5 Threats and Management

Many different land uses occur in the physical area considered in this plan (see Chapter 3, Relative landcover estimates for Adelaide Metropolitan Area), and with each different land use comes a suite of threats to biodiversity. However, the primary threat to biodiversity in the Adelaide Metropolitan Area is common to all the different land uses. Habitat fragmentation in the Adelaide region due to clearing of native vegetation for residential development and farming has resulted in a few small islands of remnant vegetation in a sea of suburbia and agriculture. Indeed, the clearance of native vegetation poses the greatest threat to terrestrial biodiversity (SOEAC 1996).

Other threats to biodiversity in the Adelaide Metropolitan Area include:

- excessive **herbivory** of native plants from introduced and native animals;
- excessive competition from **introduced plants**;
- direct competition for food and shelter from **introduced animal pests** such as rabbits, European carp, feral honey bees, and starlings;
- introduced **predators** such as dogs, cats, foxes and trout;
- **introduced diseases**;
- **collection of firewood** from remnant vegetation;
- altered **fire regimes**;
- **inappropriate management** activities;
- **water extraction/pollution.**

The process of fragmentation has the immediate and obvious effect of species loss and associated habitat loss, with the consequent death of plants and animals. Other impacts of fragmentation include fluxes of radiation, wind, water and nutrients (Hobbs & Saunders 1993); restricted ability to recover following disturbance (Hobbs *et al.* 1993); increased susceptibility to invasions by exotic flora and fauna; disruption of ecosystem processes (Saunders *et al.* 1991); and inbreeding depression (Lunney & Recher 1986). Many patches of remnant vegetation are too small to ensure long-term viability of plant and animal populations.

5.1 Herbivory

Rabbits, goats, donkeys, horses, sheep and cattle are the main introduced vertebrate herbivores in Australia. Sheep and cattle are of course managed to meet the needs of humans, but their impact on the environment is often negative and substantial. Rabbits have adapted well to the Australian environment and have existed in the wild with self-sustaining populations.

Rabbits (*Oryctolagus cuniculus*)

Competition and land degradation by feral rabbits is listed in Schedule 3 of the Endangered Species Protection Act 1992 as being a key threatening process (Environment Australia 2000). Furthermore, rabbits eat crops and pastures and compete with herbivores used in primary production. Rabbits have adapted to a wide range of habitats and now inhabit approximately 60% of the country (Biodiversity Group 1999a). It has been shown that rabbits inhibit regeneration of native vegetation, compete with native fauna for food and shelter, support populations of introduced canids and felids, and cause soil erosion. Rabbits are a known and perceived threat to many plants and animals listed under Schedule 1 of the *Endangered Species Protection Act 1992*. Species that once occurred or still occur naturally in the Adelaide area, are on Schedule 1 of the above Act and are threatened by rabbits include:

- **Greater Bilby**
  (*Macrotis lagotis*)
  (known threat)
- **Burrowing Bettong**
  (*Bettongia lesueur*)
  (perceived threat)
- **bayonet spider-orchid**
  (*Caladenia gladiolata*)
  (known threat)

- **Stiff white spider-orchid** (*Caladenia rigida*)
  (perceived threat;)

For more than a century, attempts to control rabbits have been implemented, with varying degrees of success.

While eradication is not possible, there are ways of reducing their impact on the environment. The National Threat Abatement Plan (Biodiversity Group 1999a) aims to reduce the impact of rabbits on the Australian environment by:

- implementing rabbit control programs in specific areas of high conservation priority;
- encouraging the development and use of innovative humane rabbit control methods;
- educating land managers and relevant organisations to improve their knowledge of rabbit impacts and ensure skilled and effective participation in control activities; and
- collecting and disseminating information to improve understanding of the ecology of rabbits in Australia, their impacts and methods to control them.

These broad objectives are expected to filter through to individual landholders. However, the basic methods of controlling rabbits have not changed. The recently released Rabbit calicivirus disease (RCD) has proven to be successful in reducing rabbit numbers, but its effects are more dramatic in some areas compared with others. Biological control agents such as RCD and myxomatosis are not intended to control rabbits on their own. Traditional control methods such as fumigation, ripping, fencing, and baiting will continue to be a fundamental component of rabbit control. Consequently, "…[R]abbit control will have to continue for the foreseeable future and the costs of control will be significant" (Biodiversity Group 1999a).

Domestic Stock

The grazing of domestic stock, in particular sheep, goats and cattle, on native vegetation is more widespread in other regions, but still occurs in the Adelaide Metropolitan Area. Horses are particularly common in and east of the Hills Face Zone. Damage to native vegetation from grazing by domestic stock occurs through:

- stock selectively grazing palatable native species
- destruction of soil surface crust and compaction from the hard hooves of domestic stock
- favouring weed species through changes in soil nutrients resulting from faecal deposition
- preventing regeneration through selectively grazing seedlings
- facilitating the spread of weeds into remnant vegetation through stock fur and dung
- ringbarking of plants.

It must be recognised that biodiversity conservation is not in direct conflict with stock grazing. Indeed primary production is dependant on functioning ecosystems, of which biodiversity is a fundamental component (see Chapter 1, Values of biodiversity). Furthermore, retention of remnant vegetation benefits primary producers through more obvious and tangible ways such as prevention of increasing salinity, erosion control, provision of shelter to stock etc.

Managers of primary production land have a significant opportunity to contribute to biodiversity conservation at the same time as enhancing their long-term viability. Fencing of remnant vegetation, management of stocking levels and strategic placement of watering points can all benefit their long-term viability as well as biodiversity conservation.

5.2 Environmental Weeds

Weeds have a wide range of impacts on remnant vegetation. They compete with native plants for light, space, soil moisture, pollinators and

nutrients. Weeds can form a dense cover and smother emerging native plant seedlings. They can change habitats through extra shade and alterations to the soil (Robertson 1994).

Following a survey of 15 people with expertise in our local biodiversity a list of key weed species posing threats to biodiversity has been compiled. The five weeds constituting the most serious threats to biodiversity across the Adelaide Metropolitan Area are:

- **olive**
  (*Olea europaea*)
- **bridal creeper**
  (*Asparagus asparagoides*)
- **boneseed**
  (*Chrysanthemoides monilifera*)
- **phalaris**
  (*Phalaris aquatica*)
- **blackberries**
  (*Rubus fruticosis* L.agg.)

A non-exhaustive list of other plant species posing a threat to Adelaide's biodiversity are provided on page 4.

Other weeds posing a threat to Adelaide's biodiversity include:

- **three cornered garlic** (*Allium triquetrum*)
- **alligator weed** (*Alternanthera philoxeroides*) **WONS**
- **cabomba** (*Cabomba caroliniana*) **WONS**
- **tagasaste** (*Chamaecytisus palmensis*)
- **hawthorn** (*Crataegus* spp.)
- **couch** (*Cynodon* spp.)
- **English broom** (*Cytisus scoparius*)
- **salvation jane** (*Echium plantagineum*)
- **perennial veldt grass** (*Ehrharta calycina*)
- **tree heath** (*Erica* spp.)
- **fennel** (*Foeniculum vulgare*)
- **desert ash** (*Fraxinus rotundifolia*)
- **galenia** (*Galenia* spp.)
- **Montpellier broom** (*Genista monspessulana*)
- **cape tulip** (*Homeria* spp.)
- **coolatai grass** (*Hyparrhenia hirta*)
- **box thorn** (*Lycium ferocissimum*)
- **monadenia orchid** (*Monadenia bracteata*)
- **African furze** (*Muraltia heisteria*)
- **Chilean needle grass** (*Nassella neesiana*) **WONS**
- **soursob** (*Oxalis pes-caprae*)
- **kikuyu** (*Pennisetum clandestinum*)
- **radiata pine** (*Pinus radiata*)
- **rice millet** (*Piptatherum miliaceum*)
- **sweet pittosporum** (*Pittosporum undulatum*)
- **buckthorn** (*Rhamnus alaternus*)
- **castor oil plant** (*Ricinus communis*)
- **salvinia** (*Salvinia molesta*) **WONS**
- **South African daisy** (*Senecio pterophorus* var. *pterophorus*)
- **sparaxis** (*Sparaxis* spp.)
- **gorse** (*Ulex europaeus*) **WONS**
- **bulbil watsonia** (*Watsonia meriana* cv. *Bulbillifera*)
- **pasture grasses** Many different species

WONS= Weed of National Significance. These weeds have been identified as having significant impact on biodiversity, farming, cultural and other values. They have been identified by analysing each weeds:

- invasiveness and impact characteristics,
- potential and current area of spread, and
- current primary industry, environmental and socioeconomic impacts.

Weeds as with native plants, have particular preferences for habitat types. Consequently, weeds found at one locality may not be found at another.

Clearly, this list does not represent all of the plants that have naturalised and pose a problem to remnant vegetation in the Adelaide area. A comprehensive species list database of all NPWSA reserves, council reserves and other remnant areas in the Adelaide Metropolitan Area compiled for this study, shows that within the Adelaide area, more than a third of all plants found in NPWSA reserves and council reserves are exotic. Many of these plants do not currently pose a threat to biodiversity. However, they may pose a threat to biodiversity in the future. Species which appear benign for many years and then spread rapidly following certain natural events such as flood, fire, drought or climate change, or a change in land or water management are termed 'sleepers.' The National Weeds Strategy indicates "…[T]here is a need to recognise and eliminate sleepers during their benign phase or at least identify the events that could turn them into major weeds" (ARMCANZ, ANZECC & FM 1999). Many of these sleepers are found in suburban gardens, botanic gardens, and at the local nursery. If we are to prevent further invasions of weeds into our remnant vegetation, then commitment from all levels of government, land managers and the wider community is required.

This approach is also cost effective, as eradication of plants that are not widespread, is a relatively easy and cheap exercise. Yet, if we wait until these plants are widespread and invading bushland fast, the costs of control will be significant. Furthermore, the costs to the environment will also be great. The difficulty is identifying which species are likely to become a problem in the future. Systematic monitoring of weed spread in an area can be critical in this regard.

Unless otherwise indicated control methods for the following weeds are from Robertson (1994).

European Olive (*Olea europaea* ssp. *europaea*)

The **olive** (*Olea europaea*) was an intentional introduction for horticultural purposes. Indeed, widespread plantings throughout the Adelaide Metropolitan Area have recently occurred following a revival in the olive oil industry. It is unfortunate that a plant that contributes significantly to the state economy is also extremely invasive.

Olives have the capacity to invade a variety of plant communities, and most notably grassy woodlands.

Feral olives are increasing in number in the Hills Face Zone. This is cause for concern, as the Hills Face Zone constitutes more than 30% of the total area of remnant vegetation in the Adelaide area (see Chapter 3, Native Vegetation Tenure).

Seedlings and small plants can be removed by either hand-pulling or grubbing. However, it is critical to remove the underground lignotuber as well. This is best done in the winter when the soil is moist and friable. Larger plants must have their stem(s) cut close to the ground, the edges frilled and swabbed with a systemic herbicide. Recent success has also been had by drilling into the truck and injecting with herbicide. Both of these methods do not require the removal of the whole tree, consequently the dead tree will provide perching areas for birds and minimise total

disturbance. When using herbicide to control feral olives, best results are obtained in the summer/autumn period.

A strategic approach to where olives groves can and cannot be planted, that considers proximity to remnant vegetation and likelihood of escape will reduce the risk of infestations, contribute to biodiversity conservation and limit the costs associated with control of olive infestations.

Bridal Creeper (*Asparagus asparagoides*)

Bridal creeper has been described as South Australia's "…worst threat to biodiversity…" with "…about half of all terrestrial orchid species found in South Australia…potentially threatened by bridal creeper" (Anon 1999). It is one of 20 weeds of national significance (NWSEC 2000b) and is the most threatening environmental weed in the south-east of South Australia (Croft *et al.* 1999).

Bridal creeper grows rapidly between autumn and spring. Leaves and stems die in the summer, but underground roots persist throughout the year. It invades undisturbed sites and competes with native plants by smothering and displacing them; it also prevents regeneration (Virtue & Jupp 2000).

Bridal creeper is a major threat to understorey species, in particular herbs, lilies and orchids in mallee, dry sclerophyll forest, coastal and heath vegetation (Virtue & Jupp 2000).

While sandy, alkaline soils are particularly favoured, bridal creeper can grow in a variety of soil types. Roadsides are often heavily infested as they receive extra moisture from road run-off, additional nutrients from adjacent paddocks and are not subject to grazing pressure from stock (Virtue & Jupp 2000).

Introduced into Australia as a garden ornamental plant, dispersal is primarily via introduced and native fruit eating birds, that eat the berries and excrete seeds. Rabbits and foxes are also known to eat and disperse the seeds (Willis 2000).

Control of this species is difficult and time consuming. Priority must be given to preventing the establishment of bridal creeper in unaffected areas (Willis 2000). While the general principle of working in least affected areas first applies to virtually all weeds, in areas where infestation is still only in the early stages emphasis must be placed on controlling areas of high berry production.

Isolated plants can be physically removed through hand-pulling or grubbing, preferably before they have seeded. When hand-pulling or grubbing, it is important to remove the underground tubers. Small infestations should be controlled through herbicide application (Willis 2000).

Larger infestations are best controlled by using herbicides and fire. In the absence of fire herbicides alone can still be effective (Wallis 2000). However, in these instances it is important that a strategic staged approach is implemented, so that treated areas are not reinfested (Wallis 2000).

Two biological control agents have recently been released. The leafhopper (*Zygina* sp.) was released in June 1999, and a rust fungus (*Puccinia myrsiphylli*) was approved for release in June 2000. Results of these biological control agents are still being

assessed. Other agents are currently being studied in South Africa and in quarantine in Australia (Virtue & Jupp 2000). However, biological control is not a magic bullet, but rather one more weapon that can be used in the fight against this most invasive plant.

Boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*)

Boneseed is a bushy perennial shrub up to 3m high. Originally introduced into Australia as a garden plant in the 1850s, boneseed has also been used in the eastern states to control soil erosion in denuded areas such as sand dunes. Setting seed prolifically in the summer months, the seeds remain viable for at least five years.

Posing a significant threat to biodiversity, boneseed infestations reduce the abundance and diversity of native species and adversely affect the structure and function of natural ecosystems (Thomas 2000). It is for this reason that this plant is considered one of 20 weeds of national significance. Studies in Tasmania show that dense stands of boneseed can significantly effect the availability of food sources and habitat for native birds and animals while favouring introduced animals such as blackbirds and sparrows (DPIW&E 2000).

The capacity of boneseed to proliferate in natural ecosystems results from its rapid growth rate, enormous seed production, long viability of seeds, dispersal mechanisms, lack of predators/pathogens and its adaptability to different environments. Natural ecosystems most susceptible to boneseed infestation include dune heath, grasslands, headlands with heath, mallee and a variety of forests and woodlands (Thomas 2000).

In recognition of its capacity as a highly invasive weed, a national strategy for control of boneseed has recently been released (Thomas 2000).

The primary means of dispersal is via animals such as birds and foxes that eat the seeds and spread them, sometimes up to several kilometres away in their faeces. The seedbank stored in the soil consists of about 800-2500 seeds per square metre, with some seeds remaining viable for more than 10 years (Adair & Ainsworth 2000).

Small boneseed plants are relatively easy to pull up or dig out. Larger ones can be controlled by cutting at the base and swabbing with Glyphosate. The use of fire is also an effective method of control. However, because boneseed has large and persistent seed banks in the soil follow up work for several years is required (Adair & Ainsworth 2000).

Several biological control agents have been released; a couple have returned promising early results (Thomas 2000). Successful biological control agents will not eliminate the need to employ traditional methods of control such as hand pulling, herbicide application and the use of fire.

Phalaris (*Phalaris* spp. especially *P. aquatica*)

Several species of phalaris are capable of reproducing naturally in the environment; however, *Phalaris aquatica* is by far the most serious.

Phalaris is a tall tussocky perennial grass. Typically, it forms dense clumps along creeks and road verges, smothering understorey plants and preventing seedlings from growing.

Phalaris was initially planted as a pasture grass species, however more recently it has been scrutinised for the deaths of stock such as sheep and cattle (Bourke 2000).

Management of this particular weed is best achieved by pulling or grubbing young plants before development of the underground rhizomes and the setting of seeds. In more dense infestations, spraying of the leaves when green will achieve best results.

Blackberry (*Rubus fruticosis* L. agg.)

There are several species of blackberry grouped into the above aggregate, including the most common blackberry weed found in the Adelaide area *Rubus ulmifolius* var. *ulmifolius* (David Cooke *pers. comm.*).

In 1842, blackberry was deliberately introduced to Adelaide for its fruit. It was recognised as being an invasive weed by the 1880s (Pigott & Keel 2000).

Blackberries are a perennial plant, able to invade abandoned waste areas, land managed for pasture, bushland and particularly riparian areas. Blackberries occupy or grow over remnant vegetation thus preventing regeneration (Pigott & Keel 2000).

Dispersal is achieved via a variety of vectors, most frequently foxes and birds. Berries contain about 80 seeds each and are eaten by birds and foxes, who excrete the seeds in their faeces. Seed stored in the soil can be as high as 13,000 per square metre (Bruzzese *et al.* 2000).

Blackberries pose a significant threat to a priority SA plant community- *Leptospermum lanigerum, L. continentale* Swamp Heath (see Chapter 4, Priority Plant Associations). The Silky Tea-tree swamp heath occurs predominantly adjacent to permanent water in the high rainfall areas of the Mount Lofty Ranges. It is the habitat for several conservation significant plants and animals. These areas are also frequently invaded by Blackberries.

The plant provides shelter and food for introduced animals such as foxes, starlings and blackbirds. The increased abundance of these animals further impacts native flora and fauna (Pigott & Keel 2000). However, blackberry also provides habitat for some native animals including the **Southern Brown Bandicoot** (*Isoodon obesulus*). In areas where blackberry is providing shelter to native animals, its removal should be a gradual process, so that not all habitat is removed at once. In these instances, assistance to regenerating natives (eg follow-up weed removal) should also occur.

Blackberry is easiest to control in the earliest stages of infestations, as access remains relatively easy. Larger thickets must be treated in stages by spraying with Triclopyr at the edges of infestations. Follow up work is required.

Blackberry has a capacity to invade non-bushland areas also. Control of blackberries in these areas is not a high priority for biodiversity conservation, but is important to reduce re-infestation elsewhere.

5.3 Predation

Cats (*Felis catus*)

Predation by Feral Cats is listed in Schedule 3 of the Endangered Species Protection Act 1992 as a key threatening process (Environment Australia 2000).

The problem associated with Feral Cat predation must not be confused with predation by domestic and stray cats. Several threatened animals are known to be susceptible to Feral Cat predation and Feral Cats are known to have caused the extinction of native animals on some islands (Biodiversity Group 1999b). However, domestic Cats are found generally in the built-up areas where native species that are present are generally common or adaptable species (Biodiversity Group 1999b). Nevertheless, predation by domestic cats is known to impact heavily on urban wildlife, primarily birds.

Species that once occurred naturally in the Adelaide area, are on Schedule 1 of the above Act and are threatened by Feral Cats include:

- **Greater Bilby**
  (*Macrotis lagotis*)
  (known threat)
- **Numbat**
  (*Myrmecobius fasciatus*)
  (known threat)
- **Orange-bellied Parrot**
  Neophema chrysogaster
  (perceived threat)
- **Burrowing Bettong**
  (*Bettongia lesueur*)
  (perceived threat)

Predation by the Feral Cat is not restricted to the above listed species. Therefore, management of Feral Cat predation must involve action to reduce the threat to targeted threatened species ***and*** other native species (Biodiversity Group 1999b).

Cat owners can however, take some actions to reduce the likelihood of their pet killing native wildlife. Measures such as: keeping cats inside at night to prevent the cat from hunting at this time; placing two bells on their collar to alert other animals of their presence; and desexing male and female cats to avoid unwanted kittens, will reduce the adverse impact domestic Cats have on native wildlife.

European Red Fox (*Vulpes vulpes*)

Predation by the European Red Fox is listed in Schedule 3 of the Endangered Species Protection Act 1992 as being a key threatening process (Environment Australia 2000).

Species that once occurred naturally in the Adelaide area, are on Schedule 1 of the above Act and are threatened by the European Red Fox include:

- **Greater Bilby**
  (*Macrotis lagotis*)
  (known threat)
- **Numbat**

(*Myrmecobius fasciatus*)
(known threat)

- **Orange-bellied Parrot**
  Neophema chrysogaster
  (perceived threat)

Predation by the European Red Fox is not restricted to the above listed species. Therefore, management of fox predation must involve action to reduce the threat to targeted threatened species ***and*** other native species (Biodiversity Group 1999c).

Some might be surprised to hear that foxes are known to inhabit urban areas. However, reliable anecdotal evidence suggests that the European Red Fox can be found throughout the metropolitan area, not just on the urban fringe. Foxes utilise the main riparian corridors such as Dry Creek, Little Para River and River Torrens. They are known to occur at the Adelaide Airport, on the golf courses, South Parklands and West Terrace Cemetery. They have even been sighted in the central business district (Phil Stott *pers. comm.*).

Programs addressing the threat of the European Red Fox need to recognise:

> … that foxes cannot be eradicated over most of their Australian range using current techniques and financial resources. Abatement of the threat they pose must initially be undertaken in discrete manageable areas…Fox control will have to be ongoing for the foreseeable future and therefore must make the best use of available resources.
>
> (Biodiversity Group 1999c)

5.4 Inappropriate Management

The inappropriate management of remnant vegetation and the biodiversity contained within it is proving to be a serious threat to the overall biodiversity of the region.

Inappropriate management is a broad threat that includes management of land for a particular incompatible type of landuse (eg managing remnant vegetation for mountain bike riding), specific management practices (eg slashing grass for fire prevention), and can also include the absence of any type of management (eg failing to manage weeds in an undeveloped reserve). While legislation such as the *Native Vegetation Act 1991* and parts of the *Development Act 1993* offer remnant vegetation some protection from clearance, there is no legislative support that protects remnant vegetation from inappropriate management.

Intensive Recreation Perhaps the most common form of inappropriate management is allowing excessive and/or intensive recreation in sensitive remnant vegetation areas. This threat to biodiversity is a uniquely urban threat, simply due to the close proximity of large numbers of people to remnant vegetation. While the public is entitled to well-planned quality open space, some areas are inappropriate for most recreational activities. On the surface, someone walking his or her dog through a local council park does not appear to be a threat to biodiversity. However, walkers can carry plant diseases and weed seeds; the dog may defecate, encouraging weeds and polluting a local creek, and the mere presence of an animal such as a dog can affect the feeding of native animals. Moreover, when one considers the possibility of this happening many times in one day, the diversity and severity of threats become significant.

Mountain bike riding and horse riding are also worthy of particular attention. Each of these recreational activities can have detrimental impacts on remnant vegetation.

While people from each of these groups are entitled to good quality, safe and enjoyable areas of open space to undertake their chosen form of recreational activity, just where this should occur requires careful planning on behalf of decision-makers. Given that only 12.5% of native vegetation remains:

- we need to conserve and actively manage what remains, and
- there is almost 90% of the Adelaide region that does not have remnant vegetation on it- much of this is open space and can be used for more intensive or active types of recreation.

In those areas where particular types of recreation are incompatible with the conservation of biodiversity, measures should be taken to educate the public on why these areas are unsuitable for certain activities. For example, when part of a local park is fenced off from the public for management purposes, this should be accompanied with signage that addresses the importance of remnant vegetation, why the area is fenced off and how the public can further contribute to conservation of local patches of remnant vegetation. These initiatives need to be accompanied with the development of suitable recreation facilities for the activities in non-sensitive areas.

Management Practices Some areas of remnant vegetation are subject to specific, albeit, well intentioned detrimental management practices. For example, many local parks that contain remnant vegetation are slashed for fire prevention measures. However, the timing and method of slashing can quite easily be altered with little impact on the need to protect lives and property.

The threat of inadequate management is compounded by lack of information dissemination. Where the information and adequate understanding on how remnant vegetation should be managed exists in the minds of those making the management decisions, it needs also to be disseminated to those staff actually doing the field work (see Chapter 6, Field Operators).

The work at popular Beaumont Common is a good example of how a local government can provide residents with open space that meets local recreational needs, conserves biodiversity through appropriate management and educates the public on the importance of local patches of remnant vegetation.

5.5 Introduced Diseases

Disease is an integral component of functioning ecosystems. However, exotic diseases can threaten remnant vegetation; in particular scattered trees and degraded areas.

Root-rot fungus (*Phytophthora* spp.)

There are more than 50 known species of *Phytophthora*, but *Phytophthora cinnamomi* is the most common form of this parasitic fungus. It is a soil-borne pathogen that kills a range of native plants by attacking their root system. It can be found in all Australian states and in many climatic zones. It is believed that *P. cinnamomi* first entered Australia on the roots of cultivated plants, shortly after European settlement. Species at most risk are from the families Proteaceae, Epacridaceae, Leguminosae and

Myrtaceae; however, not all genera from these families are susceptible (Croft *et al.* 1999). In the Adelaide Metropolitan Area, it is most abundant in Cleland Conservation Park.

In undisturbed vegetation, *Phytophthora cinnamomi* generally occurs in locations receiving more than 600mm of annual rainfall. It is believed that in South Australia alone, tens of thousands of hectares are affected by *P. cinnamomi* (Commonwealth of Australia 1999a).

P. cinnamomi is capable of dispersing naturally in very moist, well aerated soils. Water travelling downslope can increase the boundaries of infection by a few hundred metres per year. *P. cinnamomi* is most likely to occur in moist sites such as gullies, creeks, drains and culverts. If established on ridges and upper slopes, then areas downslope will become infected over time. There remain however, other vectors most commonly associated with human activities. Road building and maintenance, timber harvesting, mineral exploration, the nursery trade and recreational activities such as bushwalking, mountain bike riding and horse riding are the most important (Commonwealth of Australia 1999a).

Establishment success is influenced by population levels in the soil from an infected area and total amount of soil transferred. At the point of delivery survival, establishment and further spread is dependant on sufficient moisture and the presence of living host tissue (Commonwealth of Australia 1999a).

Several methods are available to reduce the spread of this species. The "Draft Threat Abatement Plan for Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)" (Commonwealth of Australia 1999a) describes the following in detail:

- preventing invasion,
- reducing the pathogen's spread by vectors, and
- reducing the pathogen's activity.

There is no cure for *P. cinnamomi*. The most tangible means of reducing the spread of this disease is by washing down vehicles, equipment and shoes that have been working in and adjacent infected areas, and restricting access to infected areas (particularly when soil is very moist).

Other measures to control the spread of *Phytophthora cinnamomi* include:

- coordination of works in infested areas when soils are dry;
- ensuring all imported materials have been subject to hygiene procedures; and
- education of field staff and general public

(Velzeboer *et al.* 2000).

Mundulla Yellows

The disease Mundulla Yellows affects a range of Australian plants, but primarily eucalypts. Early symptoms include an uneven yellowing affecting the outer part of a limb or a segment of the crown. This is followed by dieback of affected shoots with a progression of yellowing inwards towards the centre of the crown; the yellow leaves may develop red-brown spots and may become distorted. Later stages include "panic growth" where the affected plant produces many new shoots below the infected area and the plant eventually dies (University of Adelaide 1999). While it may take more than 10 years, observations so far indicate that eventual death is inevitable (Paton & Cutten 1999)

Little is known of this recently discovered disease. However, it represents a serious potential threat to remnant vegetation as well as forestry and revegetation projects (Commonwealth of Australia 2000b).

It was first noticed by a local apiarist working in and around the upper South East town of Mundulla in the late 1970s (Cotton 1999). In South Australia alone it can be found in an area greater than 25,000 km^2. There are unconfirmed reports indicating that this disease may also be present in other Australian states (Commonwealth of Australia 2000b).

Current research indicates that this disease is both biotic and contagious. Possible causes that are currently being investigated include endo-parasitic pathogens such as viruses and phytoplasmas (John Randles *pers. comm.*). It is suggested that the wide and scattered distribution of this disease indicate that it is spread through aerial transmission (University of Adelaide 1999). There are also suggestions that this disease has other non-biotic causes such as herbicide use and vehicular diesel fumes (Peter Bennett *pers. comm.*). Results from seedlings that have been grafted with infected tissue support the hypothesis that a pathogen is involved (John Randles *pers. comm.*).

While in South Australia, the disease appears most prolific in and around the South East, trees at several localities throughout the Adelaide Metropolitan Area also show symptoms of this disease (John Randles *pers. comm.*). These include the Adelaide city parklands, the foothills, Waite Arboretum, roadsides in the southern region and Cobbler Creek Recreation Park.

Given that this disease represents such a significant potential threat to biodiversity and that its origins are unknown; the obvious action at this stage is a significant input of resources into researching the disease, its causes, means of spread and management.