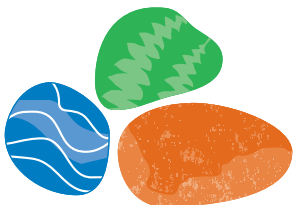


The Southwest Australia Ecoregion

Jewel of the Australian Continent



Southwest Australia
Ecoregion Initiative

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Author: Cheryl Gole, WWF-Australia

Cover photograph: Richard McLellan, WWF-Australia

First published: April 2006 by Southwest Australia Ecoregion Initiative.

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Designer: Sophia Hall, Dynamic Orange.

Printed by: Lamb Print on Monza Satin recycled paper.

For copies of this document, please contact SWAEI Secretariat, PO Box 4010, Wembley, Western Australia 6913. This document is also available from the SWAEI website at <http://www.swaecoregion.org/>

Acknowledgements

The following people reviewed this document or contributed information: Ken Atkins (Department of Conservation and Land Management), Mary-Anne Clunies-Ross (Water Corporation), Robert Davis (University of Western Australia), James Duggie (WWF), Cheryl Gole (WWF), Richard Hobbs (Murdoch University), Steve Hopper (School of Plant Biology, University of Western Australia), Richard McLellan (WWF), Cameron Poustie (Conservation Council of WA), Neil Riches (Australian Government NRM Office), Beth Schulz (Conservation Council of WA) and Nicole White (Murdoch University).

The Southwest Australia Ecoregion Initiative (SWAEI) is comprised of a consortium of member groups who are contributing ideas and resources towards the development of a Conservation Strategy for the Southwest Australia Ecoregion. A large number of people have contributed to Steering or Working Group discussions or provided written feedback, including the following: Ken Atkins (Department of Conservation and Land Management), Paddy Berry (Western Australian Museum), Mary-Anne Clunies-Ross (Water Corporation), Robert Davis (Birds Australia WA), Mike Grasby (State Government NRM Office), Cheryl Gole (WWF), Richard Hobbs (Murdoch University), Steve Hopper (Botanic Gardens and Parks Authority and University of Western Australia), Martin Heller (Australian Government NRM Office), Ric How (WA Museum), Andrew Huggett (CSIRO), Verity Klemm (Department of Environment), Robert Lambeck (Greening Australia WA), Ted Lefroy (CSIRO), Brendan Lynch (WWF), Jane Madgwick (WWF), Mike McFarlane (the community), Richard McLellan (WWF), Peter Newman (State Sustainability Office), Bob Nulsen (Department of Agriculture WA), David Nunn (Department for Planning and Infrastructure), Tom Perrigo (National Trust of Australia WA), Cameron Poustie (Conservation Council of WA), Neil Riches (Australian Government NRM Office), Rod Safstrom (Conservation Commission), Clare Taylor (Australian Government NRM Office), Lesley Thomas (Eastern Metropolitan Regional Council) and Gary Whisson (Department of Environment).



© Mick Davis, WWF-Australia
A native bee on a Verticordia flower. Most native bees are solitary bees which raise their young in burrows in the ground or in tiny hollows in timber. They are important pollinators of wildflowers and thus an important part of natural bush.

Southwest Australia Ecoregion: Our Natural Heritage

The Southwest Australia Ecoregion: a Region of Global and National Significance

The Southwest Australia Ecoregion is located in the southwest corner of Australia, one of Earth's five most megadiverse countries. It is globally recognised as one of the planet's major biodiversity hotspots. This recognition of global significance is based on high levels of natural diversity, particularly for plants and amphibians, together with high levels of threat to that diversity. It is one of only five Mediterranean-type ecosystems to be listed as globally significant. It is also one of the few hotspots found in a developed country and is the only global hotspot in Australia. The importance of Southwest Australia's biodiversity is also recognised by the Government of Australia: five of the 15 national biodiversity hotspots are located within the Ecoregion.

The Ecoregion may also be described as an ecoregion complex with a number of distinct bioregions within its boundaries. WWF, the conservation organisation, has identified a set of global conservation priorities—the Global 200 Ecoregions—whose conservation across the globe would achieve the goal of saving a broad diversity of the Earth's ecosystems. These ecoregions include those with exceptional levels of biodiversity, such as high species richness or endemism, or those with unusual ecological or evolutionary phenomena. Two of these global ecoregions are located in Southwest Australia: the terrestrial Southwest Australia Forests and Scrub Ecoregion and the freshwater Southwest Australia Rivers and Streams Ecoregion.



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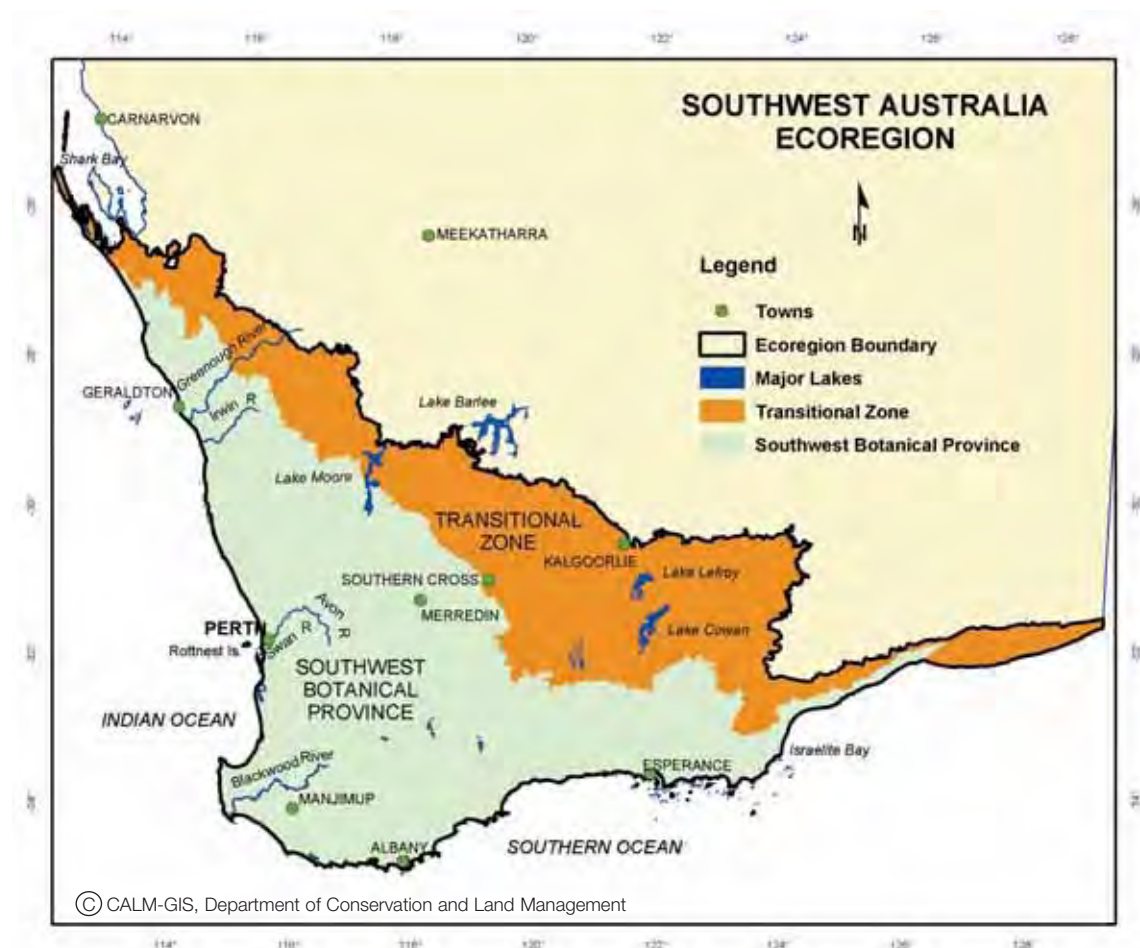
The Southwest Australia Ecoregion is also a Centre of Plant Diversity. Centres of Plant Diversity are areas defined by WWF and the International Union for Conservation of Nature and Natural Resources (IUCN) as places particularly rich in plant life. If protected, Centres of Plant Diversity would safeguard most of Earth's plant diversity. Twelve bird species are also endemic to the Ecoregion and it is thus recognised by Birdlife International as one of the globe's 218 Endemic Bird Areas, areas defined as containing two or more of the world's restricted range bird species.

The Ecoregion is comprised of the Southwest Botanical Province identified by Beard in 1980, together with an area of semi-arid gradation (the Transitional Zone) to the arid zone. The Transitional Zone represents an extension of Beard's Southwestern Interzone. Boundaries of the Transitional Zone have been determined by the inclusion of three biogeographic regions—the Yalgoo, Coolgardie and Hampton biogeographic regions.

Banksias are spectacular members of the diverse flora of the Ecoregion. Baxter's Banksia (*Banksia baxteri*) grows in Kwongan near the south coast.

It is a large Ecoregion. Covering approximately 48.9 million hectares (489,944 km²), it is roughly triangular in shape, stretching between Shark Bay in the northwest to Esperance in the southeast, with a narrow strip along the southeastern coast to the border between Western Australia and South Australia. Bounded by oceans to the west and south and arid shrublands to the north and east, it is situated between latitudes 27°S and 35°S and longitudes 112°E and 128°E. This is one of the oldest and most diverse landscapes in the world. Its major vegetation types are woody and include the temperate forests of the deep southwest; woodlands, mallee and shrublands of the temperate and semi-arid zones; kwongan heathlands; and other habitats such as naturally saline wetlands and granite outcrops. Vegetation types are often present within mosaics of plant communities that vary considerably over relatively short distances. Across climate gradations and mosaics of soil types, plant species richness and levels of endemism are high. Within the Southwest Botanical Province, 7,380 plant taxa (6,759 species) have been identified. Almost half (3,620 species) are endemic to the Province, with an unusually high diversity of species within the Proteaceae and Myrtaceae families. It is probable that a combination of ecological and phylogenetic (relating to or based on evolutionary development or history) processes have operated over long periods of time and resulted in a diverse and species-rich flora in Southwest Australia. Landscapes in the Ecoregion are relatively flat: for over 250 million years, and in the almost complete absence of mountain building, climate changes and erosion processes have leached ancient soils of much of their nutritive value. The flora is thus highly adapted to the nutrient-poor soils of the Ecoregion.

Beyond its global and national importance for biodiversity, the Ecoregion has a unique and important cultural heritage. Its landscapes have been peopled for at least 50,000 years. Aboriginal culture and relationships between groups and families are rich and complex. Although broadly, much of the Southwest has been the homeland for the Noongar (Nyooongar or Nyungar) people, for the Yamadji people in the northwest of the region, and the Wongai people in the east, Southwest Australia is a mosaic of linguistic and cultural diversity. Indigenous life relates to the connection of individual people to Aboriginal culture and Country, and Aboriginal people have a close, traditional association with many components of the Ecoregion's natural diversity. These traditional knowledge and belief systems are an important aid to conservation.



Isolated by oceans and deserts, the Southwest Australia Ecoregion has high levels of natural diversity, particularly for plants and amphibians.

European settlement has a relatively recent history within the Ecoregion, dating back to 1826, but many people depend on the natural resources of the Southwest Australia Ecoregion for their livelihoods. Outside the main population centres, where the service industries, manufacturing and commerce are the main sources of income, most income is derived from agriculture, pastoralism, forestry and mining. Most of these activities are dependent on natural resources for long-term sustainability. Natural resources such as water, biodiversity and soil are under threat from broad-scale threatening processes such as dryland salinity, altered hydrology, climate change, and degradation due to ongoing processes such as grazing by domestic stock, diseases such as *Phytophthora dieback*, inappropriate fire regimes and invasions by weeds and feral animals.

Key underlying causes for biodiversity loss and decline of other natural resources include continued clearing (vegetation stripping) for agriculture and urban development, particularly in coastal and peri-urban areas; lack of resources and incentives for conservation, particularly for private landholders; and a lack of a visionary action plan for a comprehensive conservation strategy for the whole Ecoregion. Many of the endemic species of the Ecoregion are threatened, giving Southwest Australia the highest concentration of rare and endangered species on the continent. Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*), the Western Swamp Tortoise (*Pseudemydura umbrina*) and Gilbert's Potoroo (*Potorous gilbertii*) are just some of the endangered fauna that are unique to the Ecoregion. In March 2006, 351 species and subspecies of plants were listed as threatened within the Ecoregion. Some processes pose enormous challenges. For example, within the Wheatbelt region of the Southwest Ecoregion, over 470 plant species and subspecies are at risk of extinction from the effects of dryland salinity. Salinity also affects the productivity of much agricultural land.

“ ... partnerships are the most effective means of undertaking broad-scale, ecoregion-wide conservation planning and action.”

The Southwest Australia Ecoregion: Australia's only global biodiversity hotspot

A tiny fraction of intact remnants of habitats on Earth—just 2.3% of the earth's surface—is home to more than half of the planet's living species. These areas are also among those that are most threatened. These are the global biodiversity 'hotspots': the richest reservoirs of plant and animal life on Earth. To qualify as a hotspot, a region must meet two strict criteria: it must contain at least 1,500 species of vascular (higher order) plants (> 0.5% of the world's total) as endemics, and it has to have lost at least 70% of its original habitat.

The Southwest Australia Ecoregion is one of 34 global biodiversity hotspots recognised by Conservation International. It is Australia's only global hotspot, recognised worldwide for its wealth of natural diversity, particularly in plants, and the high degree of threat to this important natural resource. The Southwest Australia Ecoregion is thus a significant part of the planet's natural heritage, and the conservation of the biodiversity of this globally significant area is the responsibility of all Australians.

What is an ecoregion?

An ecoregion is a large area of land containing a geographically distinct assemblage of species, natural communities, dynamics and environmental conditions. Working at the ecoregion scale offers several advantages for conservation planning and action. Defined in biological terms, an ecoregion focuses attention on the biodiversity at stake, compelling us to think, plan and act for a single ecological unit, unrestricted by political boundaries. Because ecoregions are identified as far as possible to be biologically coherent, it is possible to set more meaningful and strategic biodiversity conservation goals—focusing on populations, processes and ecological phenomena and threats important to the region. Ecoregion conservation is visionary, encouraging us to plan for the long term. The ecoregion approach requires us to address threats that affect the entire area, often occurring beyond the ecoregion's boundaries.

The Southwest Australia Ecoregion is a global biodiversity hotspot with outstanding natural environments whose protection is essential for the preservation of the world's biodiversity.



Roadside vegetation often has high biodiversity value. It may be extremely attractive and, in some areas, forms the basis of the important wildflower tourist industry. This pea flower (a *Sphaerolobium* species) is growing in roadside vegetation near the Mt Lesueur National Park, one of the most floristically diverse areas within the Ecoregion.



Global hotspots. The Southwest Australia Ecoregion is one of the world's biodiversity hotspots and one of only five Mediterranean-type ecosystems to be listed as globally significant. Map courtesy of Conservation International.

Conservation in the Ecoregion

The Australian Government, local government, regional Natural Resource Management groups, community groups, environmental non-government organisations, and private individuals have all made an important contribution to conservation. However, the need for conservation planning at the scale of the Ecoregion, rather than at the scale of the state, natural resource management region, or bioregion, has been recognised by government, as well as a range of concerned stakeholders. In 2002, the Western Australian Salinity Task Force Report (2002) recognised the need for *'an agreed vision for future landscapes ... that recognises the richness and vulnerability of biodiversity, the threat of salinity and climate change'* and *'a tangible long-term vision for the landscape of the South West of Western Australia with an estimate of the budget needed to achieve it'*. A consortium of stakeholders is now seeking to advance the vision of the conservation of biodiversity in this global biodiversity hotspot.

A vision for biodiversity conservation in the Southwest Australia Ecoregion

In 2003, a consortium of stakeholders with an interest in conservation planning at an ecoregional scale formed the Southwest Australia Ecoregion Initiative to advance the recognition of the global significance of this highly biodiverse region and the threats to its long-term survival. The consortium comprises relevant government agencies, environmental non-government organisations, universities, research institutions, local government and community representatives. Members of the consortium value the importance of collaborative conservation action across the Ecoregion, and the role of partnerships as the most effective means of undertaking broad-scale, ecoregion-wide conservation planning and action. A dual role for the partnership program has been identified: to provide a collective view on the value of the biodiversity of the Southwest Australia Ecoregion, and to chart a way forward that will ensure the conservation of the Ecoregion and its biodiversity and invaluable natural resources.

The Initiative aims to catalyse a concerted effort for nature conservation in the Ecoregion. It uses a visionary approach to think long term and large scale while seeking strong political and grassroots support for conservation activities on private and public land. Through a biodiversity assessment of the Ecoregion to identify biodiversity patterns and values, the Initiative aims to greatly enhance the national and international recognition of the significance of the Ecoregion. It plans to develop a comprehensive and collaborative conservation strategy that will help to attract additional funds to address key threats and priority conservation actions identified by stakeholders. This approach will seek to complement existing conservation programs and add value to existing strategies.



© Cameron Poustie, Conservation Council of WA
The Bibbulmun Track, east of Waroona. This popular hiking track passes through much of the forested part of the Ecoregion.

What is biodiversity?

Natural or biological diversity, or biodiversity, is all life on earth—plants, animals, fungi and microorganisms—as well as the variety of genetic material they contain and the diversity of ecological systems in which they occur. It includes the relative abundance and genetic diversity of organisms from all habitats including terrestrial, marine and other aquatic systems.

Biodiversity is thus usually considered at three different levels: genetic diversity, species diversity and ecosystem diversity.

- *Genetic diversity* refers to the variety of genetic information contained in all living things. Genetic diversity occurs within and between populations of species as well as between species.
- *Species diversity* refers to the variety of living species.
- *Ecosystem diversity* relates to the variety of habitats, biotic communities, and ecological processes, as well as the diversity present within ecosystems in terms of habitat differences and the variety of ecological processes.

Evolutionary change results in an ongoing process of diversity within living things. Biodiversity increases when new genetic variation is produced, a new species evolves or a novel ecosystem forms; it decreases when the genetic variation within a species decreases, a species becomes extinct or an ecosystem is lost. This concept emphasises the interrelated nature of the living world and its processes.

The importance of biodiversity

We are dependent for our sustenance, health, well-being and enjoyment of life on biological systems and processes. Humanity derives all of its food and many medicines and industrial products from wild and domesticated components of biodiversity. Natural resources also serve recreation and tourism, and underpin the ecosystems which provide us with many services.

While the benefits of such resources are considerable, the value of biodiversity is not restricted to these. The enormous diversity of life in itself is of crucial value, probably giving greater resilience to ecosystems and organisms. Biodiversity also has important social and cultural values.

A vision for the Ecoregion

The vision for the Southwest Australia Ecoregion Initiative is that of

‘a diverse and continuous mosaic of natural landscape features distributed across the landscape, interspersed with a diversity of socially and economically productive land uses which support the natural diversity and natural functioning of that landscape.’

Biodiversity of the Southwest Australia Ecoregion

Natural assets may include biodiversity, land, water and air, among others. While the values of land, water and air are well recognized due to the clear dependence of human existence on them, increasingly, biodiversity is also being recognised as being an asset. That is, biodiversity is something that is useful or valuable. Biodiversity assets may include large, intact areas of remnant vegetation; wilderness areas; protected areas such as national parks and nature reserves; habitat types such as woodlands, forests and kwongan; vegetation communities; and aquatic diversity, including a broad range of wetland types and rivers and streams. They may also include a diverse range of living things including flora, fauna, fungi and individual populations or threatened species. Assets may be particular components of biodiversity—for example, an ecological community or threatened species—or a range of components assumed or known to be contained within a larger asset such as extensive areas of intact bushland or wetland. In some cases, the intrinsic value of these assets to human communities may not be immediately apparent.

The scope of the Southwest Australia Ecoregion Initiative is all of the terrestrial and aquatic elements of the Ecoregion. The great importance of the marine components of biodiversity is acknowledged, however the conservation of these is outside the scope of the Initiative.

The biodiversity assets of the Southwest Australia Ecoregion are diverse and immeasurably valuable. As such, they are part of the natural heritage of all Australians. In this booklet, it is impossible to describe all biodiversity assets within the Ecoregion. It is hoped that details of a few special assets of one of the world's globally significant hotspots of natural diversity will provide an insight into its diversity and great value.

Special Habitats

Kwongan

Mediterranean regions of the world are characterised by typically mild climates with winter rain and summer drought, and sclerophyllous (hard-leaved) vegetation that is structurally similar. These include the South African *fynbos*, Californian *chaparral* and Chilean *matorral*. In the Southwest Australia Ecoregion, these shrublands and heathlands are known as *kwongan*, a word of Aboriginal origins. Kwongan is a highly diverse vegetation formation that is unique to Western Australia and the Southwest Australia Ecoregion.

Kwongan is any sclerophyllous (hard-leaved) shrubland plant community. It includes coastal wind-pruned heaths, scrub-heaths, hill thickets (for example those of the Stirling Ranges) and shrublands on laterite ridges, and may include scattered taller shrubs. Most kwongan is distributed across sandplains. Prior to clearing, approximately 30% of the Ecoregion was covered by kwongan. Most of the original Wheatbelt kwongan has been cleared but significant amounts remain in some coastal and near-coastal areas.



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Kingias (*Kingia australis*) in coastal kwongan at Waychinicup National Park. The diversity and endemism of kwongan flora is high, but it is threatened by clearing, particularly in urban and coastal areas, and the disease *Phytophthora* dieback.

The diversity and endemism of the kwongan flora are high. A recent study has shown that the biodiverse flora of the Southwest Botanical Province is richest in the coastal and inland kwongan. Important families include the Proteaceae (genera such as *Banksia*, *Dryandra* and *Hakea*), Myrtaceae (*Verticordia* and *Eucalyptus*) and Papilionaceae (*Daviesia* and *Jacksonia*).

Few species of fauna are endemic to kwongan, although the abundant nectar of some plant species is important for birds such as honeyeaters and the Ecoregion endemic mammal, the tiny Honey Possum (*Tarsipes rostratus*). Key threatening processes for the kwongan include clearing for urban development on the Swan Coastal Plain, dieback disease caused by *Phytophthora cinnamomi* and inappropriate fire regimes.

Granite outcrops

Granites are a major component of ancient crystalline blocks or shields forming the earth's continents. They underlie much of the Southwest Australia Ecoregion and emerge from the surface as outcrops. Near the south coast, outcrops may be part of extensive systems of inselbergs, such as the granite systems in national parks like Cape Arid, the Porongurups and Cape Le Grand. Most, however, are isolated and clearly disjunct. Within the Ecoregion, granite outcrops support characteristic assemblages of flora and fauna often isolated from the surrounding relatively low-relief environment. They show biogeographic patterns similar to those of the whole flora of the Ecoregion—that is, there is pronounced species richness and endemism in the Wheatbelt that declines as the rainfall further decreases towards semi-arid and arid areas to the north and east. The outcrops are also significant in cultural terms, with a rich Aboriginal and European history.

The biogeographic patterning of species on granite outcrops in the Ecoregion is a result of an increasing drying of the climate since the late Tertiary (65 million years ago to 1.8 million years ago) and reflects the ability of the rocks to collect water and retain moisture. High solar radiation, rapid rainfall runoff and shallow soils on rocky substrates combine to allow the formation of microhabitats with extreme seasonal and diurnal variations. There are many examples of granite outcrops retaining relict disjunct populations of plants. For example, a relict outlier of Jarrah (*Eucalyptus marginata*) survives at Jilakin Rock, 150 km inland from the main forest population in the higher rainfall zone. The isolation of plant communities between granite outcrops has contributed to speciation. Granite endemics include Caesia (*Eucalyptus caesia*), Silver Mallee (*E. crucis*), Granite Kunzea (*Kunzea pulchella*) and some orchids.



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Granite outcrops are important areas of diversity in the Ecoregion. They may be isolated outcrops or a part of larger systems of inselbergs, such as Mount Arid, east of Esperance.

Only one vertebrate animal is endemic to granite outcrops, the widespread Ornate Dragon lizard (*Ctenophorus ornatus*). The flora of granite outcrops is more endangered than flora elsewhere, owing to the isolation and small size of populations. Some species have a small number of populations on several outcrops, while others are restricted to single rocks. As granites occupy only a small proportion of most areas in which they occur, and many plant populations are by definition rare and likely to contain rare species, management is particularly important. Threatening processes include weed invasion, grazing by domestic stock and feral animals such as rabbits, inappropriate fire regimes and the introduction and spread of *Phytophthora dieback*.

Eucalypt woodlands

Woodlands are defined as ecosystems containing widely spaced trees with crowns that do not touch and a projected crown cover of less than 30%. Eucalypt woodlands were once widespread throughout much of the Ecoregion, generally appearing in complex vegetation mosaics with forests, kwongan and other shrublands. Many woodlands occurred on comparatively naturally fertile soils and these were preferentially and extensively cleared for agriculture, resulting in a significant reduction in the extent of woodlands throughout the agricultural zone. Those that remain in this area largely exist in a mosaic of isolated vegetation fragments, many of which are degrading due to fragmentation, unsuitable fire regimes, grazing, weed invasion, timber collection, and the ongoing edge effects that characterise many bushland remnants in these regions. On the valley floors, salinisation, acidification and rising groundwaters are important threats. In the transitional zone of the Ecoregion, threats include mining and grazing by domestic stock and feral animals. However, substantial tracts of magnificent woodlands still exist in these easterly, more arid areas in the transitional zone of the Ecoregion. In coastal areas, clearing for urban development is an ongoing threat.

As with other components of the Ecoregion flora, the diversity of woodlands is largely a result of abiotic (non-living) factors such as rainfall gradients and variations in landform and soils. Woodlands with the same dominant eucalypt species may vary across rainfall and soil gradients and the biotic and abiotic features of woodlands are sometimes diverse. Woodlands dominated by Salmon Gum (*Eucalyptus salmonophloia*), York Gum (*E. loxophleba*) and Gimlet (*E. salubris*) have been extensively cleared in the agricultural zone but there are large areas of relatively undisturbed vegetation in the transitional zone between the Southwest Botanical Province and the arid zone. Understorey species differ between the arid and more humid zones. Salmon Gum and Gimlet are Western Australian endemics, generally occurring in areas with an average annual rainfall of 200-500mm per annum. Significant areas (78%) of these woodlands in general have been cleared for agriculture, largely from the higher fertility areas in the broad valley floors of the Wheatbelt. Less than 10% of the pre-European extent of Salmon Gum and Gimlet woodlands still exists. Within the Wheatbelt, Red Morrel (*E. longicornis*) has also been substantially cleared and is poorly reserved in the conservation estate. There has been substantial clearing of woodlands of Salmon Gum and Morrel, Salmon Gum and Goldfields Blackbutt (*E. lesouefii*), and Salmon Gum and Red Mallee (*E. oleosa*).



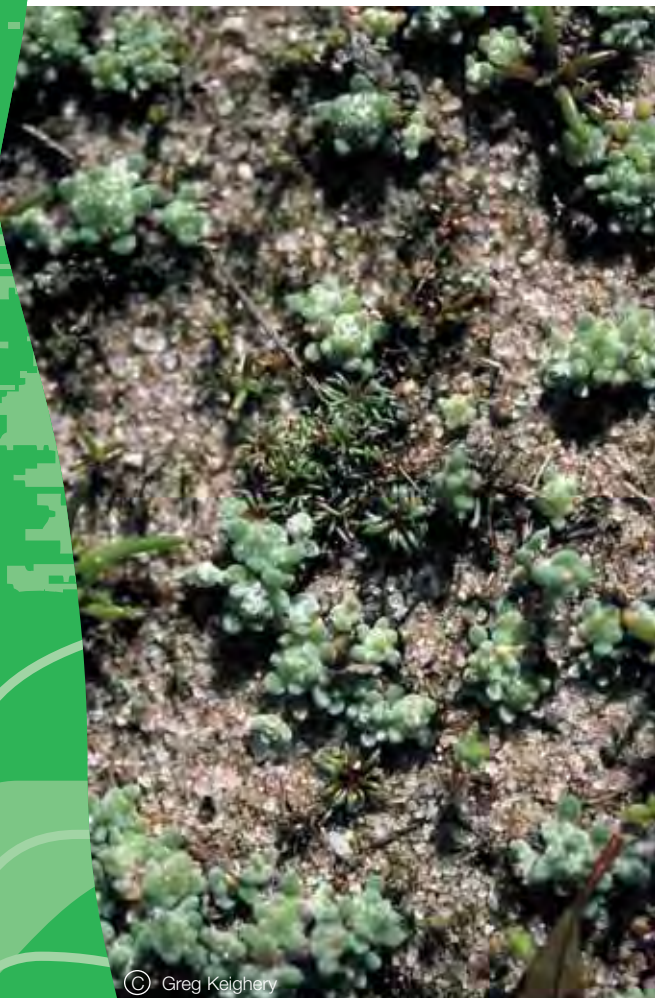
Eucalypt woodlands were extensively cleared for agriculture on the relatively fertile soils of valley floors. Those that remain are threatened by dryland salinity. This Inland Wandoo (*Eucalyptus capillosa*) woodland on seasonally wet flats shows a typically open woodland with native grasses and termite mounds.

Grazing and other degrading processes not only result in significant changes to vegetation structure and composition, but also affect surface soil condition, and the chemical, physical and hydrological properties of soil. These result in the loss of litter cover and soil cryptogams, reduced organic carbon, reduced soil water infiltration rates, altered nutrient availability and increased soil erosion.

West of the Wheatbelt, woodlands dominated by Tuart (*E. gomphocephala*) are also threatened by such processes as clearing for urban development, grazing, and a form of dieback that is causing widespread tree decline and death. Tuart woodlands occur over a 400km range from Busselton in the south to Jurien Bay in the north, largely on near-coastal sandy soils of the Swan Coastal Plain. Vegetation clearing and grazing have reduced Tuart woodlands to approximately 65% of their previous extent. Approximately one third of those woodlands remain on privately-owned land where their conservation status is not secure.

Woodlands are important habitat for the Ecoregion's birds and other arboreal fauna. A surprising number of birds are obligate hollow nesters and others use hollows as shelter and roosting sites. These include large cockatoos such as the endangered Carnaby's Black-Cockatoo but also small insectivorous birds such as Rufous Treecreeper (*Climacteris rufa*), a declining species dependent on both standing and fallen hollows and logs. Hollows in old trees are increasingly scarce. Large hollows may take up to 200 years to form and in poorly managed and degrading woodlands trees are not regenerating at a rate that will allow for eventual replacement in functioning woodland ecosystems.

The protection of all Ecoregion woodlands from all degrading processes is critical if the current decline in extent and quality of habitat is to be arrested.



© Greg Keighery

A herbfield in a naturally saline wetland at Bugin Nature Reserve. The diversity of the flora and invertebrate fauna of naturally saline wetlands is poorly appreciated.

Naturally saline wetlands

In the ancient landscapes of the Southwest Australia Ecoregion, salt has been accumulating in soil profiles and groundwaters for millions of years, much of it laid down by a variety of sources including the release of salt from the breakdown of ancient rocks, the evaporation of ancient drainage basins or inland seas, and the transport by prevailing winds of fine particles of air-borne salt from the oceans. Flat landscapes and related poor drainage meant that, over long periods of time, large quantities of salt accumulated in soils. By global standards most of the Ecoregion's wetlands are thus naturally saline.

Within the Ecoregion, only wetlands in the high rainfall areas are permanently full and even those may dry out occasionally. Elsewhere, wetlands dry out in most years or only fill episodically. Naturally saline wetlands are widespread throughout the Ecoregion. They range from very large lakes to mosaics of small playas and are a natural and ancient feature of the landscape, particularly in inland areas. Complex mosaics of soils have driven the evolution of complex vegetation systems. Such systems have a diverse fauna that has adapted to a saline environment with considerable hydrological variability. Adaptations to survival in these conditions include rapid life cycles that are completed when wetlands are full and salinity is low, and mechanisms for salt excretion.

Recent biological surveys of approximately 75% of the Ecoregion demonstrated that there are significant floristic differences in the salt lake chains comprising the paleo-drainage (ancient drainage) systems of the Ecoregion. The plant diversity of naturally saline systems is much higher than was predicted. Plant communities of naturally saline wetlands are comprised of heterogeneous communities of halophytes, such as samphires, along the wetland fringes, with perimeter shrublands and eucalypt woodlands dominating at higher levels. Dominant plant families are similar to those recorded elsewhere within the Ecoregion, however Asteraceae (daisies), Chenopodiaceae (saltbushes), Poaceae (grasses) and Apiaceae (carrot family) assume relative importance. Annual arrow grasses (*Triglochin* spp.) grow on the damp margins of naturally saline wetlands, and the Ecoregion's wetlands provide a world centre of diversity for these species.

The fauna of naturally saline wetlands is an important endemic component of the Ecoregion. There is a rich and endemic aquatic fauna of microinvertebrates, especially Crustacea. Numerous invertebrate species are restricted to naturally saline wetlands, mostly Fairy Shrimps (*Parartemia* spp.), snails (*Coxiella* spp.), Ostracods and Copepods (Crustaceans).

Naturally saline wetlands and their ecological communities occur almost exclusively on valley floors low in the landscape and are threatened by secondary salinity and inundation by rising groundwaters. Species found in naturally saline wetlands are not usually found in wetlands affected by secondary salinity. An increase in salinity in these wetlands is likely to lead to significant loss of biodiversity, as most species are associated with a particular range of water levels and salinity. There is a widespread lack of awareness of the significant biodiversity value of naturally saline systems, and an ill-informed assumption that such systems are resilient under any salinity or hydrological regime. Naturally saline areas are increasingly being used as dumping grounds for saline and hyper-saline and acidic groundwaters extracted from agricultural land by drainage and other engineering solutions to the growing problems of dryland salinity on agricultural land. There are challenges ahead in grappling with the difficulty of conserving extensive ecological systems low in the landscape that are at risk from secondary salinity and rising groundwaters.

Aquatic habitats

An integral part of the Southwest Australia Ecoregion is the enormous diversity of aquatic assets that have been shaped by, and have helped shape, many of its ecosystems. The Ecoregion's aquatic assets include river systems and streams, a diverse range of wetlands, including freshwater and naturally saline wetlands, vegetated damplands, groundwater dependent ecosystems, and subterranean karst systems. In recognition of its conservation significance the region has been selected as one of WWF's Global 200 priority freshwater ecoregions: Southwest Australia Rivers and Streams.

Within the Ecoregion, 38 rivers and more than 200 creeks and minor streams discharge into the ocean or to a coastal inlet or lake.



A series of salt lakes or playas in the Wheatbelt. These lakes are remnants of ancient drainage systems that flow only after exceptional rain. They are imbedded in a cleared landscape where vegetation is largely cleared and are affected by secondary salinisation. The paint palette effect of colours is due to the algal blooms and microbial mats that develop in response to varying levels of water and salt.

© Jenny Davis, Murdoch University

The majority of rivers originate from within 50 to 150 km from the coast. In global terms the waterways of the Ecoregion are small both in length and volume of annual water flow. However, they have a range of unique characteristics and conservation values, arising from a range of factors. These include the ancient geology of the region and the mixture of young rejuvenated rivers nearer the coast partially merging with paleo-drainage channels of ancient river systems further inland with histories of over 150 million years.

Eight Ramsar sites, registered as Wetlands of International Importance and protected under international treaty, are located within the Southwest Australia Ecoregion and others are under consideration for nomination. Nationally important wetlands range from estuarine to freshwater to naturally saline paleo-drainage lake systems.

Floristically diverse wetlands of the Ecoregion include seasonal damplands and gnammas (rock pools) on granite outcrops. Often overlooked in wetland inventories, these neglected wetlands deserve increasing focus and effort in future conservation.

Threats to the aquatic assets of the Ecoregion

The three most significant future threats to the aquatic diversity of the Southwest Australia Ecoregion are the salinisation of land and waterways; the impacts of climate change, in particular reductions in rainfall; and water abstraction and diversion for human use.

In some parts of the Ecoregion, many wetlands have been lost. On the Swan Coastal Plain, more than 75% of the permanent wetlands have been filled in or significantly modified. An even greater percentage of ephemeral wetlands and seasonal damplands has been similarly affected. In addition to the direct loss of wetlands, many of the Ecoregion's aquatic assets are degraded due to human activities including land clearing and the loss of fringing vegetation. It is estimated that, of those wetlands that remain on the Swan Coastal Plain, only 15% warrant conservation category status.

Vegetation clearance in the agricultural zone has resulted in salinisation and rising watertables. This has led to the degradation of a range of natural assets, including bushland and aquatic habitats, but has also increased the risk of severe flooding due to increased water runoff from the land into streams and rivers. Increased flows will also cause more erosion and bring more silt, nutrients, organic matter and other pollutants down the rivers to receiving water bodies like lakes, riverine pools and estuaries such as that of the Swan and Canning Rivers. 'Deluge 2000' is the name given to an event in January 2000 when flows from several rivers in the larger Avon catchment delivered peak topsoil and nutrient loads that created a relatively large toxic algal bloom in the Swan River Estuary.

Flora of the Southwest Australia Ecoregion

The Southwest Australia Ecoregion is characterised by a highly diverse flora that has evolved to cope with nutrient deficient soils, with many plants (such as the terrestrial orchids) evolving symbiotic relationships with specialised mycorrhizal fungi. A significant component of the flora consists of relictual species that often have naturally fragmented and geographically restricted ranges.

The Ecoregion's flora is dominated by woody and herbaceous perennials in families such as the Myrtaceae (myrtle family, for example eucalypts, bottlebrushes, tea trees), Proteaceae (protea family, for example banksias, grevilleas, dryandras), Papilionaceae (pea family), Mimosaceae (the wattles), Epacridaceae (or Ericaceae, the heath family), and Orchidaceae (orchid family). The *Acacia*, *Eucalyptus*, *Grevillea*, *Stylidium*, *Leucopogon* and *Dryandra* genera are particularly rich in numbers of species. The most recent estimate of species richness for the Ecoregion suggests that there are 7,380 taxa (6,759 species), of which 49% of the species are endemic to the Ecoregion. Over one third (2,500 species) are of conservation concern. Knowledge of the Ecoregion's flora is still increasing: of the species currently known, one third of the species now known has been described in the last 30 or 40 years, with new species still being discovered every year.

Even within this global biodiversity hotspot, there are smaller floristic hotspots, or areas of exceptional diversity. For example, for almost a century, it has been recognised that there are exceptionally rich floras in the Stirling Range and Fitzgerald River National Parks and hinterlands near the south coast, and the Lesueur National Park on the northern sandplains. More recently, it has been shown that there are also extremely diverse floras in the more humid forest areas of the deep southwest, the Boxwood Hills area near Ravensthorpe in the southeast, and the Swan Coastal Plain in the proximity of the Perth Metropolitan Area.

Unfortunately much of this spectacular flora is threatened. Key threats include clearing—particularly now for urban development and infrastructure; disease pathogens; inappropriate fire regimes; salinity and altered hydrology; grazing by domestic stock, rabbits and unnaturally high numbers of kangaroos; and weed invasion. In March 2006, 351 plant species within the Ecoregion were listed as threatened. It is estimated that salinity may cause the extinction of more than 470 species and subspecies in the agricultural zone alone, mainly in valley floors and low-lying landscapes vulnerable to secondary salinisation and rising water tables. In addition, a large number of poorly known taxa are potentially rare or threatened but cannot be categorised as such until further research is carried out. Such species are listed as priority flora. Most species listed as threatened are vascular (higher order) plants. The non-vascular flora (for example, mosses, liverworts and lichens) are poorly known and poorly collected. It is likely that their representation on threatened species lists is not a true representation of their real conservation status.

Western Australia and, in particular, the Southwest Australia Ecoregion, is recognised nationally and internationally for its magnificent displays of wildflowers. The better known of these include Western Australia's state emblem, the Kangaroo Paw (*Anigozanthos manglesii*), and the Scarlet Banksia (*Banksia coccinea*), an iconic south coast species vulnerable to Phytophthora dieback disease and an economically significant component of the cut flower export and domestic flora trade. Western Australia is known as the Wildflower State, with a diversity of annual floral displays, from large, dense, colourful and often spectacular carpets of a few ephemeral species of everlastings, predominantly from the daisy family (Asteraceae) in the drier districts of the Ecoregion, to the much more diverse displays in kwongan and other plant communities in the more temperate areas. Ecotourism in the Ecoregion is partly dependent on the wildflowers for which the state of Western Australia is famous.

Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages that occur in a particular type of habitat. Interactions between component species provide an important third level of biodiversity in addition to those of genes and species. In order to conserve the many components of ecological communities, it is important that they are conserved and managed as viable and functioning communities, not as collections of single species that are managed one by one.



© Richard McLellan, WWF Australia

Matchstick Banksia (*Banksia cuneata*) is only known from a handful of populations in the central Wheatbelt. Much of the land on which it grows is heavily weed-infested. It requires fire to regenerate at certain intervals as its seedpods remain closed until burnt.

Threatened ecological communities (TECs) are those subject to processes that threaten to destroy or significantly modify them, such that an ecosystem no longer functions effectively or no longer retains the species that were present. Within the Southwest Australia Ecoregion, key threatening processes include clearing, inappropriate fire regimes, weed invasion, salinity and changed hydrological processes, and diseases such as *Phytophthora dieback*. No provision is currently available within Western Australian State legislation for listing TECs. TECs recognised within the State can however be nominated for listing under the federal *Environment Protection and Biodiversity Conservation Act 1999* and are considered as environmentally sensitive areas under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Currently, 53 TECs are recognised within the Ecoregion.

Fauna of the Southwest Australia Ecoregion

While the Southwest Australia Ecoregion is recognised as a global biodiversity hotspot on the basis of the number and natural diversity of its vascular plants, it also has a rich and varied fauna. Seven species of mammals, 13 species of birds, 34 species of reptiles and 28 species of frogs are endemic to the Ecoregion. Invertebrates are relatively poorly known but it is likely that high levels of endemism are also present, particularly for some groups such as spiders in the Wheatbelt, where many are long-lived and move only very short distances over their lifetime.

The Numbat (*Myrmecobius fasciatus*), now effectively an Ecoregion endemic due to massive range retraction, is the mammal emblem for Western Australia. This attractive, diurnal (as distinct from nocturnal), termite-eating mammal is now confined to the Dryandra State Forest and a number of other woodland reserves where intensive fox baiting programs have led to successful translocation programs. Other endemic mammals include the tiny (7-12 grams) Honey Possum, which is dependent on the nectar and pollen of native flowering plants such as banksias,

and the Quokka (*Setonix brachyurus*), a member of the kangaroo family which was once widespread but is now restricted to the island of Rottnest near Perth, Bald Island, and a number of restricted mainland locations.

Endemic birds of interest include the Noisy Scrub-bird (*Atrichornis clamosus*), long presumed to be extinct until it was rediscovered in unburnt thickets and gullies in Two Peoples Bay near Albany. When rediscovered, the population was estimated to consist of only 100 individuals. Although its numbers have been built up through habitat management and translocation programs, the species is still vulnerable to catastrophic population crashes due to wildfire in its coastal habitat.

At 12.5 cm in length, the Western Swamp Tortoise is the smallest and

rarest of Australia's tortoises. These reptiles are critically endangered due to life history and threatening processes such as predation and clearing of suitable habitat. They are restricted in the wild to two very small sites.



© Robert Davis, University of Western Australia

So diverse is the biodiversity of the Ecoregion that new discoveries are still being made, even for relatively large fauna. The Sunset Frog (*Spicospina flammocaerulea*) was only discovered in 1994, near Walpole on the south coast.

Western Swamp Tortoises do not reach sexual maturity until aged 10-15 years, sometimes later, and are probably long-lived, with a life-span of perhaps 40-50 years or more. Because of their status and threats to survival, the tortoises are currently part of a captive breeding program at the Perth Zoo that aims to reintroduce the species to other locations in the wild.

The Southwest Australia Ecoregion has a rich frog fauna and although it has a low diversity of treefrogs compared to other areas of Australia—only 3 native species—it is characterized by a high endemism and diversity of ground frogs (family Myobatrachidae), including unusual species such as the Turtle Frog (*Myobatrachus gouldii*) and the Sandhill Frog (*Arenophryne rotunda*) which require no water to breed. The Ecoregion has 31 frog species, 28 of which are endemic.

The Sunset Frog (*Spicospina flammocaerulea*) is the most recently described frog in Western Australia. Surprisingly, it was discovered only in 1994 and represents an entirely new genus of frog and the only species within that genus. It appears to be an ancient species with molecular estimates of more than 30 million years old. Although some frogs such as the Sunset Frog have highly restricted ranges, making them vulnerable to threats such as habitat loss, in general the Ecoregion's frogs are faring better than those in eastern Australia, where catastrophic declines have resulted from the spread of the frog-killing *Chytrid* fungus.

The Southwest Australia Endemic Bird Area

The Southwest Australia Ecoregion is a globally significant Endemic Bird Area, an area recognised by BirdLife International as containing at least two endemic bird species. The Ecoregion substantially exceeds this minimum criterion, with 13 endemic birds. Of these, four species are listed as threatened and the subspecies of two more are also threatened. The endemic species are:

- Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*)
- Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*)
- Western Corella (*Cacatua pastinator*)
- Western Rosella (*Platycercus icterotis*)
- Red-capped Parrot (*Purpureicephalus spurius*)
- Noisy Scrub-bird (*Atrichornis clamosus*)
- Red-winged Fairy-wren (*Malurus elegans*)
- Western Bristlebird (*Dasyornis longirostris*)
- Western Thornbill (*Acanthiza inornata*)
- Western Wattlebird (*Anthochaera lunulata*)
- Western Spinebill (*Acanthorhynchus superciliosus*)
- White-breasted Robin (*Eopsaltria georgiana*)
- Red-eared Firetail (*Stagonopleura oculata*)

Rufous Treecreeper (*Climacteris rufa*), an insectivorous bird dependent on standing and fallen hollows and now declining or locally extinct in some parts of the Wheatbelt. It is still common wherever larger areas of woodlands remain in good condition, such as the transitional woodlands of the eastern Ecoregion.



© B & B Wells, CALM

Threatened ecological communities of the Southwest Australia Ecoregion

Fifty-three ecological communities are currently recognised as threatened within the Southwest Australia Ecoregion. Currently the highest number is represented on the Swan Coastal Plain. Several TECs illustrate some of the key threats to ecological communities.

Perched wetlands of the Wheatbelt region with extensive stands of living sheoak (*Casuarina obesa*) and paperbark (*Melaleuca strobophylla*) across the lake floor



© Ken Atkins

Lake Toolibin, a freshwater lake with extensive stands of Sheoak (*Casuarina obesa*) and Freshwater Paperbark (*Melaleuca strobophylla*). This threatened ecological community is one of only two of its kind surviving in the Wheatbelt.

Key threat: secondary salinisation and altered hydrological regimes

Seasonal freshwater wetlands dominated by extensive stands of Freshwater Paperbark were once widespread in the Western Australian agricultural zone. There are now only two occurrences, of which Lake Toolibin is the largest and best known, and the community is listed as Critically Endangered. The lakebed community is characterised by seasonal fresh water inundation and the main tree species and other biota are dependent on relatively fresh water and regular drying out of the lakebed for survival. Management actions include engineering and revegetation solutions.

Melaleuca huegelii-*Melaleuca systena* shrublands of limestone ridges

Key threats: clearing for urban development, infrastructure and limestone extraction together with degrading processes such as weed invasion and inappropriate fire regimes

This community is located on the Swan Coastal Plain within the Perth Metropolitan Area or its vicinity. There are many occurrences but most are small and vulnerable to clearing, limestone mining or degradation. Many recognised occurrences on public land have not yet been reserved. The community is listed as Endangered. Management actions include management for degrading processes such as fire frequency, public access and weed invasion.

Montane mallee thicket of the Stirling Range

Key threat: *Phytophthora dieback disease*

This TEC occurs in the Stirling Range, usually more than 400m above sea level on the slopes and summits of several peaks. The flora of the Stirling Range is characterised by a high degree of species diversity with numerous rare and geographically restricted species. There are a number of TECs, including the Endangered montane mallee thicket. A large number of plants that occur in this community include endemic, threatened and priority taxa that are highly susceptible to *Phytophthora cinnamomi* infection. These are predominantly members of the families Proteaceae, Epacridaceae (Ericaceae) and Papilionaceae.

Threats to biodiversity of the Southwest Australia Ecoregion

There are many threats to biodiversity and these exist at a range of scales from large to small. Some of these are natural processes or events, such as extensive floods and fire to small, highly localised events such as tree fall or wind damage. However, many serious threats are caused by human activity. Exponential growth in human populations and material goods or resource consumption result in large-scale effects on biodiversity. These include the clearing and fragmentation of natural habitats, dryland salinity resulting from broad-scale clearing, feral animal and weed invasions, exploitation and over-harvesting, and the spread of disease. At large scales, such events and processes may threaten whole vegetation types, remnants or populations of species. At small scales, microhabitats and small populations may be threatened. Threats may result in degradation or outright loss of biodiversity assets. Threats to biodiversity demand that conservation and land managers actively manage those threats. Although all threatening processes impact negatively on biodiversity, a number of threats are particularly important within the Southwest Australia Ecoregion.

Clearing and fragmentation

The clearing of native vegetation is a significant threat to biodiversity. Since European settlement, most native vegetation in the Southwest Australia Ecoregion has been removed or significantly modified by human activity—such as logging—or impacted by human-induced processes such as disease and changes in fire regimes. Land clearing destroys biodiversity, resulting directly in the loss of plant and animal species and the destruction of habitat. The Ecoregion's agricultural zone has been greatly impacted by clearing. Only 7% of the original vegetation is intact, with the remaining vegetation scattered in fragmented remnants of varying sizes, condition and degree of isolation. Fragmentation results in the isolation of remnants from each other and affects the ability of native animals and plants to disperse across landscapes. This is particularly problematic for fauna which are unable to move across cleared landscapes.



A landsat image of Southwest Australia shows the massive clearing of native vegetation across significant parts of the Ecoregion. Extensive tracts of vegetation are now largely restricted to the pastoral zone and the forested deep southwest. Map courtesy of the Department of Land Information, Satellite Remote Sensing Services.

While the impact varies for different species and habitats, habitat loss and fragmentation will generally be accompanied by continuing loss of species which occur long after land is initially cleared. Research on birds suggests that extinction rates begin to accelerate when less than 30% of native vegetation remains in a landscape.

While the numbers of bird species listed as threatened is relatively small in the Ecoregion, many species continue to decline and are locally or regionally extinct. For example, the insectivorous Gilbert's Whistler (*Pachycephala inornata*) is still relatively common in extant woodlands to the east of the agricultural clearing line, but is now all but extinct in its former range across the Wheatbelt.

Small-scale but widespread clearing for activities such as infrastructure development and mining is ongoing. While active broad-scale clearing in most areas has generally ceased, it still occurs, particularly in urban, peri-urban and coastal areas, where clearing for urban development and tourism facilities continues to reduce the amount of native vegetation that remains. In Perth, Western Australia's capital and largest city, the clearing of Banksia woodlands and coastal heath continues to reduce the extent of native vegetation on the species-rich Swan Coastal Plain. The fragmentation of habitat and resulting degradation due to 'edge effects' such as weed invasion, different levels of exposure to wind and sun and changes in air temperature are as problematic in urban areas as they are in the agricultural zone. Passive clearing by activities such as stock grazing still occurs.

Phytophthora dieback

The biological bulldozer

Phytophthora root rot, a form of dieback, is a disease affecting many native plants and ecosystems. The disease is caused by an introduced microscopic soil-borne water mould (*Phytophthora cinnamomi*) that invades the host plant's roots and stems for nutrients, killing plant cells and reducing the plant's ability to transport water and nutrients. Eventually, susceptible host plants die. Within the Southwest Australia Ecoregion, Phytophthora dieback is a significant threat to vulnerable plants and plant communities in areas receiving at least 400 mm annual rainfall. Although more prevalent in higher rainfall zones (>800 mm annual rainfall) it also spreads through 'water gaining' sites such as wetlands and rivers, in the 400-600mm rainfall zone. It is a recognised Key Threatening Process under federal legislation.

The pathogen is spread by direct relocation of infested soil (for example, on earthmoving machinery, vehicle tyres or boots) or through water or root to root contact. Although phosphite treatment by spray or injection can be effective in providing resilience to plants for short periods, there are no known eradication methods, and limiting the spread of the disease is currently the most cost-effective control measure known.

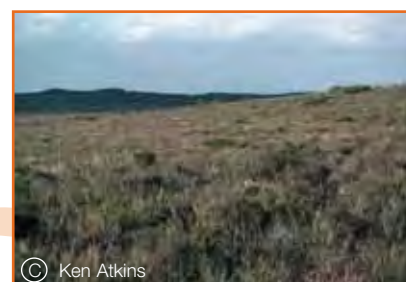
It has been estimated that more than 2000 of the Ecoregion's vascular plants are susceptible or highly susceptible to the disease. Plant families most affected are the Proteaceae (92%), Epacridaceae (80%), Papilionaceae (57%) and Myrtaceae (16%). The understorey of large areas of jarrah forest has lost a significant number of susceptible plant species, while in the Two Peoples Bay Nature Reserve near Albany, only a few individuals of the once common Candlestick Banksia (*Banksia attenuata*) survive. More than 50% of Declared Rare Flora are susceptible to the disease.



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A series of photographs shows the effect of Phytophthora dieback disease on a plant community. Scarlet Banksia (*Banksia coccinea*) is infected by the disease and dies. The original vegetation community is eventually replaced by Phytophthora-resistant plants, reducing the floristic diversity and affecting habitat values for fauna.

Phytophthora dieback has an extremely wide host range, affecting mainly woody shrubs and trees and causing changes to both the composition and structure of plant communities. These changes also affect fauna, resulting in reduced protection from predators and a loss of food resources. Mammals such as the Honey Possum are thus vulnerable to local extinction through the effects of the disease on its habitat.

Beyond the cost for biodiversity, Phytophthora dieback has a direct and significant economic impact on the cut flower industry, both for wild-picked flowers and those grown in horticulture, and impacts on road construction, logging, mining and other industries such as commercial cropping.

The economic value of the native cut flower industry

The Southwest Australia Ecoregion flora is renowned around the world for its beautiful and unusual forms. Beyond their biodiversity value, a number of native plants in the Ecoregion also have commercial importance, largely for the cut flower industry.

Natural bushland in the Ecoregion is an important contributor to the sustainability of the cut flower trade. In the period 2000-2004, all wild-picked cut flowers utilised by the industry in Western

Australia were accessed from within the Ecoregion. In the same period, 45% of native cut flowers were obtained from wild picking on private or Crown land¹. Of the five native plant families supplying the highest number of cut flowers to this industry, two—Podocarpaceae and Dasypogonaceae—are restricted in the State of Western Australia to the Southwest Australia Ecoregion.

Of the native flora species picked by the industry in the period 2000-2004, most are Banksias and other Proteaceae species. Hooker's Banksia (*Banksia hookeriana*), Baxter's Banksia (*B. baxteri*) and Acorn Banksia (*B. prionotes*) contribute the largest number of stems harvested over this period. While a significant part of the harvest is from cultivated plants, the trade is dependent on wild-picked flowers for some species. For example, Slender or Candlestick Banksia (*B. attenuata*) is picked largely from Crown land and Snottygobble (*Persoonia longifolia*) picking is almost solely confined to wild plants on private or Crown land.

A number of plants of commercial value are vulnerable to Phytophthora dieback disease. Of the ten species with the highest number of stems harvested, eight are species commonly used as indicator species in *Phytophthora cinnamomi* interpretation in the field. These include seven banksias, Snottygobble and Blueboy (*Stirlingia latifolia*). Due to its continued spread, Phytophthora dieback disease increasingly has potential to impact significantly on the cut flower industry.

¹Source: Department of Conservation and Land Management Flora Industry Data Management System.



© Katrina Bercov

The State floral emblem of Western Australia, the ecoregion endemic Green and Red Kangaroo Paw (*Anigozanthos manglesii*).

Salinity

Dryland salinity is a significant threat to biodiversity in the Southwest Australia Ecoregion, where it is damaging or destroying native species, ecological communities and functioning ecosystems. Beyond its effect on biodiversity, salinity is also a major economic problem, impacting on agricultural production, water quality and infrastructure such as roads, buildings, bridges and pipelines. Dryland salinity reduces crop yields and retards the growth of cereal crops and traditional pasture grasses; affects water supplies for drinking and irrigation; degrades bitumen and concrete; and destroys natural habitats, particularly in Wheatbelt valley floors and around wetlands, rivers and streams. It is predicted that salinity will affect 17 million hectares in Australia by 2050, including 2 million hectares of remnant and planted perennial vegetation. The effects of salinity are often largely irreversible.



Dryland salinity is a significant threat to biodiversity in the Southwest Australia Ecoregion, where it is damaging or destroying native species, ecological communities and functioning ecosystems. The original plant community here has been destroyed by salinity and rising groundwater and has been replaced by salt-tolerant halophytes such as samphire.

© Richard McLellan, WWF Australia

The term salinity refers to the salt content of soil or water. Increases are caused by a rise in the level of underground water tables bringing naturally occurring salt to the surface. This concentrates the salt at the surface and affects the environment dependent on that soil and water. Primary salinity is caused by naturally occurring salt deposits. The widespread clearing of native vegetation for agriculture and replacement of deep-rooted perennials with shallow-rooted annual crops that use little water has caused rising water tables to bring stored salts to the surface. This has led to changes in soil composition and increased water volumes in wetlands and rivers and streams and resulted in longer periods of inundation and more widespread acidity.

It has been estimated that 470 flora species and sub-species from low-lying areas of the Wheatbelt are at risk of extinction from salinity. Up to one-third of wetland and river invertebrate species, large numbers of wetland plants and a substantial proportion of the waterbird fauna will disappear from this region. Increased salinities are not the only threat associated with salinisation: increased water volumes, longer periods of inundation and more widespread acidity are also likely to be detrimental to biodiversity of the Southwest Australia Ecoregion.

Much controversy surrounds the use of engineering solutions to combat the effects of dryland salinity. It seems likely, however, that solutions—where they exist—may require a mix of engineering and revegetation solutions that will be dependent on knowledge of local hydrological processes for success. One of the greatest threat management challenges within the Southwest Australia Ecoregion is the development of innovative and effective approaches to salinity that also achieve biodiversity conservation outcomes. This will require whole of government and community approaches with significant resources for many years to come.

Weeds

Invasive plants are one of the most widespread of the threats to biodiversity in the Southwest Australia Ecoregion, where many landscapes are now seriously invaded and degraded by weeds. The degradation of ecosystems by invasive plants may be direct—for example, through simple weed invasion—or indirect, such as the change to ecosystems wrought by hot fires in the wake of the build up of fuels such as introduced grasses. It is possible that climate change may allow weeds to spread further than might otherwise have been expected. Both terrestrial and aquatic ecosystems may be seriously degraded by invasive plants. Beyond their effect on biodiversity, weeds are also a serious problem in agriculture where millions of dollars are spent in control and attempted eradication measures.

Weeds vary in the speed at which they become serious invaders of natural ecosystems. Some are almost immediately invasive while others—the so-called ‘sleepers’—erupt out of control after a lengthy period of appearing to be fairly quiet or innocuous. A shift from apparent dormancy to aggressive invader may result from changed climatic conditions or chance opportunities that result in a move to conditions that better suit the spread of the weed.

Two weeds of national importance—Bridal Creeper (*Asparagus asparagoides*) and Blackberry (*Rubus fruticosus* aggregate)—are among the serious environmental weeds of the Ecoregion. Both have originated from garden or horticulture escapes. The garden industry is by far the biggest importer of introduced plant species and escapees from gardens and parks—including botanic gardens—account for 65% of Australia’s weed species. Many weeds known to be serious invaders of natural ecosystems are still available for sale. Although progress has been made in the last decade, the horticulture, gardening and landscape industries are still major players in weed control.

The ten most serious invasive garden plants available for sale in Southwest Australia

- Arum Lily (*Zantedeschia aethiopica*)
- Black Flag (*Ferraria crispa*)
- Broadleaf Pepper Tree (*Schinus terebinthifolius*)
- Coastal Tea Tree (*Leptospermum laevigatum*)
- Freesia (*Freesia alba x leichtlinii*)
- Spotted Gum (*Eucalyptus maculata*)
- Sweet Pittosporum (*Pittosporum undulatum*)
- Sydney Golden Wattle (*Acacia longifolia*)
- Watsonia (*Watsonia* spp.)
- Weeping White Broom (*Retama raetum*)

Of these plants, only Weeping White Broom is not a widespread weed.



Bridal creeper (*Asparagus asparagoides*) is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread and economic and environmental impacts. It entered Australia as a garden plant and is now a major weed of bushland where it smothers native plants and even whole ecosystems.

Feral Animals

Introduced animals are now common in Australia and feral animals with wild populations often have significant negative effects on biodiversity. The record of extinction for mammals across Australia has been unequalled anywhere on Earth: a massive 22 species of mammals have gone extinct since colonisation by Europeans. Of the 77 indigenous mammals recorded in the Southwest Australia Ecoregion, almost one-third (23) are now extinct within the Ecoregion itself. Eight are totally extinct and 15 survive elsewhere in Australia. A number of mammals that are extinct in the Ecoregion still survive on off-shore islands where threats such as foxes are actively managed.

Most of these mammals are medium-sized, Critical Weight Range mammals vulnerable to predation by foxes and feral cats. The Numbat once had an extensive range across drier regions of Australia but due to predation by feral animals has been reduced to relictual and translocated populations in the Southwest Australia Ecoregion. Due to its range retraction it is now effectively an Ecoregion endemic.

Rabbits are the most damaging of the herbivores introduced to the Ecoregion, affecting the natural regeneration of trees, shrubs and herbaceous plants. Nutrient loads and excavations for burrows cause weed invasion and erosion in natural habitats. Two biological control diseases (myxomatosis and the rabbit haemorrhagic disease caused by calici virus) have been introduced to control rabbits, both of which caused reductions in rabbit populations to varying degrees and at various times, but failed to eliminate the pest. Currently, much rabbit control relies on ad hoc or opportunistic shooting and the use of poison baits by land managers.



© Tony Kirkby, Cockatoo Care

Feral European Honeybees (*Apis mellifera*) often use hollows in old trees for their hives. The bees are increasingly serious competitors for hollows used by a number of animals and birds. Although research is continuing, permanent control of feral bees is currently impossible.

The Red Fox (*Vulpes vulpes*) was first reported in Western Australia in 1911-1912 and within 26 years, the fox had occupied most of the state except for the Kimberley region. Foxes have been implicated in the extinction or regional extinction of many Australian mammals: 12 that once occurred in Western Australia are now extinct. The management of foxes and feral cats is the Ecoregion's most critical feral animal management issue.

Managing fox populations

If the numbers of feral predators such as the fox and cat are controlled, many native species can recover in suitable habitats. Fox numbers are controlled by baiting with the poison 1080 ('ten-eighty', or sodium monofluoroacetate).

The Department of Conservation and Land Management's 'Western Shield' program aims to control predators and reintroduce native mammals to a number of former habitats across the Ecoregion. Over a seven year period, Western Shield successfully showed that predator control can result in the increase in populations of previously endangered mammals such as the Numbat, Woylie (*Bettongia penicillata*) and Black-footed Rock-Wallaby (*Petrogale lateralis*), the latter now restricted to some Wheatbelt granite outcrops.

Community-based programs also attempt to maintain local fox control. A widespread program recently implemented across much of the Southwest Australia Ecoregion is attempting to coordinate fox baiting and other control measures such as shooting so that these activities can be more effective.

The Ecoregion's fauna and the 1080 toxin

Within Western Australia, but particularly within the Southwest Australia Ecoregion, a number of native plant species naturally produce the toxin '1080' or monofluoroacetate. 1080 is present in a number of plants, particularly in the *Gastrolobium* genus, with most species occurring only in the Ecoregion. Where plants containing 1080 grow elsewhere, such as northwest Australia, the level of the toxin is lower.

Due to the occurrence of this natural poison, the Ecoregion's fauna has evolved in a virtual 'arms race' between plants and animals in which plants evolve increasing levels of the toxin to avoid being eaten, and animals evolve increasing levels of tolerance to avoid poisoning. As a consequence, the native fauna of the Ecoregion is significantly more tolerant to the toxin than fauna of the eastern states of Australia. For example the Ecoregion's Bob-tailed or Blue Tongue Skinks (*Trachydosaurus rugosus*) are four times more tolerant of 1080 than the same species in the eastern states, and Brush-tailed Possums (*Trichosurus vulpecula*) 125 times more tolerant. This tolerance means that, within the Ecoregion, 1080 poison is a highly selective and effective control option for introduced animals such as foxes, cats, rabbits and pigs, which have little or no natural defence against the toxin.

Problem animals in the Southwest Australia Ecoregion

Most problem animals in the Ecoregion have been introduced (e.g. Red Fox, Rainbow Lorikeet and feral European Honeybee). Sometimes they represent populations of native animals whose ranges or abundance has extended or increased beyond historic natural populations because of conditions provided by agriculture or urban development.

- Red Fox (*Vulpes vulpes*)
- Cat (*Felis catus*)
- Pig (*Sus scrofa*)
- Rabbit (*Oryctolagus cuniculus*)
- Grey Kangaroo (*Macropus fuliginosus*)
- Goat (*Capra hircus*)
- Donkey (*Equus asinus*)
- Rainbow Lorikeet (*Trichoglossus haematodus*)
- Galah (*Cacatua roseicapilla*)
- (Eastern) Long-billed Corella (*Cacatua tenuirostris*)
- Western Corella - the Wheatbelt subspecies (*Cacatua pastinator butleri*)
- Little Corella (*Cacatua sanguinea*)
- Feral European Honeybee (*Apis mellifera*)

Fire

Fire and the Southwest Australia Ecoregion

Over the past 250 million years, the landscapes of the Southwest Australia Ecoregion have been shaped by changing climate and related phenomena such as drought. Much of the Ecoregion is now characterised by a seasonally dry, Mediterranean climate that is prone to fire and other natural disturbances including flood, wind, and drought. Fire is one of the most pervasive of these and is an integral and natural part of the Ecoregion's landscapes. Fire frequency has increased from the time humans first populated the Australian continent approximately 50,000 years ago, but modern vegetation types, the Mediterranean climate, and fire regimes have existed in parts of the Ecoregion since about 30 million years ago. The role of fire in the speciation of the Ecoregion's flora is uncertain.

Fire as a natural ecological process

Fire is a significant disturbance event, with an important role to play in biodiversity patterns and processes. A natural fire regime is variable in both space and time, usually resulting in a mosaic of habitats with vegetation at different stages of floristic and structural post-fire succession. Fire can maintain and provide important variation in vegetation structure and plant community composition through the reduction or elimination of competition from other plants by opening up of the canopy. It can also provide soil nutrients from ash. Short-lived plant species such as fire ephemerals and some acacias might be dependent on fire for long-term survival. For some species, fire or smoke may be the trigger for germination.

Fire may also open up opportunities for fauna. For example, early post-fire vegetation regrowth may attract small insectivorous birds such as Scarlet Robin (*Petroica multicolor*). Post-fire recolonisation is poorly known for many fauna species but well known for others. The number of Honey Possums in burnt heathland and shrubland declines markedly after fire, remains low for 4-5 years then increases over the next 20-25 years, with maximal abundance about 30 years after fire.

Fire as a threat

Inappropriate fire regimes may be a significant threatening process, although fire regime is not listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that provides for the identification and listing of key threatening processes. Too frequent fires might result in the extinction of plant species that have a long juvenile phase and do not set seed for a long time or resprouters that take many years to become fire-tolerant. However, too few fires might also negatively affect the structure and components of natural communities.

Even in environments where fire is a significant natural process, some fauna may be sensitive to inappropriate fire regimes. For example, four threatened bird species from the south coast area of the Ecoregion—Noisy Scrub-bird, Western Ground Parrot (*Pezoporus wallicus flaviventris*), Western Bristlebird (*Dasyornis longirostris*) and Western Whipbird (*Psophodes nigrogularis*)—have been negatively affected or suffered drastic population declines as a direct result of fire. Mammals such as Dibblers (*Parantechinus apicalis*) are also negatively impacted by fire. Population declines or extinctions in fauna may be due to mortality during the fire itself, the loss of critical resources such as feeding and breeding habitat, or increased predation due to changes in vegetation structure and thus shelter and protection. Fire is also problematic for fauna in highly cleared areas such as the Wheatbelt and the Swan Coastal Plain where remnants may be fragmented and isolated. It is possible that fire may cause the permanent local extinction of fauna where recolonisation from other remnants is not possible.

Unfortunately, some invasive weed species also benefit from frequent fires. In the Perth metropolitan area, frequent recurrent fires in native bushland in Kings Park, a large urban reserve, has led to massive replacement of native understorey plants by the introduced South African Perennial Veldt Grass (*Ehrharta calycina*). A management strategy has been in place for some time to reverse this trend.

Across the Ecoregion, because of soil differences, rainfall gradients and natural biological diversity, there is a diversity of responses by both species and ecosystems to fire and fire regimes. No one fire regime is ideal for all organisms and ecosystems at regional scales. Rather, regional planning demands consideration of more localised management approaches based on efforts to know and manage local species and ecosystems.

This is a complex problem. Firstly, the fragmentation and isolation of remnants due to broad-scale clearing for agriculture and urban development, together with threatening processes such as weed invasion, disease due to *Phytophthora cinnamomi* and land use practices, have led to significant alteration in natural responses to fire and fire regimes. Secondly, the large turnover of plant species over very short distances across the Ecoregion leads to different responses over short distances from the same fire regime.

Adaptive management—an ongoing process where management actions are regarded as an experiment and outcomes are monitored and evaluated for possible changes to actions and policy—is critical for fire management in such biodiverse landscapes. Examples of such adaptive management in relation to fire include the protection from prescribed burns and wildfire of young Karri (*Eucalyptus diversicolor*) regrowth in southwest forests, and urban bushland remnants threatened by invasive populations of the introduced weed Perennial Veldt Grass. There is an ongoing need for research that assists with management decisions in relation to less resilient plants such as those that have long juvenile stages before they reach first flowering, low seed producers and those with short-lived seed banks. In addition, there is little information on the effects of repeated burning or frequent fires on fauna.



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Fire is both a natural process and a threat. Where weeds are present, too frequent fires may benefit weeds if they germinate before native plant species have a chance to reestablish.

Climate Change

Climate is a key determinant of the location, structure and function of natural ecosystems. On geological timescales climate change has been shown to affect the distribution of flora and fauna and the survival and ranges of whole ecosystems. There is considerable scientific consensus that predicted human-induced climate changes are likely to have a profound impact on natural ecosystems and their species.

The Australian Terrestrial Biodiversity Assessment 2002 and State of Environment reports have shown that, as a direct consequence of continuing human activities, many of our natural systems are already under severe stress. Existing threats may be even more damaging to native biodiversity under the influence of changing climates. For example, fire, drought and flood events may increase in both number and intensity.

From 1910 to 1999, Australia's continental average temperature increased 0.7°C, with most of the increase recorded since 1950. This is consistent with global trends. The year 2005 was Australia's warmest year on record, and the 1990s the warmest decade. Projections indicate that by 2030, annual average temperatures will be 0.4°C to 2.0°C higher. Winter rainfall in the Southwest Australia Ecoregion has also decreased substantially since the mid-20th century.

The relatively modest warming experienced thus far has already had measurable impacts on the distribution, physiology and life cycle of a range of plants and animals across the globe. Evidence suggests that the rate of climate change will be faster than the rate at which many species can adapt, and may result in shifts in species distributions and species extinctions.

Species most vulnerable to climate change may be those with long generation intervals, low mobility, highly

specific host relationships, small or isolated ranges, and low genetic variation. Alteration in water cycles would affect species and ecosystems that are dependent on inland rivers and wetlands. Populations within isolated remnants and ecosystems such as montane zones in the Stirling Ranges may be particularly vulnerable. However, there is currently much uncertainty about how individual species and ecosystems will respond to the combined effects of climate change and other existing threats.

Ecosystems that are already stressed as a result of human-induced or other disturbance are likely to be particularly vulnerable to climate change impacts. Any added stresses of



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Climate change may adversely affect montane communities such as the montane mallee thicket threatened ecological community in the Stirling Ranges. This community already has high numbers of threatened flora. At Mondurup Peak, the endemic Stirling Range Banksia (*Banksia solandri*) grows alongside other species such as dryandras and isopogons.

climate change are likely to further decrease resilience. However, species in relatively pristine ecosystems may also be particularly vulnerable if barriers to upwards or polewards migration are present—for example, if the pristine ecosystems are habitat islands, adjacent to ranges, deserts, oceans, cities, or cleared areas—or if they are affected by invasive species or other changes in species interactions.

Biodiversity conservation in action

Across the Southwest Australia Ecoregion, many large-scale projects and programs are addressing key threatening processes and targeting biodiversity conservation. A number of projects and programs provide excellent examples of the benefits and achievements of collaborative multi-stakeholder projects.

Conservation planning for the Southwest Australia Ecoregion

Currently, bioregions, natural resource management regions, and government agency administrative regions form the basis for much conservation planning and allocation of scarce resources. Considerable evidence suggests that the ten bioregions (IBRAs) comprising the Southwest Australia Ecoregion may be an inadequate basis for conservation planning in the Ecoregion. Regional Natural Resource Management strategies are a critical component of the timely and effective management of natural resource management in this Ecoregion. Whilst regional groups do work collaboratively across boundaries they do not necessarily have the resources to plan and act at scales necessary for cross-regional, broad-scale, ecoregion-wide conservation planning. Conservation planning at the Ecoregional scale is the task taken on by the consortium of members of the Southwest Australia Ecoregion Initiative, which has representation from a broad range of stakeholders and strong links to many others.

The science of conservation planning

The scale of threat and the need to prioritise in order to effectively utilise precious financial and human resources are dual imperatives that drive large-scale conservation planning processes for areas of the size and complexity of the Southwest Australia Ecoregion. 'Systematic conservation planning' is one term sometimes used for conservation planning that systematically identifies the best set of conservation areas that together achieve explicit conservation goals. Conservation areas may be any area, including private land, that meets the conservation goals and can adequately protect associated biodiversity assets. Often, explicit targets are set for the conservation of particular assets or features, such as species or vegetation or wetland types.

Conservation planning generally involves the extensive use of data such as species lists or vegetation types and takes advantage of the power of computers to efficiently handle large amounts of information. Such approaches are not used alone; rather, they are used to help inform efficient, objective and defensible decisions made by teams of people with expertise and knowledge of the region.

In some developing countries, conservation planning tools may provide 'first step' conservation and reservation plans. In developed countries like Australia, where numbers of government agencies and non-government organisations have varying degrees of responsibility for conservation action, conservation planning for a large region such as the Southwest Australia Ecoregion takes into account existing plans. Importantly, however, the purpose of a 'new' action plan is the analysis of gaps and the consideration of all aspects of conservation planning and management and resource allocation at the scale of the region in question. This consideration of appropriate scale is the task of the conservation planning exercise for the Southwest Australia Ecoregion.

Global biodiversity conservation priorities and the Southwest Australia Ecoregion

The diversity and richness of life on earth are in decline and too few resources are available to fully arrest that decline. In order to prioritise the way existing resources are used for effective global conservation action, a number of approaches have been adopted by international conservation organisations to identify places most in need of immediate action. These include:

- Global Biodiversity Hotspots (Conservation International),
- Global 200 Ecoregions (WWF),
- Endemic Bird Areas (BirdLife International) and
- Centres of Plant Diversity (WWF/IUCN).

There is often considerable overlap between the various approaches. All global hotspots contain at least one Global 200 Ecoregion and all but three contain at least one Endemic Bird Area. Sixty percent of Global 200 terrestrial Ecoregions and 78% of Endemic Bird Areas overlap with hotspots. There is an overlap of 70% between the location of Endemic Bird Areas and Centres of Plant Diversity.

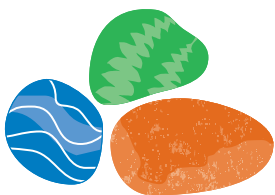
The Southwest Australia Ecoregion is a global biodiversity hotspot comprising two Global 200 Ecoregions, a Centre of Plant Diversity and an Endemic Bird Area. As such, the Ecoregion is clearly globally significant and in need of immediate broad-scale conservation planning action.

The process of identifying areas that have global significance for biodiversity is an important one, but is insufficient on its own for effective action to proceed. Identifying a vision, goals and objectives for the conservation of these areas is equally important. The Southwest Australia Ecoregion Initiative is a consortium of Western Australian government and non-government stakeholders whose task it is to formulate an action plan to conserve the Ecoregion and its natural assets.

Much can be gained by working at an ecoregional scale. Goals and targets for the Ecoregion can help inform the future planning of many stakeholders, including conservation organisations, local government, local communities and regional Natural Resource Management groups. Greater opportunities for collaboration will become possible as conservation projects and programs are identified that cross existing boundaries. Lastly, greater awareness and a higher profile for the great natural diversity of the Ecoregion, and the processes that threaten it, will lead to an increased ability to attract funding for the work necessary to achieve these goals.

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