local Government Association Perth Biodiversity Project, unpublished data, 2007).

Broad vegetation change in the South West can be assessed through the Land Monitor program, but it is not possible to

accurately distinguish native vegetation from other vegetation (such as orchards and plantations), or vegetation removal as a result of bushfires. Loss or degradation of vegetation cover appears to be continuing across the South West, which may be attributed to the effects of a drying climate (and therefore less vegetation cover or tree foliage) (Figure B2.2). Loss in the eastern agricultural Wheatbelt areas (east of Katanning) may be attributed to fires, with much of this vegetation likely to regrow over time. Agricultural Wheatbelt areas may be losing vegetation cover (or perhaps tree foliage) due to the effects of land salinisation. In coastal South West areas, loss of vegetation cover is likely to have been caused by direct clearing for urban development, expanding agriculture, harvesting of plantations, or the effects of *Phytophthora dieback*. Further investigation is required to explain the loss of vegetation cover in these areas.



Clearing of land for the Brighton subdivision in the northern coastal corridor of Perth (Department of Environment and Conservation)

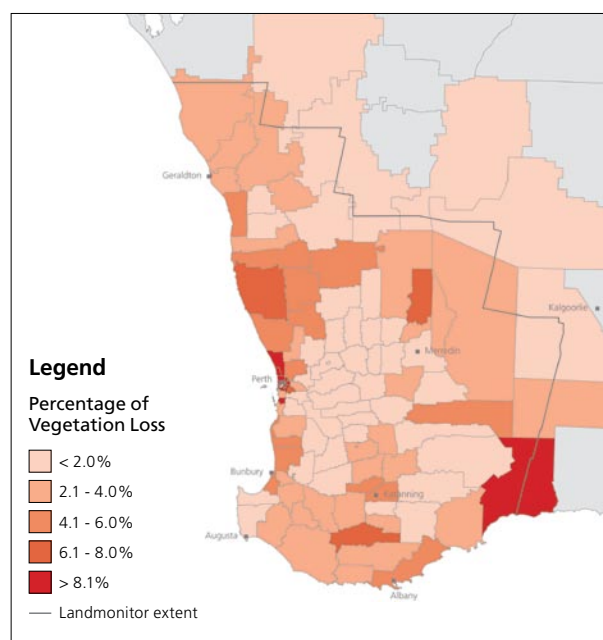
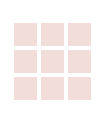


Figure B2.2: Vegetation loss or decline in the South West by local government area, 1996-2004.

Data source: Department of Land Information – Land Monitor [ver. 2004]; Analysis: EPA; Presentation: EPA



Indicator B12: Change in rangeland native vegetation density or perennial grass frequency.

Monitoring results from the Western Australian Rangeland Monitoring System were analysed at the bioregional scale to determine change in vegetation condition, i.e. shrub density or perennial grass frequency (Figure B2.3). Change was determined by comparing data for the most recent sampling period (1999–2004) with that of the period 1993–2002. A majority of sites in bioregions showed stable or improving vegetation cover over the past decade (Figure B2.3). Only a few

bioregions in the Murchison and Pilbara showed a majority of sites with declining vegetation density or frequency. While these areas recently experienced a prolonged drought, there are also indications that inappropriate grazing management has contributed to the decrease (Department of Agriculture, unpublished). Overgrazing, a form of indirect clearing, can be caused by a variety of animals including domestic stock (cattle, sheep and goats), native animals (kangaroos) and introduced animals (camels, donkeys, horses, pigs, feral cattle, feral goats, rabbits).

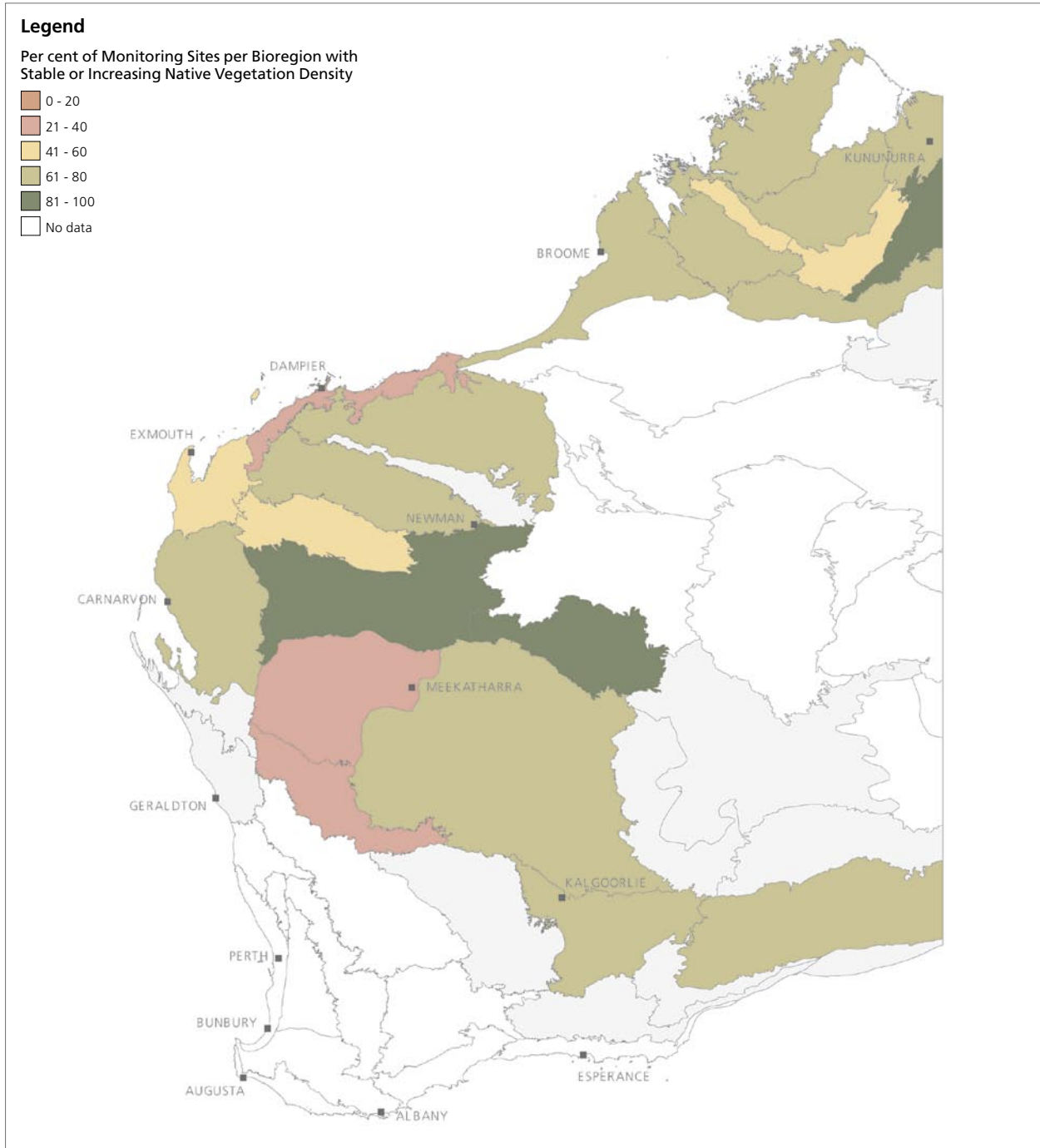


Figure B2.3: Change in native shrub density and perennial grass frequency at Western Australian rangeland monitoring sites, by bioregion.

Data source: Department of Agriculture – WARMS [ver. 2005]; Analysis: EPA; Presentation: EPA.

Indicator B13: Change in rangeland perennial plant species richness.

Patterns of richness of native perennial species, revealed by similar analysis of monitoring system data, are quite different (Figure B2.4). The Kimberley bioregions have declining richness (loss of biodiversity), but most other areas show stable or increasing richness. It is believed that perennial

tussock grasses in the Kimberley, although still common and widespread, have been replaced in many areas by annual grasses as a result of heavy grazing and changed fire regimes (Start, n.d.). As a result of grazing activity, threatened ecological communities have been declared in the rangelands, including themeda grasslands (at Hamersley Station in the Pilbara) and many Kimberley mound springs.

Legend

Per cent of Monitoring Sites per Bioregion with Stable or Improving Native Perennial Species Richness

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- No data

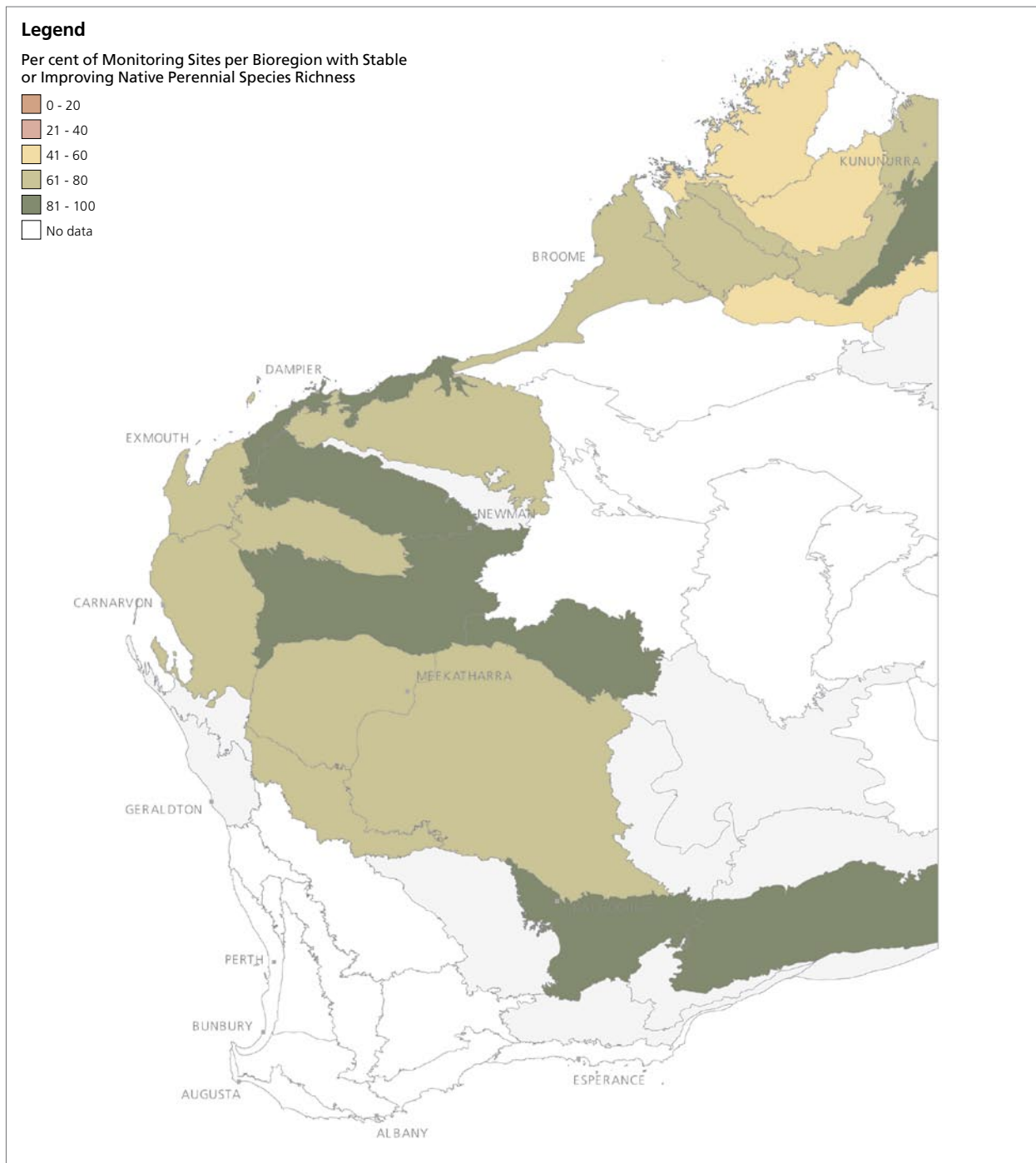


Figure B2.4: Per cent of monitoring sites showing stable or improving species richness of native perennials at Western Australia rangeland monitoring sites, displayed at terrestrial subregion scale.

Data source: Department of Agriculture – WARMS [ver. 2005]; Analysis: EPA; Presentation: EPA.

Pressures

Historically, widespread clearing occurred for development of intensive agriculture in the South West, namely sheep and wheat farming. Since the 1980s agricultural expansion has slowed and clearing controls have been enforced. Recent expansion of the wine and plantation industries has renewed clearing activity in small pockets of the South West.

Population increases result in increased housing demand, and consumption patterns show that West Australians have a preference for larger houses and fewer people per household compared to other parts of the world (see '*Settlement patterns*'). This results in large land areas being needed to accommodate urban centres and consequent clearing of native vegetation and farmland for housing. Urban expansion has increased dramatically around Perth and other major coastal regional centres in the South West. The urban area of Perth has doubled since the 1970s and this has resulted in clearing

of large areas of native vegetation, fragmentation of remaining areas and leads to the loss of species and ecosystems. Vegetation communities of the Swan Coastal Plain are highly represented on the list of threatened ecological communities, although this is in part due to the more extensive research in this area and it's under representation in the conservation reserve system. Continued loss of native vegetation in the Perth metropolitan region is forecast as many areas have been zoned urban in the planning system but have not yet been developed (see '*Settlement patterns*').

Outside the South West, mining activity is the primary reason for vegetation clearing. The current resources boom has accelerated clearing of native vegetation in the rangelands but the proportion of land impacted is relatively small. In many cases mining companies are required to undertake land rehabilitation and revegetation upon completion of extraction activities. This sector's growth is projected to continue into the foreseeable future.

Indicator B14: Rate of approval of native vegetation clearing.

Comprehensive statistics on the rate of clearing of native vegetation are difficult to obtain and there are major challenges in accurately representing the data. Since July 2004, clearing regulations under the *Environmental Protection Act 1986* have enabled comprehensive records to be kept of all applications approved and refused to clear native vegetation. Prior to the clearing provisions, a system of 'notice of intent' to clear applied under the *Soil and Land Conservation Act 1945*. These figures do not give accurate clearing statistics, but rather an indication of the trend in clearing proposals (Figure B2.5).

Prior to the change in native vegetation clearing regulations in 2004, both the number of notices and the approved area to clear for agricultural purposes were generally in decline. It is interesting to note the area approved to clear without objection in the late 1980s was more than 30 000 hectares per year (and as high as 62 000 ha in 1988-89), and this had declined to around 1000 ha by the early 2000s (Figure B2.5). The *Soil and Land Regulations 1992* were introduced and then a memorandum of understanding was made in 1997 between state agencies, both of which resulted in significant decreases in area clearing notified for agriculture (Figure B2.5). However, there was a sharp increase in the number of notices of intent to clear in 2003-04, when introduction of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* was imminent.

Notices of intent to clear for mining purposes ranged from 2880 to 30 442 ha annually between 1998-99 and 2003-04, but these statistics are not reliable. Additionally, many areas previously cleared for mining have been rehabilitated and revegetated.

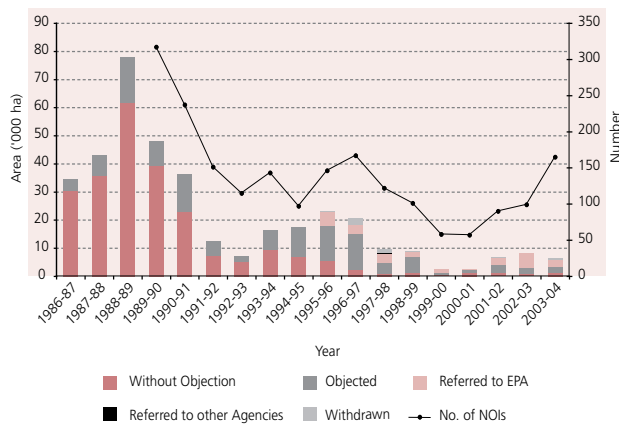


Figure B2.5: Number of notices of intent to clear for agriculture purposes, and area involved, 1986-2004.

Data source: Department of Agriculture [ver. 2005]. Presentation: EPA.

Statistics on clearing applications improved significantly after introduction of regulations in 2004 (which operated under the *Environmental Protection Act 1986*) (Figure B2.6). During 2005 and 2006, applications were made to clear approximately 15 000 ha of vegetation each year. Of this, a total of 7058 ha were approved for clearing under this legislation in 2005, and 8030 ha in 2006. This equates to about 10 football ovals per day approved to clear in 2005, and 11 per day in 2006. These figures cannot be directly compared to data from the notice of intent process. The year 2004 is excluded because it does not include a full year of data. Mining and other extractive industries still represent the primary reason for clearing approvals under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. The new clearing provisions are far more comprehensive in the assessment processes for granting

or refusing applications than the previous notices of intent to clear process. However, the statistics do not consider clearing approvals granted through the Environmental Protection Authority's environmental impact assessment process, especially for large mining proposals or projects with significant environmental impacts. Therefore it is not possible to provide the total rate (or area) of native vegetation approved for clearing in WA. Unauthorised (illegal) clearing continues to occur, although the scale of this problem remains unknown.

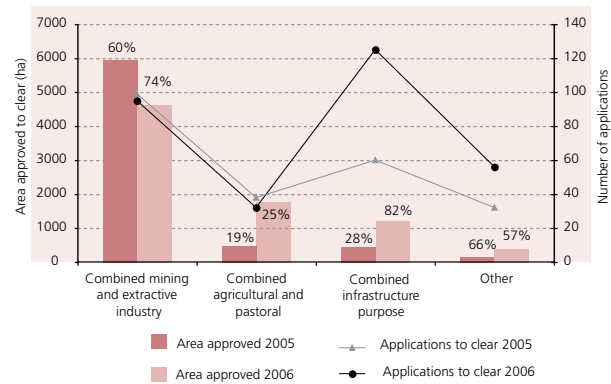


Figure B2.6: Number of applications and area approved for clearing under the 2004 clearing regulations, by activity type, 2005-06.

Data source: Department of Environment and Conservation [ver. 2007]. Analysis: EPA. Note: Data for calendar year 2004 is not included because it was for Aug to Dec of that year only (Environmental Protection (Clearing of Native Vegetation) Regulations 2004 came into effect in June 2004). Percentages on graphs show the proportion of total applications were approved. These data are for areas formally approved for clearing only, they do not include applications that were declined, refused or withdrawn.

Current responses

Legislation and policy: Legislation and policy direction has proven an effective means of influencing the clearing rate. *The Environmental Protection (Clearing of Native Vegetation) Regulations 2004* were gazetted on 30 June 2004 and clearing provisions of the *Environmental Protection Act 1986* commenced on 8 July 2004.

All clearing of native vegetation now requires a permit (unless an exemption applies) and the principles in Schedule 6 of the *Environmental Protection Act 1986* allow proposals to be assessed so that land, water quality and biodiversity values are taken into account. Clearing is administered by the Department of Environment and Conservation with a delegation of clearing for mining and petroleum under the *Mining Act 1978* and various Petroleum Acts to the Department of Industry and Resources.

Natural Heritage Trust/National Action Plan for Salinity and Water Quality (NHT/NAP): These are two Commonwealth Government programs that aim to ensure environmental (on-ground) improvements occur via a targeted strategic approach at the regional level. This covers a wide range of actions aimed at progressively limiting clearing and preventing further loss of species and ecosystems, and limiting degradation of land and water.

Revegetation groups: There are many government programs and non-government organisations which focus on revegetation, rehabilitation of areas that have already been cleared, and preventing further degradation of remaining bushland by landscape-level threats such as salinity and soil erosion. Programs include the Greening Challenge (Department of Agriculture), Landcare and Greening Australia (non-government organisations).

Off-reserve conservation: There are many programs focused on preventing further clearing of bushland, and in some cases these assist with management of land that is not in the formal conservation reserve (see 'Conservation'). Examples include Bushland Benefits, Bush Forever, Roadside Conservation Committee initiatives, Nature Conservation Covenant Program, Land for Wildlife, Urban Nature, biodiversity incentives administered by Department of Environment and Conservation, Gondwana Link, and the Threatened Species Network and Woodland Watch (WWF).

Planning: Many planning and policy instruments are designed to minimise clearing in the metropolitan area of Perth, and provide protection for remnant bushland. Examples include Bush Forever, Coastal Planning and Network City. Bush Forever has recently expanded from areas around Perth to include surveys and protection of remnant bushland on the northern and southern parts of the plain.

Biodiversity Conservation Strategy: The Department of Environment and Conservation has released *A 100-year Biodiversity Conservation Strategy for Western Australia: Blueprint to the Bicentenary in 2029* for public comment. A final biodiversity conservation strategy is in preparation (Department of Environment and Conservation 2006a).

Local government: The Perth Biodiversity Project is a partnership project between 30 local governments, the Western Australian Local Government Association, the Swan Catchment Council, Department of Environment and Conservation, the Department for Planning and Infrastructure and Greening Australia WA. Local Governments participating in the Project are encouraged to become more involved in bushcare and biodiversity conservation (Western Australian Local Government Association, n.d.). The *Local Government Biodiversity Planning Guidelines* were released in 2004 to describe a consistent, staged process that can be used by local government to prepare local biodiversity strategies (Del Marco et al., 2004). The process encourages biodiversity targets and criteria to be set, enabling local governments to identify biodiversity values and integrate biodiversity conservation into their planning and decision making processes.

Implications

Removal of native vegetation has obvious environmental implications, but it also has significant social and economic implications. In some parts of WA (especially the Wheatbelt and parts of the Swan Coastal Plain) native vegetation has been cleared beyond safe ecological limits. Continued clearing will result in loss of biodiversity and extinctions, with fragmented habitats becoming more susceptible to climate change, disease, and weed and introduced animal invasion. Salinisation of land and inland waters, altered water regimes, soil erosion, eutrophication and increased greenhouse gas emissions are all direct consequences of clearing native vegetation. Benefits of retaining native vegetation include cultural benefits (i.e. 'sense of place' and recreational value) and ecosystem services (e.g. pollination, maintenance of local climates, healthy land and waterways, sequestration of greenhouse gases) that underpin the economy and society. Consequently everyone has a role in preventing further clearing and protecting existing native vegetation remnants, not just landholders.

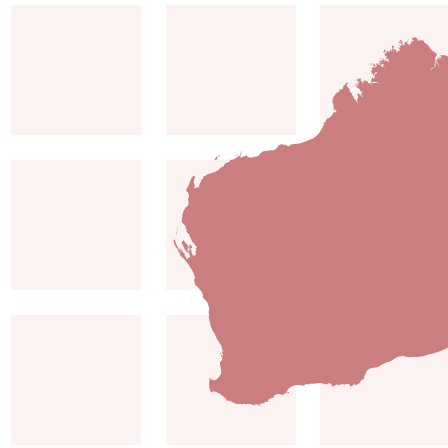
SUGGESTED RESPONSES

- 5.8. Prohibit clearing in local government areas with less than 15% native vegetation remaining and prohibit further clearing of vegetation types that are found to be at less than 10% of their pre-European extent.
- 5.9. Develop and implement a policy of 'no net loss' of native vegetation due to land use that comprehensively considers biodiversity values in clearing applications.
- 5.10. Establish a central database to make information on all clearing activities (including environmental impact assessment) publicly available.
- 5.11. Carefully monitor for illegal clearing and breaches of conditions set under the *Environmental Protection Act 1986* and take appropriate action should they occur.



Clearing of native vegetation for a new plantation near Bridgetown (Department of Agriculture and Food)





INDICATIVE EXTENT OF ISSUE

PRIORITY RATING: 1

KEY FINDINGS

- The distribution and abundance of cats and pigs increased between 2000 and 2005.
- The population of camels in the central deserts of WA is large and rapidly increasing.
- There is a need for enhanced monitoring to determine the extent and density of introduced animal species in WA.
- Western Shield, a predator control program, has been credited with bringing at least 13 native fauna species back from the brink of extinction.
- To date, quarantine and preventative procedures have been successful in excluding some invasive species present in other Australian states (e.g. cane toads, Indian mynas, red-eared slider turtles and red imported fire ants).

Description

Many terms are used to describe introduced and native animals (Table B3.1). There are many types of animals introduced in WA, including different groups - birds, mammals, reptiles, amphibians, fish, crustaceans, molluscs, worms and insects.

Introduced animals that become established in Australia generally have a number of characteristics that allow them to survive and spread. These include having a similar climate between their native geographic range and their introduced location, a history of establishing invasive populations elsewhere in the world, a high reproductive rate, a generalist diet and an ability to live in modified landscapes (Hart & Bomford, 2006).

Introduced species are a global problem, and ranked second only to habitat change and loss of global biodiversity (Millennium Ecosystem Assessment, 2005). Animals have been introduced to WA for various reasons.

- Animals introduced as livestock, pets or pollinators (e.g. pigs, horses, cattle, deer, camels, donkeys, goats, honeybees, dogs and cats).

Table B3.1: Common terms used to describe animals.

Term	Meaning
Introduced	A general term to describe animals that are not native to WA. Some introduced animals are not native to WA (e.g. foxes, black rats and rabbits), but others native to other parts of Australia are introduced in WA (e.g. kookaburras).
Invasive	The ability to spread beyond the introduction or colonisation site, and to compete with native species to gain resources. Not all introduced species are invasive if there are controls on spread or competitiveness.
Feral	A formerly domesticated animal which has become wild or no longer lives in association with people. These animals originate mainly as livestock, working animals and pets.
Pest	Any animal that has a negative effect on human or economic activities. They can include both introduced and native species (e.g. kangaroos and emus are native animals but are sometimes considered pests).
Exotic	An animal occurring in a place that it is not native to.
Native	Species that occurred in an area before European colonisation.
Endemic	Species that are restricted in range to a particular area and do not occur elsewhere (scales can be local, regional or continental).

- Animals introduced for hunting, fishing or ornamental purposes (e.g. pigs, deer, rabbits, redfin perch, trout, carp, yabbies, rainbow lorikeets, ring-necked pheasants, doves, red-browed waxbills, white swans, sulphur-crested cockatoos, eastern long-billed corellas, Indian ring-necked parrots).
- Animals introduced as biological controls of other animals (e.g. cats and mosquito fish).
- Animals accidentally introduced through transport networks (e.g. rats, mice, tree sparrows, house crows, European wasps (*Vespula germanica*), coastal brown ants (*Pheidole megacephala*), Argentine ants (*Linepithema humile*) and Portuguese millipedes (*Ommatoiulus moreleti*).
- Invasive animals that have migrated from other parts of Australia (e.g. foxes, rabbits and starlings, cane toads).
- Animals that have been deliberately smuggled into WA for food or as exotic pets (e.g. edible snails and red-eared slider turtles).

Introduced animals cause environmental impacts because natural ecological constraints on them (such as predation, competition from other species, diseases and parasites) are often absent. If not adequately managed or quarantined, introduced animals have the potential to escape into the environment and breed if environmental conditions are favourable. Many are an environmental problem because they can compete with native animals for food and habitat; predate on native animals; destroy or degrade habitats; overgraze; carry and spread harmful diseases and parasites; and can inter-breed with native species producing hybrid animals. Some introduced animals are considered problems for human health (e.g. they carry diseases or are toxic) and some are considered pests to the agricultural, pastoral, plantation and construction industries.

Objectives

- To conserve WA's biodiversity by managing and reducing the impacts of introduced animals and by preventing further introductions and spread.

Condition

Indicator B15: Number of introduced animals by bioregion.

There is limited data for introduced animals in WA, but reliable information exists for introduced mammals at a large scale (Figure B3.1). The highly populated areas of the Swan Coastal Plain have the most introduced mammals, while forested areas of the South West, the northern agricultural area, the Gascoyne–Murchison, the Carnarvon basin and the Pilbara also have a high count of introduced mammals. There is corresponding evidence that native mammals have undergone significant range contractions (especially the Carnarvon Basin and the Jarrah Forest bioregions), and significantly reduced native mammal diversity in arid and semi-arid regions (especially Yalgoo and Nullarbor bioregions) (Commonwealth of Australia, 2002). There are comparatively fewer introduced mammal species in the central deserts and Kimberley, where climatic factors and remoteness may help limit the spread of introduced mammals. There are no bioregions in WA with less than four identified introduced mammals.



Feral cat (Department of Environment and Conservation)



Fox (Department of Environment and Conservation)



House mouse (Department of Environment and Conservation)



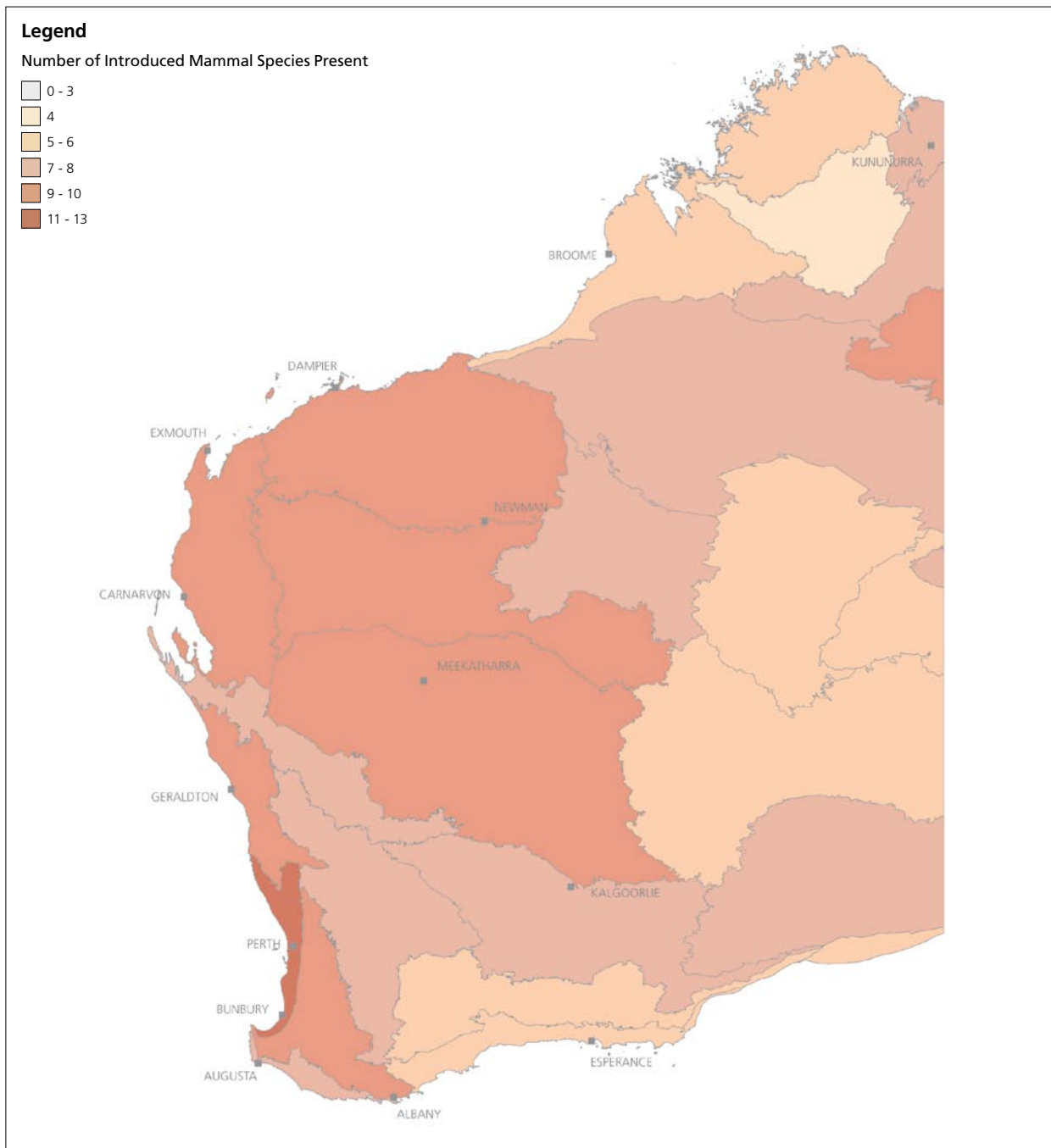


Figure B3.1: Number of introduced mammal species found in each terrestrial bioregion.

Data source: Department of Conservation and Land Management [ver. 2005]. Analysis: Department of Conservation and Land Management. Presentation: EPA.

Indicator B16: Level of impact of introduced animals.

Some surveys for agricultural and pastoral animal pests have been undertaken to determine the approximate distribution and density across WA (Figure B3.2). The effects of introduced herbivores in the rangelands are often associated with overgrazing and land degradation. Large herbivores in particular (especially camels, horses and donkeys) have serious detrimental effects in arid and semi-arid environments (causing soil erosion, disturbing wetlands, eating vegetation). It was estimated that there were 238 000 feral camels in WA in 2005 (Ward et al., 2005). The density of camels was about 5 times higher in desert regions than in the pastoral zone in inland WA (0.23/km² compared to 0.05/km²) (Ward et al., 2005). Camel densities in the Little Sandy Desert region were an average of 0.26/km², with lower densities at an adjoining pastoral station (Ward et al., 2006). The camel population of central Australia is thought to be increasing at approximately 10% per year and doubling every eight years (Edwards et al., 2004). The number of donkeys in the Kimberley was very

high in the past, but control measures have now reduced the population to near eradication (Department of Agriculture and Food, 2006b). The number of donkeys in the Pilbara and desert regions remains of concern.

Goats are most abundant in the Mid West and are causing considerable environmental damage, especially as they are becoming popular as livestock in this area. Surveys in 1987 and 1990 showed that goat populations were increasing by 18% per annum in WA even though commercial harvesting was occurring (Southwell & Pickles, 1993). Wild pigs are a problem in the South West forested areas, near Geraldton, and are particularly abundant and increasing in the Kimberley. At present, no control program for pigs is currently in place in the Kimberley although pigs are culled opportunistically in areas where the donkey eradication program is in progress (Department of Agriculture and Food, 2006b). There is evidence that they are being deliberately introduced to some areas to provide game for recreational shooters.

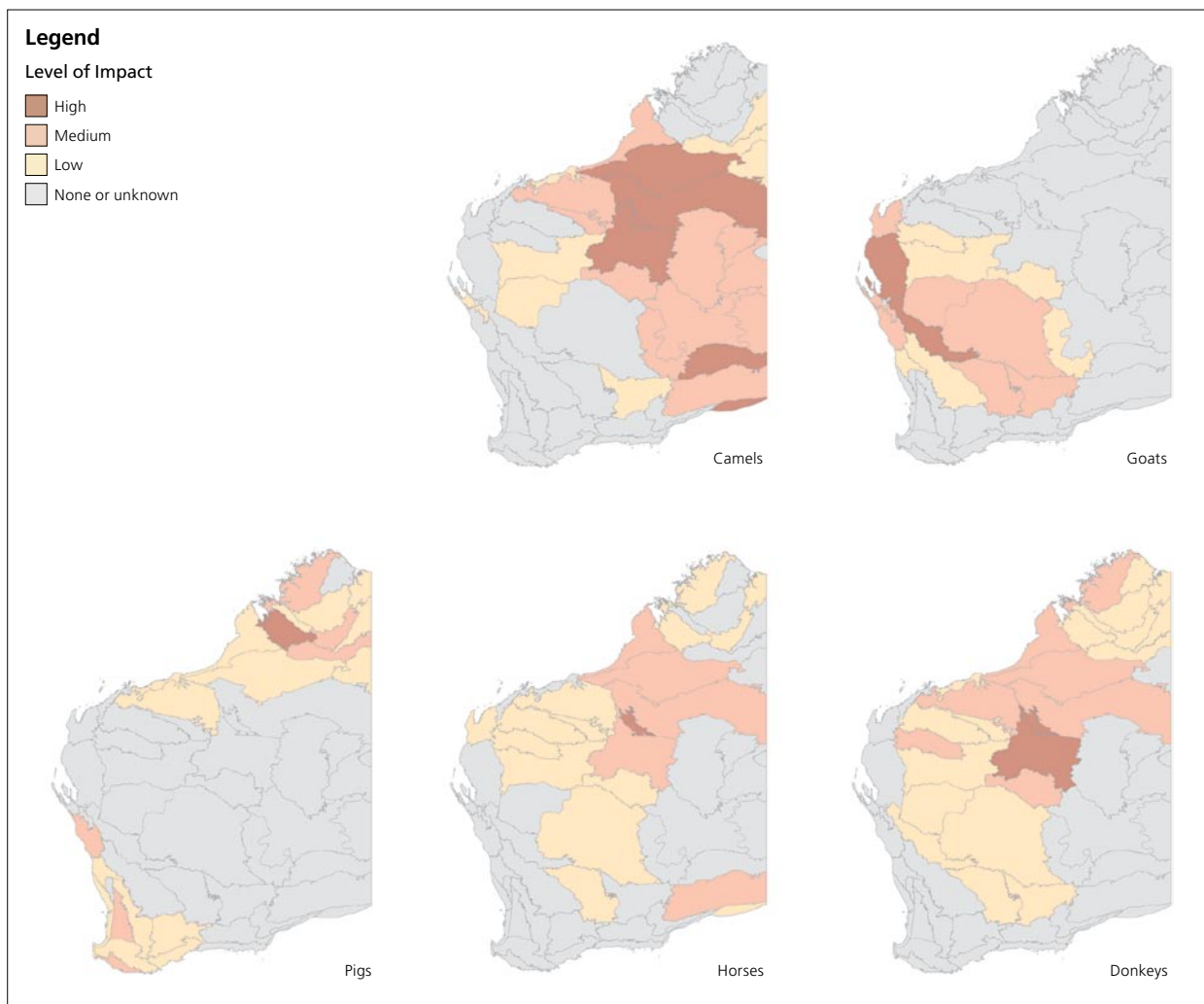


Figure B3.2: Level of impact on native ecosystems of selected introduced animals by bioregion.

Data source: Woolnough et al. (2005). Presentation: EPA.

Some introduced animals are relatively restricted in range and have limited effect on native species. For example, the Indian palm squirrel was introduced to Perth Zoo in 1898 and has gradually spread to South Perth and surrounding suburbs, but is not known to affect native species (M Massam, Department of Agriculture and Food, pers. comm.). However, others are ubiquitous and immensely damaging. For example, house mice have spread in agricultural and bushland areas, competing with native rodents and birds for food sources and nesting areas, and potentially transmitting diseases.

The decline in populations and extinction of small and medium-sized mammals has been attributed to predation by cats and foxes, the introduction of herbivores (especially rabbits, sheep and cattle) and changed fire regimes (Maxwell et al., 1996). Research shows that foxes have the highest triple bottom line impact (negative economic, environmental and social consequences) in the agricultural region, while cats have the greatest environmental impacts (Woolnough et al., 2005). Feral pigs and cats were key species thought to have increased in distribution and abundance in the agricultural region between 2000 and 2005. In the pastoral region, there have been reports of an increase in distribution and abundance of wild dogs (however these are indistinguishable from dingoes), leading to increased control efforts. The population of rabbits in the rangelands has declined in recent years as a result of the spread of rabbit haemorrhagic disease (Edwards et al., 2004). Feral cats are widely distributed across WA and predate on a wide variety of native animals.

Other groups of animals have not been as well studied as mammals, but it is likely that many other species are affected by introduced animals. For example, there has been a loss

of ant biodiversity in the Perth metropolitan area over the last 15 years, and there is circumstantial evidence that this is due to increased populations of two invasive ant species, namely the coastal brown ant (*Pheidole megacephala*) and the Argentine ant (*Linepithema humile*) (Heterick et al., 2000). The distribution of these species is known to have changed and increased over time, but has not been re-mapped since 1986 (Figure B3.3).

Island populations of native species are at particularly high risk from introduced animals as they are usually small in size, have limited options to escape predators, and have few alternatives in the face of direct competition for resources.

Pressures

The pressures exerted by introduced animals differ according to geographical area, population density and interactions with other species. The presence of an introduced animal represents a threat to local biodiversity and can cause a number of environmental impacts (Table B3.2). The Global Invasive Species Database has compiled a list of 100 of the worst invasive species from across the world. Many are present in WA (Table B3.2). The list is compiled to recognise species that have shown very high invasive ability in various places around the world, either demonstrating a very high impact in small areas (such as islands) or less visible damage over a large area. These species tend to be well adapted to living close to humans or in human-modified environments. Some introduced animals have been recognised by the State agencies as posing a risk to agricultural or fisheries production, and have been restricted from entry or movement within WA.



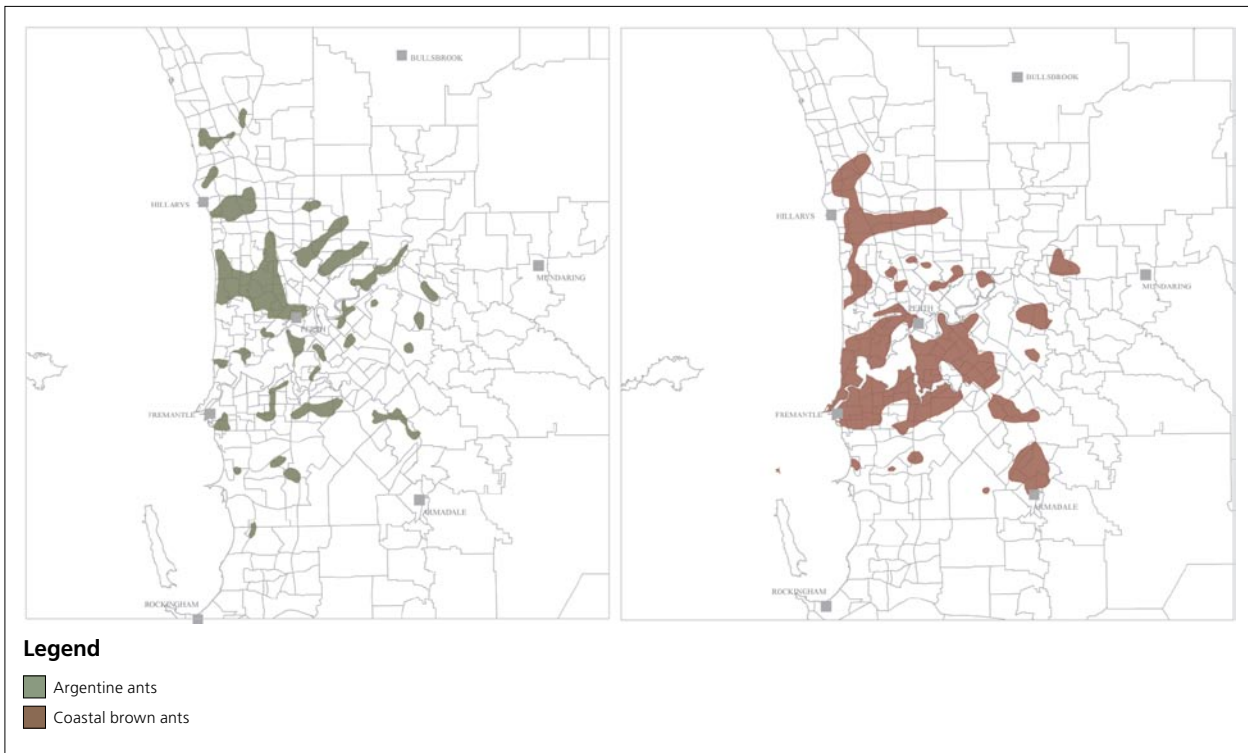


Figure B3.3: Distribution of coastal brown and Argentine ants in metropolitan Perth.

Data source: Majer & Brown (1986). Presentation: EPA. Note: Distributions in 1986 are shown here, however, it is likely that both species have increased their range since then.



Redfin perch (Department of Fisheries)



Feral goat (Department of Agriculture and Food)



Rainbow lorikeet (Department of Agriculture and Food)



Feral pig (Department of Environment and Conservation)



Honeybees (Department of Agriculture and Food)



Sulphur-crested cockatoo (Department of Agriculture and Food)

Table B3.2: Scale and effects of selected introduced animals in Western Australia.

Animal	Appears on '100 of the World's Worst' invasive species list	Declared or restricted in WA	Scale and area of impact	Effect on native species and ecosystems					
				Compete for food and habitat	Predation	Degradation of watercourses/ waterholes	Degradation of soil structure	Grazing pressure on vegetation/seeds	Spread weeds/ diseases/pathogens
Cat	✓		Statewide	•	•				
Fox	✓	✓ ^a	Statewide, except the Kimberley	•	•				
Goat	✓	✓ ^(feral)	Mid West, Goldfields, Nullarbor	•		•	•	•	
Rabbit	✓	✓ ^a	Statewide, except the Kimberley	•			•	•	
Pig	✓	✓ ^(feral)	South West, Mid West, Kimberley	•	•	•	•	•	•
Camel		✓ ^(feral)	Statewide, except the South West.	•		•		•	
Deer (all species)	✓	✓ ^a	South West (small areas)	•			•	•	
Horse & donkey		✓ ^(feral)	Statewide, except the South West.	•		•	•	•	•
Cattle			Pilbara, Kimberley	•		•	•	•	•
Rat (black and brown)	✓		Statewide (around urban areas)	•	•			•	•
House mouse	✓		Statewide	•				•	•
Rainbow lorikeet		✓ ^a	Perth	•				•	•
Kookaburra		✓ ^a	South West	•	•				
Starling	✓	✓ ^a	Nullarbor and areas around Esperance	•					•
Laughing and spotted turtle-dove		✓ ^a	South West	?					
Mallard			South West	?					
Red-browed waxbill			South West (Perth hills)	?					
Sulphur-crested cockatoo		✓ ^a	South West	•					
Eastern long-billed corella, Western long-billed corella & little corella		✓ ^a	South West (around urban areas)	•					
Indian ringnecked parrot			South West (Perth and Albany)	•					
Asian house gecko			Statewide (around urban areas)	•	•				
Honeybee			South West, Mid West	•					
Coastal brown ant	✓		Statewide (around urban areas)	•	?				
Argentine ant	✓	✓ ^a	Statewide (around urban areas)	•	?				
Yellow crazy ant	✓		Christmas Island	•	•				
Snail		✓ ^a	South West	•	•			•	
European wasp		✓ ^a	Perth	•	?				
Portuguese millipede			Perth	•	?				
Redfin perch		✓ ^c	South West	•	•	•			
Rainbow trout	✓		South West	•	•	•			
Brown trout	✓		South West	•	•	•			
Carp/goldfish/koi	✓	✓ ^(1 species)	South West	•		•			
Mosquito fish	✓	✓ ^c	South West	•	•	•			
Tilapia	✓		Mid West	•		•			
Cichlids		✓ ^(1 species)	Perth	•	•	•			
One-spot livebearer			Perth	•				•	
Swordtail			Mid West	•				•	
Yabbies		✓ ^c	South West	•		•			
Redclaw		✓ ^c	Kimberley	?	?				

Data source: numerous papers, websites and personal communications with experts; Global Invasive Species Database (2007); Department of Agriculture and Food (2006a); Department of Fisheries (2005). Notes: A question mark (?) indicates the effect is possible but not well known or researched; A dot (•) indicates that the effect is known or recorded in the literature; (a) Declared under the *Agriculture and Related Resources Protection Act 1976* – there are a variety of categories including entry prohibited, subject to eradication in the wild, keeping prohibited, entry subject to Departmental permits or conditions, numbers will be reduced or controlled, keeping subject to Departmental permits or conditions and the requirement for a management program; (b) Classified as noxious fish under the *Fish Resources Management Regulations 1995* and prohibited from import into the State; (c) restricted under the *Fish Resources Management Regulations 1995* written approval or authority is required to import these species into WA.



Indicator B17 High risk invasive animal threats to WA.

Many potential invaders are known and represent a significant risk to the State's environment if they become established here (e.g. cane toads, Indian mynas, starlings, red-eared slider turtles and red imported fire ants) (Table

B3.3). All of these animals have been recognised for their invasive potential in other parts of the world and are listed as being the world's 100 worst invasive species. In addition, most have also been recognised under State legislation and are prevented from entry into WA.

Table B3.3: Animals that represent a high risk to biodiversity in WA.

Animal	Status in Australia	Appears on '100 of the World's Worst' invasive species list	Declared in WA
Cane toad (<i>Bufo marinus</i>)	Common in north New South Wales, Queensland and the Northern Territory. Currently in the Victoria River area of the Northern Territory (approximately 120 kms from the WA border) and moving toward the Kimberley region	✓	✓
Red imported fire ant (<i>Solenopsis invicta</i>)	Present in several Brisbane suburbs. Has the potential to travel and establish in WA via transport networks	✓	
Indian myna/ common myna (<i>Acridotheres tristis</i>)	Found in urban areas and in pastoral and agricultural districts near towns in eastern Australia. Thousands can roost communally in street trees, under bridges and in buildings. Mynas appear to be omnivorous, feeding on fruits, berries, grains, flower nectar and insects. They are aggressive, especially to other birds, compete for nesting hollows, destroy chicks and eggs and can evict small mammals.	✓	✓
Starling (<i>Sturnus vulgaris</i>)	Found in a variety of urban to rural habitats all over Victoria, New South Wales and Tasmania and many parts of Queensland and South Australia. They are now found in a small part of south eastern Western Australia but have potential to spread much more widely. Starlings are aggressive, social birds that can form very large flocks that move, feed, and roost together. They feed on nearly everything edible including insects, seeds, grains, and fruit.	✓	✓
Red-eared slider turtle (<i>Trachemys scripta elegans</i>)	The turtle is very aggressive towards other animals and competes with native species if it becomes established in the wild. One breeding population was discovered in Brisbane suburbs in 2004 and eradication efforts continue. 14 animals have been found in Perth in the last 10 years and the possible presence of these animals as pets (which is illegal) or in the wild is of continued concern.	✓	

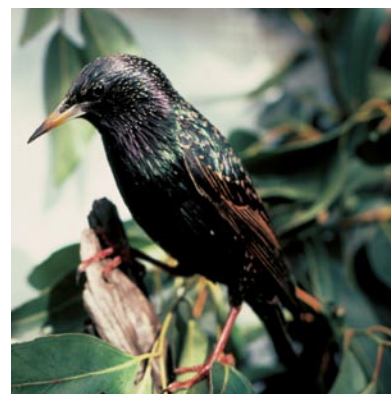
Data source: numerous papers and websites; Global Invasive Species Database (2007); Department of Agriculture and Food (2006a); Note – In WA species can be declared under the *Agriculture and Related Resources Protection Act 1976* – there are a variety of categories including entry prohibited, subject to eradication in the wild, keeping prohibited, entry subject to Departmental permits or conditions, numbers will be reduced or controlled, keeping subject to Departmental permits or conditions and the requirement for a management program



Cane toad (Department of Agriculture and Food)



Red imported fire ant (Department of Agriculture and Food)



Starling (Department of Agriculture and Food)

Cane toads were deliberately introduced into north Queensland in 1935 in an unsuccessful attempt to control sugar cane beetles. Since then they have spread widely through Queensland, northern New South Wales and the Northern Territory. Cane toads eat a wide variety of prey items, breed opportunistically, are able to produce more offspring than native frogs, and develop rapidly in tropical conditions. They tolerate a broad range of environmental and climatic conditions, and occupy many different habitats where they compete for resources with native species. Most significantly, cane toads reproduce in high numbers and all life stages (from egg to adult) are highly toxic to native vertebrate predators (especially quolls, large lizards and freshwater crocodiles). Climate-based modelling of the potential distribution of cane toads across Australia (Figure B3.4) indicates that populations could migrate and establish in the Kimberley, and could survive if introduced to the South West (particularly in a warming climate). The current frontline of the cane toad advance is in the Victoria River area of the Northern Territory, approximately 120 kms from the WA border (Department of Environment and Conservation, 2006c). Recent data suggests that cane toads are moving about 55 kilometres per year towards the WA border due to evolving for competitive advantage, or entering an environment more favourable to spread (Phillips et al., 2007).

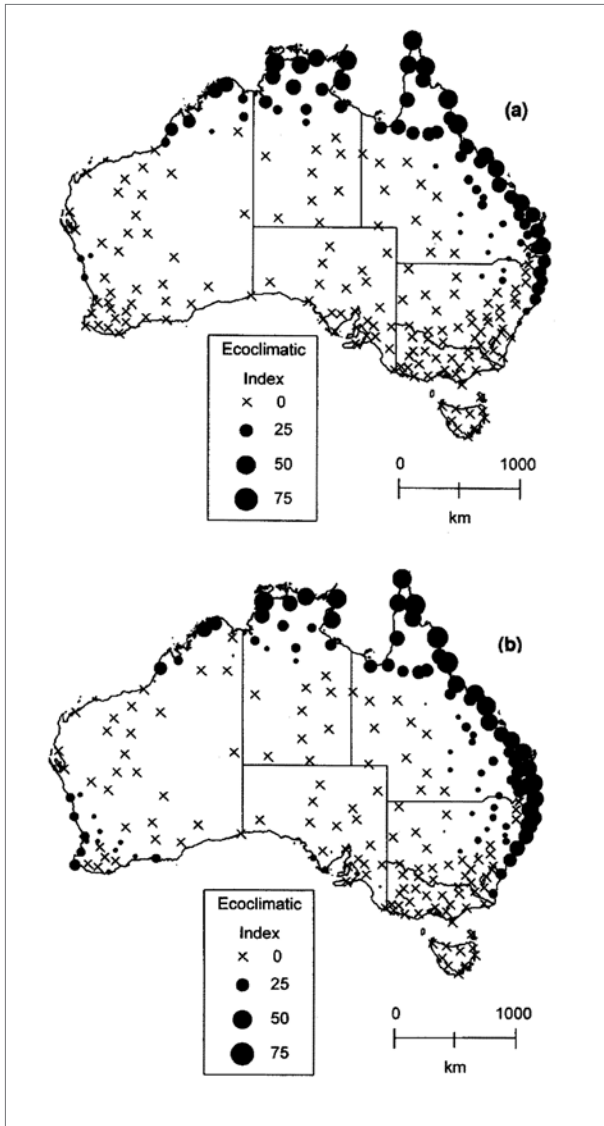


Figure B3.4: Modelled potential geographic distribution of cane toads in Australia based on two climate scenarios: (a) long-term average climate; and (b) the 2030 climate change scenario.

Data source: Sutherst et al. (1995); Presentation: Sutherst et al. (1995). Note: The climatic suitability of each location for permanent colonisation is proportional to circle area.

The red imported fire ant is a new addition to the list of invasive species in Australia, first detected in Brisbane in 2001. The ant is an aggressive predator and preys on ground-dwelling and nesting animals including insects, frogs, reptiles, birds and mammals (Moloney & Vanderwoude, 2002; Davis & Grimm, 2003); and can damage native flora (by eating it directly or reducing populations of beneficial animals). The ants have a dangerous sting that can cause severe pain and death of affected organisms, including humans. Introduction of the red imported fire ant to WA could cause significant economic loss through damage to plants (roots, fruits or crops), ingestion by livestock, and damage to underground cabling and pipes (Davis & Grimm, 2003). Modelling of the potential range of red imported fire ants in Australia (Figure B3.5) indicates that climatic conditions are suitable for spread along coastal parts of the Kimberley and South West, and further inland if water is available.

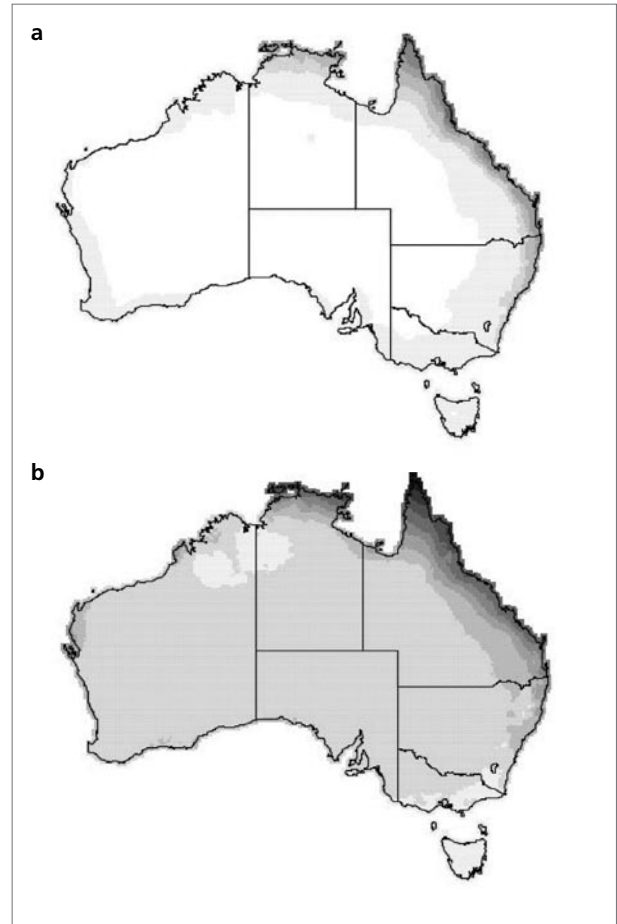


Figure B3.5: Potential range of red imported fire ants in Australia with (a) natural rainfall and (b) irrigation.

Data source: Sutherst & Maywald (2005). Presentation: Sutherst & Maywald (2005).

Indicator B18: Prevention, eradication and control of introduced animals.

The hot desert climate of central Australia provides a natural barrier to the movement of many animals from the rest of Australia into the South West. In comparison, the Kimberley has less natural protection from other parts of northern Australia, with the wet season providing an opportunity for some animals to travel long distances between neighbouring wetlands and watercourses. Animals which successfully spread from their place of introduction to surrounding habitats are often disturbance specialists or prefer to live in human-modified landscapes. Transport networks also present many opportunities for the introduction of new species in cars or in freight transported by vehicles, aircraft, trains or ships. Quarantine and inspection services play an important role in preventing incursions into WA.



Preventing the entry of new animal species into WA and the early detection and eradication of incursions if they do occur is the first line of defence. If new incursions are discovered before they become established, eradication is possible. Eradication may not be possible for introduced animals that are widely distributed, so activities need to focus on controlling their spread. Control measures may include:

- fencing – widely used in agriculture, horticulture, forestry and pastoralism;
- trapping – often used in pastoral areas around waterholes;
- baiting – often used to control foxes, pigs and rabbits using 1080 poison in conservation areas;
- shooting – often used in agriculture, pastoral and conservation areas to control feral horses, camels, donkeys, pigs, goats, and foxes;
- biological control – using parasites, diseases, or natural predators.

Although the task is far from complete, WA leads the other states in eradication of introduced animals on islands. Six exotic mammals (fox, feral cat, goat, rabbit, black rat and house mouse) have been eradicated from more than 45 islands in a series of projects since the 1960s (Burbidge & Morris, 2002). Effort has been directed at black rats, and more than 30 islands are now clear of this species, but eradication of other introduced species on islands is still required. Removal of introduced bird species (particularly tree and house sparrows, Indian mynas, house crows, Indian ringnecks and European starlings) has been successful – but repeat incursions still occur. Some vertebrates (whose numbers are too large for eradication) are confined to small areas of the State, largely through control activities of the Department of Agriculture and Food. These are typically species with potential for large population growth, such as the sulphur-crested cockatoo and Indian palm squirrel.

Current responses

Quarantine: The role of the Australian Quarantine and Inspection Service is to prevent entry of introduced animals (as well as plants and pathogens) to Australia in incoming luggage, cargo and mail, or associated imported goods. The Western Australian Quarantine and Inspection Service (part of the Department of Agriculture and Food) aims to prevent pest and disease incursions from other parts of Australia. A system of risk assessment is now used to assess species proposed for import, to ensure that only those posing an insignificant level of risk are allowed to enter the State.

Legislation: The *Agriculture and Related Resources Protection Act 1976* is administered by the Department of Agriculture and Food on behalf of the Agriculture Protection Board. The Act allows for management of listed (declared) animals in order to protect primary industries and related resources. All land managers are responsible for controlling declared animals, irrespective of whether the land is public, municipal or private. A Biosecurity and Agriculture Management Bill has been drafted, with the aim of replacing 17 existing Acts in the Agriculture portfolio. The drafted Act seeks to establish a modern biosecurity regulatory scheme to prevent serious pests, weeds and diseases that impact primary production, the environment or public amenity from entering the State, and to minimise the spread and impact of any that are already present. The bill was passed by the Lower House of Parliament in 2006 and has been introduced to the Upper House.

Threat abatement plans: Eight of the 16 key threatening processes listed under Commonwealth legislation (the *Environment Protection and Biodiversity Conservation Act 1999*) concern introduced animals. Threat abatement plans

provide for research, management and any other actions necessary to reduce the impact of a listed key threatening process on a threatened species or ecological community. Current plans concern cats, rabbits, foxes, goats and pigs (draft).

Eradication and control: The Department of Environment and Conservation operates the Western Shield program which uses poisoned baits to control predators (foxes and cats) on about 3.5 million hectares of land across the South West (Department of Conservation and Land Management, 2005b). Native mammals can be re-introduced following predator baiting and trapping efforts. Western Shield has been credited with bringing at least 13 native fauna species back from the brink of extinction (Department of Conservation and Land Management, 2003d). Project Eden was established in the Shark Bay World Heritage area in 1995 to address declining populations of many native animals. It involved removal of introduced animals (goats, rabbits, foxes and cats) and re-introduction of native animals (bilby, rufous hare wallaby, banded hare wallaby and western barred bandicoot). In addition, introduced animal control is an integral part of conservation reserve management, and management of threatened species and communities, undertaken by the Department of Environment and Conservation across the State.

The Department of Environment and Conservation began the Saving Our Species program in 2006 and adds to Western Shield and other introduced animal control programs. It targets introduced animals in areas where they are known to have an impact on biodiversity and where it is feasible to eradicate or significantly reduce populations. Projects include: wild dog control in the rangelands and parts of the eastern Wheatbelt; pig control on the Darling Scarp and Swan Coastal Plain and in the forests around Manjimup and Lake Muir; goat control in Kennedy Range, Cape Range and Kalbarri national parks; fencing some of the conservation estate in the north of the State; fencing former pastoral lands purchased for conservation in the Goldfields and Midwest regions; camel, donkey, wild horse and wild cattle control in the western Little Sandy Desert and at a nature reserve in the Kimberley; a camel survey in Rudall River National Park; donkey control in some areas of the Pilbara; starling control on the south coast; and control of introduced bird species in the metropolitan area and around Albany and Denmark.

Natural Heritage Trust/National Action Plan for Salinity and Water Quality (NHT/NAP): These are two Commonwealth Government programs that aim to ensure environmental (on-ground) improvements occur via a targeted strategic approach at the regional level. All regional NRM groups have identified introduced animals as a problem and have initiated a wide range of actions to control them.

Management activities: The Department of Agriculture and Food coordinates surveillance and undertakes eradication and control activities, but mostly for introduced animals that can harm agricultural and pastoral production. Introduced animals that have a negative affect on native species and ecosystems are sometimes a lower priority than those impacting agricultural production. Many private landholders undertake control of introduced animals and procedures have been established to assist their efforts.

The State Cane Toad Initiative run by Department of Environment and Conservation funds the activities of several organisations to prevent the entry of the cane toad to WA including the Stop the Toad Foundation, Kimberley Toadbusters and Frogwatch (Northern Territory). The Kimberley Toadbusters, Stop the Toad Foundation and teams from State government agencies have been able to catch and destroy large numbers of toads in the Northern Territory to try and slow or stop their entry to WA (a total of about 260

000 toads were removed between 2005 and March 2007, L Scott-Virtue, Kimberley Toadbusters, pers. comm.). Efforts have focussed on physical collection and destruction of toads, but other methods such as cane toad traps and barrier fences are also being developed for areas that are hard for humans to regularly access.

Research: The Department of Agriculture and Food, Department of Environment and Conservation and CSIRO have current and ongoing programs that address control of introduced animals, particularly predators. Until recently, CSIRO conducted research into threatened species, in particular the reasons for their decline and techniques for re-establishment. The Department of Agriculture and Food has been researching methods for control of vertebrate pests including investigation of the sensitivity of non-target species to 1080 (a toxic compound also found in legume plants native to WA); investigating biological control of rabbits (myxomatosis and rabbit haemorrhagic disease); developing control strategies and techniques, baits and poisons for rabbits, foxes, birds and wild dogs.

Invasive Animals Cooperative Research Centre: was launched in 2005 by the Commonwealth Government to build on the work of the Pest Animal Control Cooperative Research Centre to counteract the impact of invasive animals through the development and application of new technologies and by integrating approaches across agencies and jurisdictions. It is the first time that research, industry, environmental, commercial and government agencies will work together to create and apply solutions for invasive animal threats.

Biodiversity Conservation Strategy: The Department of Environment and Conservation has released *A 100-year Biodiversity Conservation Strategy for Western Australia: Blueprint to the Bicentenary in 2029*. Public submissions were requested and a final biodiversity conservation strategy is in preparation (Department of Environment and Conservation 2006a).

Local governments: Many local governments have policies and strategies to prevent the spread of stray and feral cats including licensing, limiting the number of cats per household and a subsidy for cat sterilisation. The Perth Biodiversity Project is coordinated by the Western Australian Local Government Association to help local governments protect and manage natural areas, including the impacts of invasive animals.

Implications

Failure to control introduced animals is likely to result in further loss of biodiversity and further decline or extinction of native species or ecosystems. Introduced animals have been implicated in the extinction of 10 native mammal species in WA (Department of Conservation and Land Management, 2003d) and the decline in population and range of many others (Commonwealth of Australia, 2002). Introduced animals are also adversely affecting birds (Olsen et al., 2006), and many other groups for which detailed analysis has not been done. Introduced animal control needs to be consistent and sustained, and a proactive approach is required to prevent new introduced species becoming established. With increasing human population and associated travel, transport and trade, the risk of introducing new species is likely to grow (Convention on Biological Diversity, 2005). The potential cost of introduced animals is enormous, and includes costs of control measures, loss of biodiversity and damage to agricultural, forestry, pastoral and construction industries, in addition to effects on public health and amenity. For example, the environmental costs alone (i.e. not including the economic costs) of foxes and cats across Australia is estimated to be about \$190 and \$144 million respectively (McLeod, 2004).

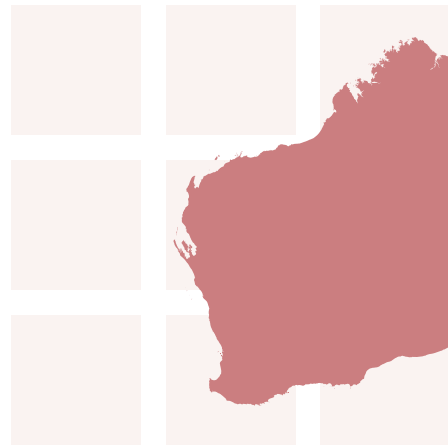
SUGGESTED RESPONSES

- 5.12 Finalise and enact the Biodiversity Conservation Bill and the Biosecurity and Agricultural Management Bill.
- 5.13 Finalise and implement the draft *A 100-year Biodiversity Conservation Strategy for Western Australia*.
- 5.14 Expand current programs for introduced animal surveillance and control (such as Western Shield, Save Our Species and cat and herbivore control).
- 5.15 Expand sound biological control of introduced animals to include environmentally damaging species to the same extent as agriculturally damaging pests.



Survey of camel population at Rudall River National Park in November 2006 (B. Ward)





INDICATIVE EXTENT OF ISSUE

PRIORITY RATING: 1

KEY FINDINGS

- WA has over 1200 recognised weed species.
- The Swan Coastal Plain and the Jarrah Forest in the South West have the highest number of weeds in the State (700-800 identified species).
- WA has 11 of the 20 weed species of national significance. An additional seven other weed species pose an imminent threat.
- Garden plants are the main source of Australia's weeds, accounting for 66% of recognised weed species. Other major sources of weeds include plants introduced as crops, pastures, and for aquariums.

Description

Many terms are used to describe introduced and native plants (Table B4.1). Weeds are plants that are not considered native to WA, and have the capacity to impact upon environmental, social or economic values. They may include herbs, grasses, shrubs, trees, vines and aquatic plants. Weeds have been introduced deliberately for agricultural benefits (for crops,

pastures or seed), soil stabilisation (for erosion control), for ornamental purposes (e.g. garden plants, fish tanks) or accidentally in products such as animal feed or pot plant soil (Hussey et al., 1997). Many plants introduced into Australia over the past 200 years have become weeds.

Plants that become weeds can often propagate themselves in more than one way and typically produce large numbers of seeds, assisting their spread. Seeds spread into natural environments, including waterways, by wind, water, people, vehicles, machinery, birds and other animals. Weeds can rapidly invade natural sites where the soil has been disturbed, where there has been clearing, or where fire regimes have changed. Weeds also thrive in nutrient rich soils or where fertilizers have been added.

Weeds threaten the survival of many native flora and fauna because they grow faster and out-compete native plants for available nutrients, water, space and sunlight. They can smother and replace native plants including those used by animals for habitat, and are commonly resilient to pests or diseases. Consequently, weeds have the potential to dominate and simplify natural ecosystems. They may also lead to significant changes to ecosystems and fire regimes. Weeds also cause economic losses in agriculture as they reduce yields, contaminate crops, poison stock, reduce livestock carrying capacity, downgrade wool or taint milk (Hussey et al., 1997).

Table B4.1: Common terms to describe plants.

Term	Meaning
Weed	A plant that requires some form of action to reduce its harmful effects on the economy, the environment, human health and amenity (Australian Weeds Committee, 2006), and can include plants from other countries or other regions in Australia or WA.
Environmental weed	An introduced plant that establishes in natural ecosystems and adversely modifies natural processes, resulting in decline of invaded communities.
Naturalised	A plant that is not native to an area but has become established and can reproduce there. Not all naturalised species become weeds or have detrimental environmental or economic effects, but many do.
Invasive	An introduced species with the ability to spread beyond the site of introduction or colonisation and to compete with native species to gain resources. Not all introduced species are invasive if there are controls on their spread or competitiveness.
Exotic	A plant occurring in a place to which it is not native.
Native	A species which occurred in an area before European colonisation.
Endemic	A species restricted in range to a particular area and not occurring elsewhere.

Objectives

- To conserve WA's biodiversity by preventing entry of additional weed species and adopting appropriate control measures for those already established.

Condition

Indicator B19: Number of weeds per bioregion.

A total of 1233 weed species (defined as being able to reproduce without human involvement) have been recorded in WA, 55% of which are considered primarily environmental weeds (Keighery & Longman, 2004). At present, there are only 92 formally declared weed species under State legislation

(which means they are subject to restrictions on movement or sale and control must be undertaken; Department of Agriculture and Food, 2007a). Weeds are present across most of WA (Figure B4.1). The Swan Coastal Plain has the highest number of weeds identified – over 800 species. In general, most South West bioregions have over 300 weed species identified (Figure B4.1). This could be associated with densely populated areas and highly disturbed environments (cleared and fragmented native vegetation), but could also be attributed to greater survey efforts. Parts of the Goldfields, Mid West, Pilbara and Kimberley have between 100–200 weed species identified. In comparison, there are very low numbers of weeds identified in the central deserts.

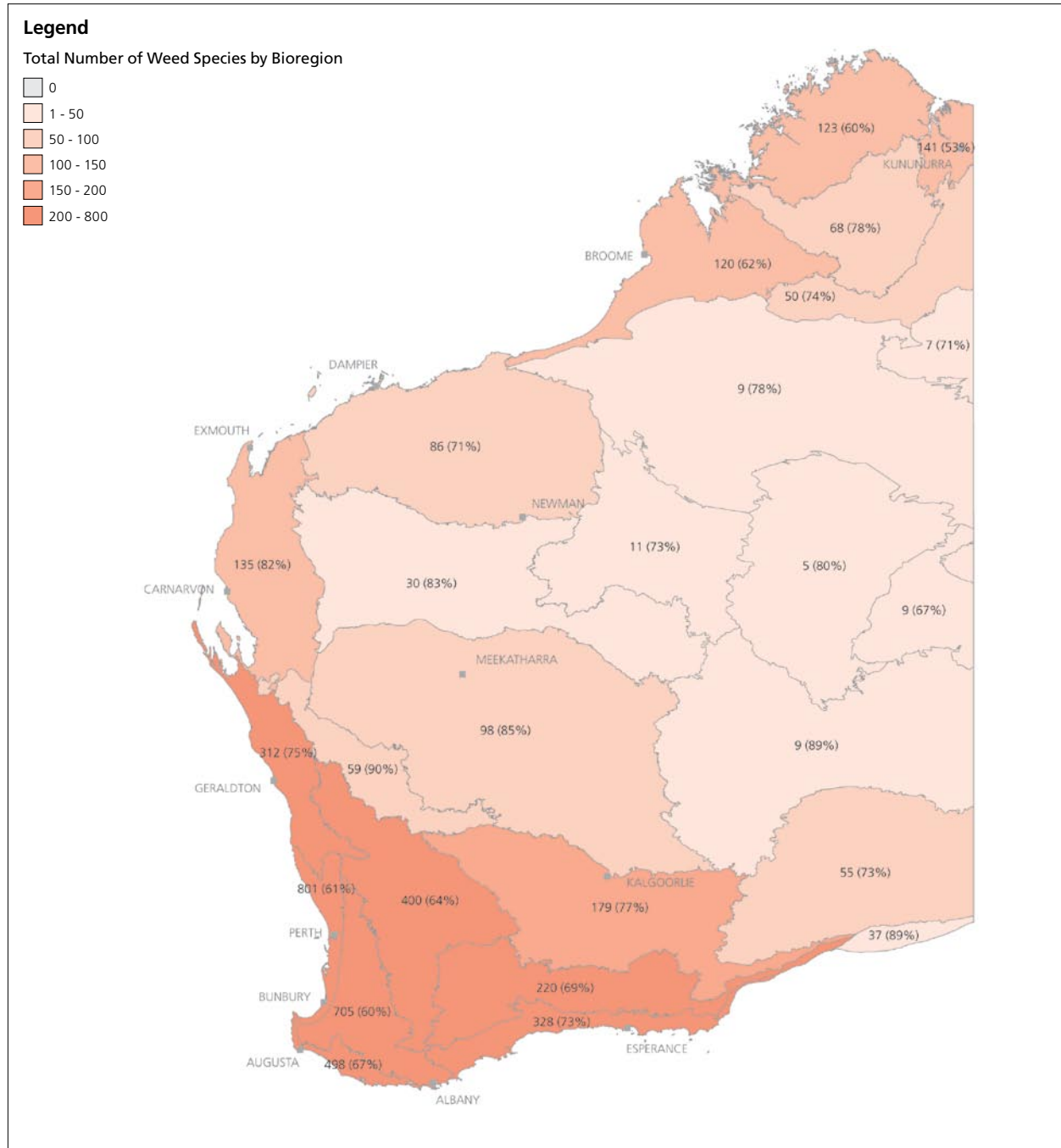


Figure B4.1: Number of weed species found per terrestrial bioregion.

Data source: Keighery & Longman (2004). Presentation: EPA. Note: Each IBRA region is labelled with the total number of weeds and the percentage of the total number which are classed as environmental weeds (in brackets).

Indicator B20: Most significant weeds by geographic location.

While the total number of weed species is a good measure of overall condition, the environmental effects of these species vary considerably. Some environmental weed species are recognised as being very significant in various regions in terms of having current or potential impacts on WA biodiversity (Tables B4.2 and B4.3). This is based on factors such as proven ability to spread in other places with similar climatic conditions, ability to alter ecosystems and threaten native species, and absence of appropriate management action.

The list of Weeds of National Significance details the top 20 weed species Australia-wide based on invasiveness and impact, potential and current spread, and current primary industry, environmental and socioeconomic impacts (Australian Weeds Committee, 2004). A total of eleven of these occur in WA and all have the potential to expand their range. A further seven weed species have the potential to spread from other states to WA.

Table B4.2: Top five worst terrestrial environmental weed species by geographic region.

Region	Appears on '100 of the World's Worst' invasive species list	Weed of National Significance	Declared in WA
South West			
Watsonia (<i>Watsonia</i> spp.)			
Arum lily (<i>Zantedeschia aethiopica</i>)			✓
Bridal creeper (<i>Asparagus asparagoides</i>)		✓	✓
Perennial Veldt grass (<i>Ehrharta calycina</i>)			
Freesia (<i>Freesia</i> hybrid)			
Mid West – Pilbara			
Mesquite (<i>Prosopis</i> spp.)	✓	✓	✓
Mediterranean turnip (<i>Brassica tournefortii</i>)			
Buffel grass (<i>Cenchrus ciliaris</i>)			
Ward's weed (<i>Carrichtera annua</i>)			
Mexican poppy (<i>Argemone ochroleuca</i>)			✓
Central Deserts			
Buffel grass (<i>Cenchrus ciliaris</i>)			
Ward's weed (<i>Carrichtera annua</i>)			
Prickly pear (<i>Opuntia</i> spp.)	✓		✓
Spiked malvastrum (<i>Malvastrum americanum</i>)			
Kapok bush (<i>Aerva javanica</i>)			
Kimberley			
Kapok bush (<i>Aerva javanica</i>)			
<i>Calotropis gigantea</i>			
Hyptis (<i>Hyptis suaveolens</i>)			
Noogoora burr (<i>Xanthium occidentale</i>)			✓
Bathurst burr (<i>Xanthium spinosum</i>)			✓

Data source: Department of Conservation and Land Management - worst environmental weeds (unpublished data) [ver. 2006]; Global Invasive Species Database (2007); Australian Weeds Committee (2004), Department of Agriculture and Food (2007a.).



Buffel grass (Department of Agriculture and Food)



Kapok bush (Department of Agriculture and Food)



Arum lily (Department of Agriculture and Food)

Table B4.3: Top five worst aquatic or wetland environmental weed species by geographic region.

Region	Appears on '100 of the World's Worst' invasive species list	Weed of National Significance	Declared in WA
South West			
Spiny rush (<i>Juncus acutus</i>)			
Divided sedge (<i>Carex divisa</i>)			
<i>Isolepis hystrix</i>			
<i>Sparaxis bulbifera</i>			
Couch (<i>Cynodon dactylon</i>)			
Mid West – Pilbara			
Athel pine (<i>Tamarix aphylla</i>)	✓	✓	✓
Burrgrass (<i>Cenchrus echinatus</i>)			
Castor oil plant (<i>Ricinus communis</i>)			
Date palm (<i>Phoenix dactylifera</i>)			
Central Deserts			
Date palm (<i>Phoenix dactylifera</i>)			
Kimberley			
Salvinia (<i>Salvinia molesta</i>)		✓	✓
Water hyacinth (<i>Eichhornia crassipes</i>)	✓		✓
Paragrass (<i>Brachiaria mutica</i>)			
Grass species (<i>Echinochloa</i> spp.)			
Date palm (<i>Phoenix dactylifera</i>)			

Data source: Department of Conservation and Land Management - worst environmental weeds (unpublished data) [ver. 2006]; Global Invasive Species Database (2007); Australian Weeds Committee (2004), Department of Agriculture and Food (2007a.).

In addition to the weeds listed in Tables B4.2 and B4.3, another seven Weeds of National Significance are present in WA. These are alligator weed (*Alternanthera philoxeroides*), bitou bush/boneseed (*Chrysanthemoides monilifera*), blackberry (*Rubus fruticosus* agg), gorse (*Ulex europaeus*), lantana (*Lantana camara*), parkinsonia (*Parkinsonia aculeata*) and rubber vine (*Cryptostegia grandiflora*). Gorse and lantana are also recognised on the international 100 worst invasive species list along with three other species that are present in WA - black wattle (*Acacia mearnsii*), giant reed (*Arundo donax*) and maritime pine (*Pinus pinaster*).

Indicator B21: Change in distribution of significant environmental weeds.

Monitoring trends in weed species distribution is a difficult and time consuming task and few examples are available. One example of weed spread over time comes from surveys conducted in the Ashburton River catchment for 1978 and 2001-02 (Payne et al., 2004). Buffel and Birdwood grasses (*Cenchrus ciliaris* and *C. setigerus*) distribution was determined over the two periods (Figures B4.2 and B4.3). The weeds had spread considerably and increased in dominance at many sites. Pastoralists reported a rapid expansion after a flood in 1997 which deposited silt and sand over the catchment's extensive alluvial plains.



Date palm (Department of Agriculture and Food)



Salvinia (Department of Agriculture and Food)



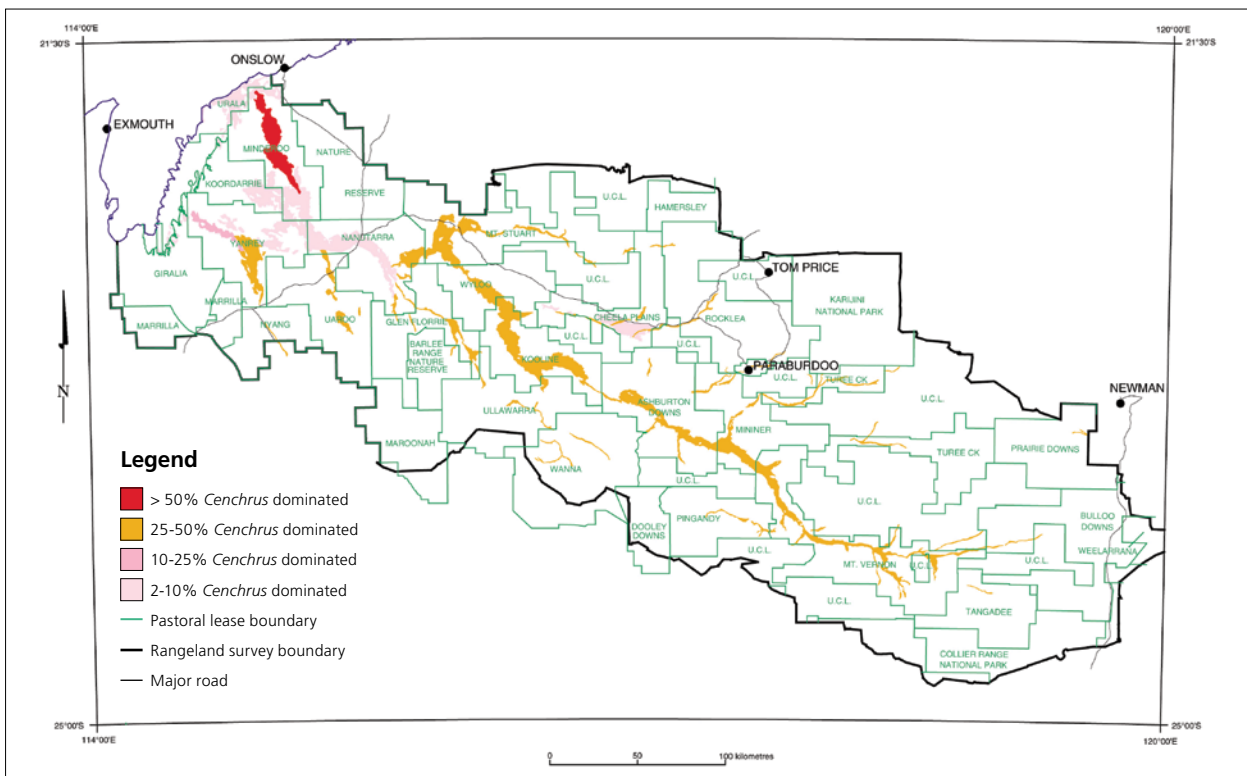


Figure B4.2: The extent of vegetation dominated by *Cenchrus* spp. (buffel and Birdwood grasses) in 1978.

Data source: Payne, et al. (2004). Presentation: Payne, et al. (2004).

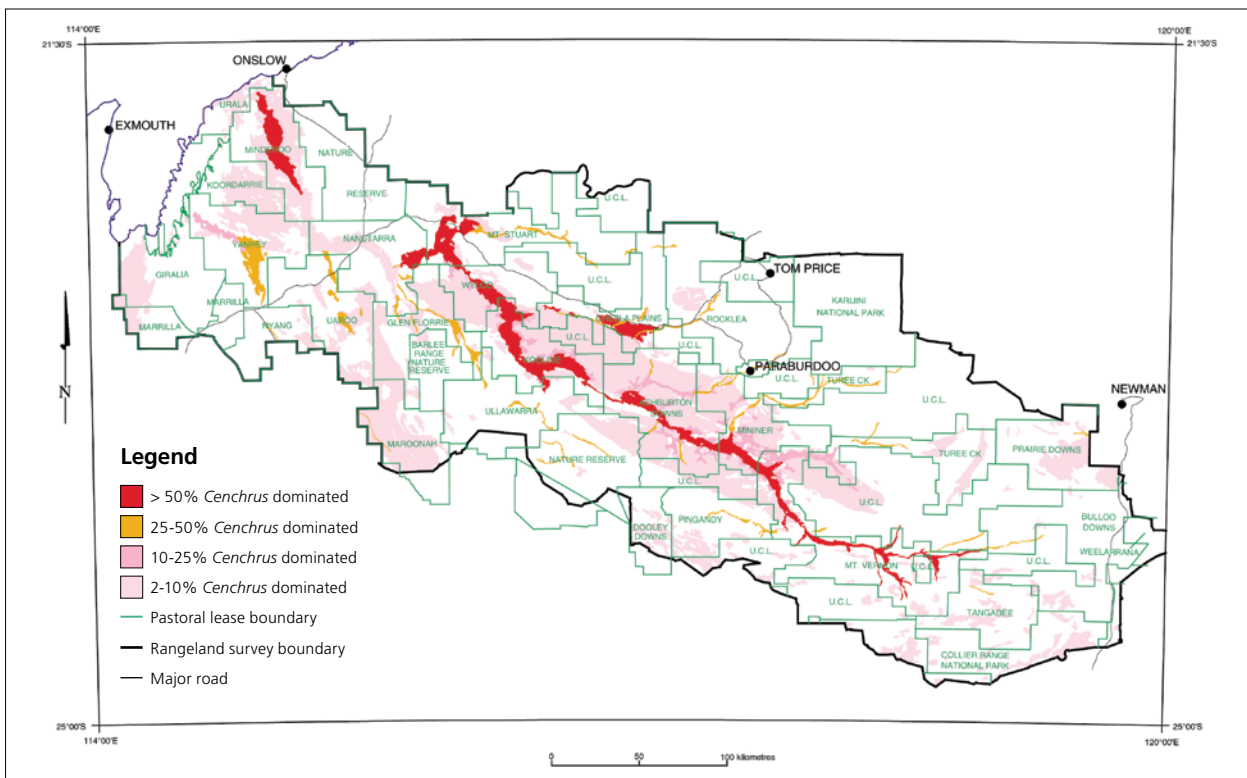


Figure B4.3: The extent of vegetation dominated by *Cenchrus* spp. (buffel and Birdwood grass) in 2002.

Data source: Payne, et al. (2004). Presentation: Payne, et al. (2004).

Pressures

Plants that become successful weeds are usually those that have adapted elsewhere to a similar climate. For example, the South West is vulnerable to plants that have adapted to other Mediterranean climates - South Africa, California, South America and Mediterranean countries. The Kimberley is vulnerable to plants from tropical areas of the world. The desert areas of central and northern WA have acted as a barrier to many weeds from eastern Australia.

Weeds often dominate new locations because they lack natural competitors, herbivores and pathogens that would regulate them in their native environment. Many weed species introduced for agricultural and pastoral production have become very significant environmental weeds, notably buffel grass in the rangelands. Of 463 exotic pasture species introduced to northern Australia, less than 5% became useful, and less than 1% of those are useful without also being a weed. About 10% of species became weeds with no recorded use (Lonsdale, 1994).



Bridal Creeper can completely cover native vegetation (Department of Agriculture and Food)



Mesquite can grow in thick clumps and out compete native species (Department of Agriculture and Food)

The gardening industry is by far the largest importer of exotic plants, accounting for 94% of new species brought into Australia (Groves et al., 2005). About two-thirds of the weeds now established in Australia originated from gardens. Many garden plants known to be weeds continue to be imported and sold in nurseries. Controlling the spread of weeds has centred on restricting the sale of many species known to become weeds, vigilance in detecting new garden escapees and national coordination of regulation and resourcing (Groves et al., 2005). Transport networks also present many opportunities for the introduction of new species, with seeds being accidentally dispersed by vehicles, aircraft, trains or ships. Cuttings or seeds can also be found in imported goods, cargo, mail and luggage and require vigilant quarantine and inspection procedures.

Quarantine and inspection services play an important role in preventing incursions into WA. This may include preventing the entry of weed species into WA and the early detection and eradication of weeds. If new weeds are discovered before they are become established, eradication is possible. Once weeds become well established, control methods must be used to limit further spread and to protect natural resources. Examples of control methods include:

- soil cultivation and herbicides – widely used to control weeds in agriculture, horticulture, forestry and home gardens;
- land management practices – including crop rotation, farm hygiene, burning, strategic grazing and maintenance of vegetation cover;
- hand removal – often used in sensitive environmental areas (such as wetlands) where the use of herbicides is not appropriate;
- biological controls – using native and introduced parasites and predators; and
- monitoring and minimising soil and vegetation disturbance.

Indicator B22: High risk invasive weed threats to WA.

Many potential weeds are known to be invasive in other parts of the world, Australia and within WA, and represent a significant risk to local environments if they become established. For example, the most serious potential terrestrial and aquatic weed threats from a biodiversity perspective (Department of Conservation and Land Management,

unpublished data, 2006) to WA are:

- yellow soldier (*Lachenalia reflexa*) and giant bacopa (*Bacopa caroliniana*) for the South West;
- the rubber vine (*Cryptostegia grandiflora*) and giant sensitive plant (*Mimosa pigra*) for the Kimberley;
- the karoo thorn (*Acacia karroo*) for the Mid West and Pilbara; and
- the buffel grass (*Cenchrus ciliaris*) for the central deserts.

Current responses

Quarantine: The role of the Australian Quarantine and Inspection Service is to prevent entry of introduced plants (and animals and pathogens) to Australia in incoming luggage, cargo and mail, or associated imported goods. The Western Australian Quarantine and Inspection Service (run by the Department of Agriculture and Food) aims to prevent weed incursions from other parts of Australia. As of March 2007, 1364 taxa had been assessed and judged a quarantine risk to WA (in addition to the 92 declared weeds) and were prohibited entry to the State. These weeds are featured in a WA quarantined species list. Over 14 400 taxa have had a formal weed risk assessment and can be imported into WA. Any species not on the list must undergo a weed assessment prior to importation (Department of Agriculture and Food, 2007a & 2007b).

Legislation: *The Noxious Weeds Regulations 1973* and *Agriculture and Related Resources Protection Act 1976* provide for plants or seeds to be prevented from entering WA (for trade, sale or transit to other states); require eradication across affected areas, control of weed populations, and quarantine of existing populations; and require the control of weeds on public land or land under control of local government. There are currently 92 declared weeds in WA. The Department of Agriculture and Food is responsible for overseeing legislation requiring the management of declared weeds.

Strategies: The *National Weed Strategy* was released in 1997 to prevent the introduction of new weed species around Australia and strengthen action against those already established. The strategy focused on weeds of national significance, which were selected according to invasiveness, current location and potential to spread, and impacts on primary industry, the environment and social



values (ARMCANZ, et al., 1997). This was reviewed in 2002 and found to have been highly successful with 15 strategies completed, 10 strategies with significant work undertaken (and ongoing work required) and only one strategy requiring major work for completion (National Weeds Strategy Executive Committee, 2002).

The *Australian Weed Strategy* was released in 2006 and replaced the *National Weed Strategy*. It addresses the prevention of new weeds, abatement of existing weeds and the enhancement of capacity to combat such problems. It is a national framework to guide and complement state, territory, regional and local government strategies and industry initiatives that are translated into on-ground weed management actions (Australian Weeds Committee, 2006).

The *Weed Plan for Western Australia* (also known as the State Weed Plan) was released in 2001 to coordinate effective weed management across the State (State Weed Plan Steering Group, 2001). The Western Australian Weeds Committee has been set up as a result of the plan. An *Environmental Weed Strategy* for Western Australia was released in 1999 (Department of Conservation and Land Management, 1999b) to address and record environmental weeds specifically. Many actions contained in the strategy were not commenced until the Saving Our Species suite of programs commenced in 2006.

Natural Heritage Trust/National Action Plan for Salinity and Water Quality (NHT/NAP): These are two Commonwealth Government programs that aim to ensure environmental (on-ground) improvements occur via a targeted strategic approach at the regional level. All regional NRM groups have identified weeds as a problem and implemented a range of actions to control and manage weeds.

On-ground actions: Many government agencies (including the Department of Agriculture and Food, Department of Environment and Conservation, Main Roads, Westrail and local governments) have programs to remove weeds on land under their jurisdiction. Individual landholders are responsible for controlling weeds on their land (including declared plants). Many community groups, most notably the Environmental Weeds Action Network and its associated clubs and societies, conduct removal and management of weeds.

The Saving Our Species program began in 2006 and the weed eradication and control component builds on the *Environmental Weed Strategy for Western Australia* (Department of Conservation and Land Management, 1999b). Forty weed species are being targeted in the initial 18 projects to eradicate entire weed populations at a local scale where possible. Targets under the program include: cactus on pastoral land north of Carnarvon; asparagus fern in Denmark, Albany and Margaret River; cape tulip and watsonia in parts of the Perth metropolitan area; athel pine (tamarisk) at Lake Boonderoo; various weed species on the south coast; neem in Kununurra; prickly acacia in the Durack River area in the Kimberley; date palms in Pilbara wetlands; and various weeds in the Shark Bay World Heritage Property. Projects targeting South African grass species in high conservation value areas in Perth are also a priority.

Biodiversity Conservation Strategy: The Department of Environment and Conservation has released *A 100-year Biodiversity Conservation Strategy for Western Australia: Blueprint to the Bicentenary in 2029*. Public submissions were requested and a final biodiversity conservation strategy is in preparation (Department of Environment and Conservation 2006a).

Research: The Department of Agriculture and Food conducts research on a wide range of weed species and houses the largest group of weed researchers in the State, whose primary focus is on agricultural weeds. The Cooperative Research Centre for Australian Weed Management is working to reduce risks posed by current and new weed incursions through programs in research, education and information delivery across Australia. Major research efforts have contributed to the search for biocontrol insects to control weeds such as blackberry, bitou bush/boneseed, parthenium weed and Paterson's curse.

Implications

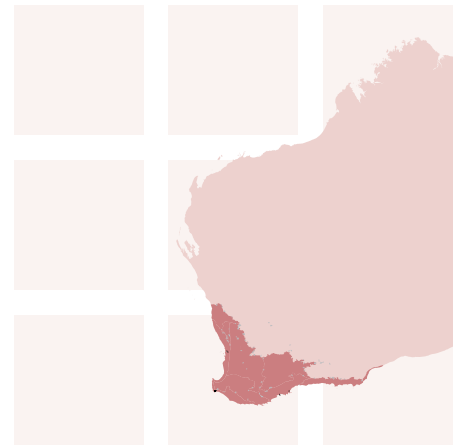
Weeds have significant impacts on WA's environment, society and economy. It has been estimated that the cost to Australian agriculture alone is over \$4 billion a year (Australian Weeds Committee, 2006) and may consume as much as 20% of production costs (State Weed Plan Steering Group, 2001). Aquatic weeds can also foul water supplies and clog irrigation and drainage systems, requiring extensive maintenance works. Weeds can impact human health if they produce toxic substances, irritants or allergens and may lead to a loss of recreational and aesthetic values. The cost of weeds to the environment is incalculable. Loss of biodiversity (including extinctions and permanent changes to ecosystems) will continue with further invasion and spread of weeds. Weed control requires consistent and sustained effort over time. Environmental weeds are generally not well controlled compared to agricultural or pastoral weeds. Many areas of WA have significant economic and workforce limitations that make ongoing control very difficult. The spread of weeds can also contribute to changed fire regimes and landscape-level change to ecosystems.

SUGGESTED RESPONSES

- 5.16 Implement the *Environmental Weed Strategy for Western Australia*. While the strategy was launched in 1999, very limited progress has been made to date.
- 5.17 Prevent the entry of exotic plants to Western Australia, and restrict the sale of potential environmental weeds throughout the State.
- 5.18 Expand current programs for weed surveillance and control.



Prickly pear (Department of Agriculture and Food)



INDICATIVE EXTENT OF ISSUE

PRIORITY RATING: 1

KEY FINDINGS

- Up to 40% of South West flora is susceptible to infection by *Phytophthora dieback*.
- *Phytophthora dieback* is present in about one quarter of the South West area where mapping has been undertaken.
- Currently there is no way of stopping the spread of the disease, and no cure exists for infected plants.

Description

Phytophthora dieback (also known as 'dieback' or 'jarrah dieback') was first observed in WA in about 1921 as unexplained death of shrubs and jarrah trees. It is believed to have been introduced with horticultural plants soon after European settlement in the South West (Government of Western Australia, 1998). The common name, jarrah dieback, is misleading as the disease affects a very wide range of plant species. The term dieback also refers to vegetation decline caused by salinity, drought, insect damage and other pathogens in other parts of Australia. It was not until the mid-1960s that the causal relationship between large scale tree decline and death and the pathogen *Phytophthora cinnamomi* was established. Originally the *Phytophthora dieback* organism was thought to be a fungus but it has subsequently reclassified as a water mould (Dieback Working Group, 2000). The pathogen has been listed as one of the worst 100 invasive species in the world.

Phytophthora dieback represents a serious threat to native flora and biodiversity in the South West. The organism lives in soil and can invade plant roots, causing decay and reducing the plant's ability to absorb water and nutrients and resulting in the eventual death of plants. The infection can spread naturally through movement of soil through water by animals disturbing soil, or from root-to-root contact between affected and healthy plants. Human activities, including road construction, earth moving, livestock movement, wood harvesting and the movement of people and vehicles across infected areas can distribute the disease rapidly across a wide area.

The presence of *Phytophthora dieback* is not obvious until plant death has started and the foliage begins to turn yellow or brown. Some plants die very rapidly, while others undergo a general decline as the foliage recedes down the tree. The infection can destroy whole ecological communities, also preventing the regrowth of many plant species and reducing available habitat for animals (Department of Conservation and Land Management, 2003c). Some garden, orchard and plantation species are also susceptible. Unfortunately there is no cure for plants once they are infected, and no way of preventing spread through the soil via water flow. The only treatment (phosphite) provides a boost to the plant's immune system but does not eliminate the disease, and requires on-going labour intensive treatments over time to be effective.

Objectives

- To reduce the further spread of *Phytophthora cinnamomi* and its impact on biodiversity.

Condition

Indicator B23: Area of land affected by *Phytophthora dieback*.

Phytophthora dieback is known to occur in forested areas of the South West between Jurien and Esperance (Figure B5.1). *P. cinnamomi* is found throughout the landscape in areas receiving above 800 mm of rainfall annually, and is confined to stream systems and road verges where annual rainfall is between 600–800 mm. Where rainfall is less than 600 mm, *P. cinnamomi* is restricted to low-lying areas which can fill with water, or sites that have been altered and receive excessive drainage. There is no record of *P. cinnamomi* in regions receiving less than 400mm annual rainfall (Department of Conservation and Land Management, 2004a).

A total of 720 000 ha of land in the South West has been intensively mapped for dieback. Of this at least 170 000 ha (24%) were found to be affected. This figure is an underestimate because many of these areas were mapped some years ago, and the disease is likely to have spread since then (Department of Environment and Conservation, 2006b). One of the worst affected areas in the State is the Stirling Range National Park near Albany – 65% of the park is currently affected by *Phytophthora dieback*. In the South Coast region 800 000 ha have been remotely surveyed for *Phytophthora dieback* and 58% (465 000 ha) appears to be infested by the pathogen.

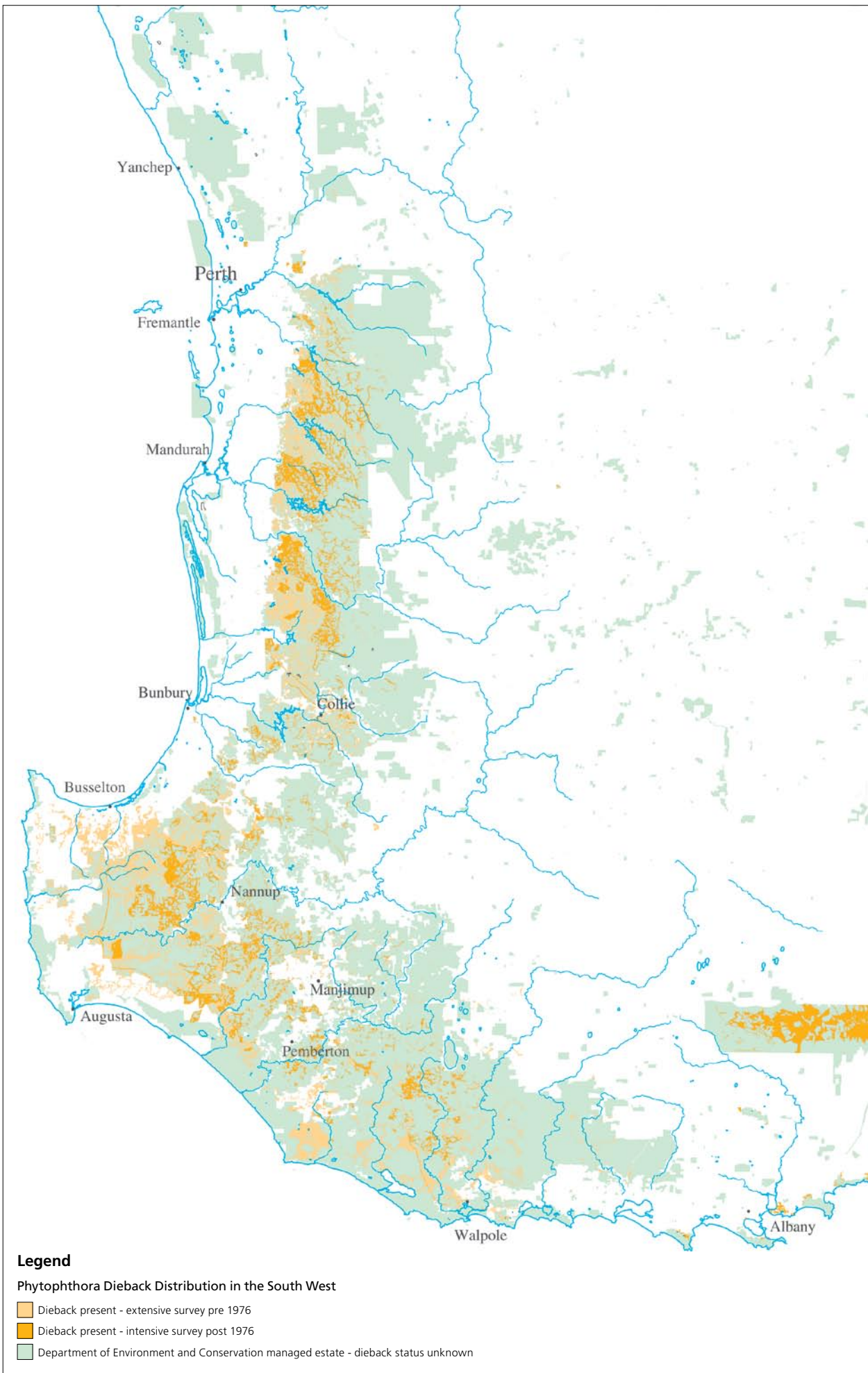


Figure B5.1: Known Phytophthora dieback occurrence in Western Australia.

Data source: Department of Conservation and Land Management [ver. 2006]. Presentation: Department of Conservation and Land Management. Note: Dieback data was compiled from various sources dating from 1976 to 2001, and it has not been updated to show spread from original mapping sites.



The effects that *Phytophthora* dieback has on the landscape are devastating (T. Chvojka)

Indicator B24: Number of species affected by *Phytophthora* dieback.

About 14% of South West flora species are highly susceptible to infection by *P. cinnamomi*, and 40% of species are considered susceptible (Shearer et al., 2004). This equates to 2284 susceptible plant taxa, including 800 that are highly susceptible (of the 5710 described taxa in the South West described in 2004). Of the State's threatened flora, 49% are susceptible to the pathogen (Shearer et al., 2004). *Phytophthora* dieback is the primary extinction threat to the critically endangered Montane Thicket of eastern Stirling Range threatened ecological community, and threatened flora species including the feather-leaved banksia (*Banksia brownii*), Fairall's honeysuckle (*Lambertia fairallii*), *Dryandra montana*, *Lambertia echinata* subsp. *echinata* and *Lambertia orbifolia* subsp. *orbifolia* (D Coates, Department of Conservation and Land Management, pers. comm.).

Animals threatened by changes to plant communities caused by *Phytophthora* dieback include the woylie (*Bettongia penicillata*), honey possum (*Tarsipes rostratus*), dibbler (*Parantechinus apicalis*), mardo (yellow footed antechinus; *Antechinus flavipes*), Gilbert's potoroo (*Potorous gilbertii*), western spinebill (*Acanthorhynchus superciliosus*), ground parrot (*Pezoporus wallicus*), western bristlebird (*Dasyornis longirostris*), western whipbird (*Psophodes nigrogularis nigrogularis*) and many invertebrates (comp. Carter, 2004; Garkaklis et al., 2004; D Coates, Department of Conservation and Land Management, pers. comm.).

Pressures

There are no eradication methods for *P. cinnamomi*. This means that the only way to address the existing problem is to prevent its spread and manage impacts in affected areas. This may involve quarantining infected areas with hygiene procedures such as thorough washing of machinery, vehicles or footwear prior to leaving infected areas or entering uninfected areas. Alternatively it may involve limiting forest-related activities (e.g. tourism, wood harvesting, road construction) to dry soil conditions and limiting access to infected areas by fencing, signage, upgrading tracks or restricting access.

Direct application of the chemical phosphite is useful for helping to protect susceptible vegetation from *P. cinnamomi*. Phosphite is a biodegradable fungicide that helps to improve a plant's immune system. Phosphite needs to enter a plant's water system to be effective, and this can be done by injection or spraying the foliage or trunk of understorey plants. Phosphite is not toxic to people or animals and has a very low pollution risk. Phosphite only provides temporary protection against *P. cinnamomi*, so treatment needs to be ongoing. Existing application methods are labour intensive, require human access to infested areas and cannot be conducted on a large scale.

Options for the restoration of areas with serious environmental damage through *P. cinnamomi* infection, or for the successful translocation of threatened flora, are limited. If a species is susceptible to *Phytophthora* dieback, its long-term survival options are limited to phosphite application and ex situ conservation and research. This could include research on germination processes, site establishment and collection, and possible reintroduction to suitable sites.

Indicator B25: Area being treated for *Phytophthora* dieback.

The Department of Environment and Conservation undertakes an annual phosphite-spraying program over 164 ha across the South West and protects 17 critically endangered species of native flora and two threatened ecological communities (Department of Environment and Conservation, 2006b). An infested area in the Fitzgerald River National Park is currently being fenced and being subjected to a range of experiments to try to contain the pathogen (such as using high intensity phosphite applications and by controlling surface and subsurface waterflows).

Current responses

Dieback Consultative Council: The Dieback Consultative Council was created in 1997 to provide advice on *Phytophthora* dieback matters to the Minister for the Environment. It includes representatives from the community, government agencies, industry and tertiary institutions and helped to develop the Dieback Response Framework. The Council also identifies research priorities and funding and the raising of public awareness of the issue.



Dieback Working Group: The Dieback Working Group is a community organisation which aims to raise public awareness and understanding of Phytophthora dieback in Perth and the South West, encourage the adoption of dieback prevention and management policies and encourage the implementation of management procedures to minimise the spread and impact of the pathogen.

Dieback Response Framework: is a whole-of-government framework being implemented for the management and control of Phytophthora dieback. Actions include the development and release of a Phytophthora dieback atlas for WA; developing a whole-of-government policy on Phytophthora dieback management; developing guidelines for private and local government land; and developing a generic Phytophthora dieback risk assessment methodology for broad community use.

Dieback Response Group: The Dieback Response Group began in 2004 and comprises representatives from the Dieback Consultative Council, Murdoch University's Centre for Phytophthora Science and Management, the Dieback Working Group, the Department of Environment and Conservation, and the Conservation Commission. The group is progressing implementation of the *Dieback Response Framework* and monitors its progress. It has recently published an atlas of known Phytophthora dieback occurrences in WA (Department of Environment and Conservation, 2006b). A website was recently launched to bring together all the groups working in Phytophthora research, management and policy, and provide an easy way for people to access information about the disease.

Dieback guidelines: The former Department of Conservation and Land Management's *Threat Abatement Plan for Phytophthora cinnamomi* and *Best Practice Guidelines for the Management of Phytophthora cinnamomi* provide guidance on how to manage and prevent the spread of Phytophthora dieback (Department of Conservation and Land Management, 2004b; 2004c).

On-ground management: Department of Environment and Conservation is responsible for coordinating Phytophthora dieback activities including the detection, diagnosis and mapping of the occurrence of *P. cinnamomi*, preparing disease management plans for all uninfected areas, and an annual phosphite spraying program. Community groups such as the Friends of Lightning Swamp Bushland and the Roleystone Dieback Action Group undertake on-ground management and awareness-raising.

The Saving Our Species program began in 2006 and its projects include radical treatment of an infestation in the Fitzgerald River National Park, strategic and operational mapping of Phytophthora dieback and risk assessment modelling in partnership with regional natural resource management groups, and increased application of the chemical phosphite to protect threatened plants in Stirling Range National Park and in areas around Albany, Esperance, Busselton and the Walpole Wilderness Area.

Biodiversity Conservation Strategy: The Department of Environment and Conservation has released *A 100-year Biodiversity Conservation Strategy for Western Australia: Blueprint to the Bicentenary in 2029*. Public submissions were requested and a final biodiversity conservation strategy is in preparation (Department of Environment and Conservation 2006a).

Natural Heritage Trust/National Action Plan for Salinity and Water Quality (NHT/NAP): These are two Commonwealth Government programs that aim to ensure environmental (on-ground) improvements occur via a targeted strategic approach at the regional level. The Swan, South West, South Coast and Northern Agricultural catchments councils are undertaking projects to manage the spread of Phytophthora dieback in their regions.

Threat abatement plan: Phytophthora dieback is listed as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) and a threat abatement plan has been completed.

Research: Murdoch University's Centre for Phytophthora Science and Management is providing research on the biology of *P. cinnamomi*, management of the disease, ecosystem restoration and detection, diagnosis and mapping of the disease.

Implications

The death of native plants caused by Phytophthora dieback reduces the biodiversity of the South West and has the potential to cause extinction of threatened flora and fauna. Community amenity and aesthetics are lost when local bushland, backyards and gardens become infected. Public access and enjoyment of national parks are lost if they are forced to close or restrict access to some areas to contain disease spread. There is also the cost of 'cleaning up' dead trees, ensuring public safety, and rehabilitating areas damaged by Phytophthora dieback. Phosphite treatments are not a cure and must be repeatedly applied to postpone onset of the disease, making it an expensive and unsustainable long-term solution (comp. Carter, 2004). The cost of Phytophthora dieback treatment and prevention on former Department of Conservation and Land Management administered land was estimated at \$1.6 million in 2005 (Department of Conservation and Land Management, unpublished data) and control is currently undertaken only in very small areas. Phytophthora dieback is also a major economic cost for the mining, horticulture, floriculture, wood production and tourism industries. The estimated economic losses from Phytophthora dieback are \$200 million per year (Hardham, 2003).

SUGGESTED RESPONSES

- 5.19 Develop and implement an effective whole of government policy to reduce the spread of Phytophthora dieback (including an investment strategy).
- 5.20 Expand specialised control in areas of high biodiversity value (e.g. threatened ecological communities and the Fitzgerald River National Park).
- 5.21 Expand research into more effective control methods for Phytophthora dieback, while also continuing research to find a method of eradication.

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Snappy gum and spinifex in the Pilbara region of WA (Tourism WA)

