# Conservation issues for the vascular flora of Lord Howe Island

*Tony D. Auld[1] and Ian Hutton[2]*

[1]Biodiversity and Conservation Science Section, Department of Environment and Conservation (NSW)
PO Box 1967 Hurstville NSW 2220, AUSTRALIA Email: tony.auld@environment.nsw.gov.au
[2]PO Box 157 Lord Howe Island, NSW 2898 AUSTRALIA

***Abstract:*** The flora of the Lord Howe Island Group (31°30'S, 159°05'E) comprises a unique mix of elements of Australian, New Zealand and New Caledonian floras. It is significant for its high degree of endemism and for its structural and biological (leaves, flowers, fruit) role in supporting a diverse array of fauna. Conservation of this flora is dependant upon: reducing current habitat degradation (mostly the result of exotic weeds); minimising any future impacts, in particular the effects of climate change on the unique cloud forests of the southern mountains and the continued introduction and spread of weeds and the pathogen *Phytophthora cinnamomi*.

We provide a description of the nature of the major threats to the flora and suggest an area-based scheme, focussed on the relative conservation significance of remaining vegetation, as a mechanism for developing priorities for threat mitigation activities. While a number of threat control works are in place, eg. weed control, some re-emphasis is needed. In addition, some new initiatives are required including: reducing the rate of introductions of new exotics; a system to remove potential environmental weeds from the settlement area; phytosanitary guidelines; pathogen quarantine measures; search and removal of environmental weeds from remote areas; and *ex situ* initiatives for plant species restricted to the cloud forests of the southern mountains.

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## Introduction

Lord Howe Island (31°30'S, 159°05'E) is a small oceanic island some 570 km from the east of Australia, 1350 km from New Zealand and 1250 km from New Caledonia. The Lord Howe Island Group consists of the main Lord Howe Island (11 km long and between 0.6 and 2.8 km wide, with a land area of 1455 ha) and a number of small surrounding islands (including Admirality Islands, Blackburn (or Rabbit) Island, Mutton Bird Island, Gower Isalnd and Balls Pyramid). The flora of the island has high conservation significance for a range of reasons. The flora represents a unique mixture of Australian, New Zealand and New Caledonian floral elements (Oliver 1917, Pickard 1983a, Green 1994), the combination of which is extremely rare in the world. Although other Pacific Islands such as Norfolk Island and the Kermadec Islands also have these three floral elements (Mueller-Dombois & Fosberg 1998), each of these island groups has a unique flora. On the basis of floristic affinity, van Balgooy (1971) considers Lord Howe Island to represent a floristic district within the New Zealand sub region, based on the distinctiveness of the genera shared with New Zealand and the absence of the most characteristically Australian genera such as *Eucalyptus, Acacia* and those from the Proteaceae. However, as most plant affinities with mainland Australia are for rainforest elements, the lack of dry forest Australian genera is not too surprising. Australia and Lord Howe Island have never been connected and the entire flora is considered to be long-distance dispersed. Submerged seamounts in the Tasman Sea indicate the former existence of other islands that have probably facilitated migration of plants and animals between Lord Howe Island, Australia and New Caledonia. A suite of plants exist on Lord Howe Island that have been transported by wind, birds or ocean currents along these former stepping stone islands.

The flora of Lord Howe Island has a high level of endemism and many of the floristic assemblages are also unique to the island group (Pickard 1983a, Green 1994). There are five plant genera endemic to Lord Howe Island — *Negria, Lordhowea* and three palm genera *Howea, Hedyscepe* and *Lepidorrachis.* For the vascular plants, Green (1994) lists 459 species, 241 indigenous (53%), of which 105 are endemic (44%) and 218 naturalised (48%). Of the indigenous vascular plants, 58 species are ferns and 183 are flowering plants. Several more species of both indigenous and naturalised plants have been found since Green's (1994) work. The high level of endemism is typical of islands and comparable with megadiverse regional areas of continents (Lowry 1998). Of the 241 indigenous vascular plant species on Lord Howe Island, 129 are also found in Australia, 102 are also found in New Caledonia, 75 also occur in New Zealand and 66 also occur on Norfolk Island. The only genus confined to Lord Howe Island and Australia is *Westringia*, the only genus confined to Lord Howe Island and New Zealand is *Carmichaelia.* Lord Howe also has many plant genera that occur more widely across the Pacific islands, such as *Alyxia, Dracophyllum, Elaeocarpus, Elaeodendron, Melicope, Metrosideros, Ochrosia, Pisonia, Psychotria, Sophora* and *Xylosma*. The floristic structural and biological (e.g. leaves, flowers, fruits) components of the flora are important as habitat structure and resources for the unique Lord Howe Island fauna (Cassis et al. 2003).

Less detailed information is available on the non-vascular flora. The mosses of Lord Howe Island are diverse and show great affinity with the mosses of Australia and New Zealand. Ramsay (1984) listed 105 moss species from 36 families, with 21% endemic species for Lord Howe Island. 102 species of lichens are listed for Lord Howe Island (Elix & McCarthy 1998) with a number of endemics. For example, Archer and Elix (1994) studied the lichen genus *Pertusia* on Lord Howe Island and listed 20 species, 5 of them endemic.

Although there has been extensive clearing for settlement of the lowland area of the main island on the Lord Howe Island Group, much of the northern hills and southern mountains remains intact and protected within a Permanent Park Preserve. This represents some 80% of the main island (Davey 1986). A number of major threats currently affect the survival and reproduction of the flora and the interactions that occur between plant and animals species. Management of these threats requires an understanding of: (i) the conservation status of the various species, populations and ecological communities and their distribution across the landforms of the island; (ii) the dynamics of component species and communities; and (iii) the nature and potential impact of threats. Whilst Pickard (1983b) assessed the conservation status of vascular plant species on Lord Howe Island, our understanding of the other issues is somewhat limited. Because of the different soil types and landform features, the vegetation varies across the island. When combined with the history of clearing for the settlement area (generally in the low lying areas), the remnant vegetation and associated species of conservation significance are not evenly distributed across the island and associated islets. This variation influences the practicalities of how to best deal with the conservation of the flora for land managers. Lord Howe Island is a part of New South Wales and both state (NSW *Threatened Species Conservation Act* 1995) and Federal (*Environment Protection and Biodiversity Act* 1999) threatened species legislation applies to the island.

## Landforms and climate

The Lord Howe Island Group is considered to be the eroded remnant of a large shield volcano, approximately 7 million years old. Together Lord Howe Island and Balls Pyramid are the emergent portions, on two adjacent summits, of a large, nearly truncated, seamount. The water surrounding Lord Howe Island and in the Tasman Sea generally is between 1000 and 4000 metres deep.

The original Lord Howe Island would have been approximately 30 km in diameter, and 1,000 metres above current sea level in height. Today the island is 11 km long and 2.5 km at its widest point and a height of 875 metres above sea level. Balls Pyramid is a rocky island 23 km south-east of Lord Howe Island, with its base 1 km long and about 200 m wide. The volcanic rocks of both islands are typical mid-oceanic hot spot lava flows interspersed with tuff layers.

In more recent geological history, sedimentary calcarenite has been deposited on the low lying areas of the island as old lagoon floor, beach and sand dune deposits. The grains of sand in this calcarenite are calcium carbonate, derived from marine organisms such as corals, molluscs and foraminifera living in the surrounding shallow waters that existed as large shelf areas in periods of lower sea levels over the past 120,000 years.

The climate of Lord Howe Island is humid-subtropical. It has a mean annual temperature of 19.2°C, ranging from 25°C –17°C in summer to 18°C–14°C in winter (Mueller-Dombois & Fosberg 1998). Average annual rainfall is 1717 mm, with a maximum of 2886 mm and a minimum of 998 mm (Mueller-Dombois & Fosberg 1998). Rainfall is unevenly distributed throughout the year, with an average low of 100 mm in February and a high of 200 mm in June/July. Generally the rainfall is in the form of short duration, moderate to heavy showers and thunderstorms rather than slow steady rain. Relative humidity is consistently moderate, at 75–78%. Strong winds are characteristic, with westerlies dominating in winter and easterlies in summer (Hutton 1986).

## Major threats to the vascular flora

### Weeds

The vegetation of Lord Howe Island has been severely affected by introduced plants and over 241 plant species have become naturalised (Pickard 1984, Green 1994, Hutton & Le Cussan 2001). A number of these are having a serious impact on the persistence of individual native species and the structure of ecological communities. Pickard (1984) demonstrated that the arrival of exotic plants onto Lord Howe Island had occurred at an exponential rate from 1853–1981. Data from Hutton and Le Cussan (2001) on current weed species on Lord Howe Island and exotics arriving since 1980 match the expected number of exotics based on an exponential rate of increase (Pickard 1984). This implies that there has been no slowing of the rate of introductions of exotics in the past 20 years and that new introductions are continuing e.g. the legume *Macroptilium atropurpureum* (Siratro) was first recorded on Lord Howe Island in 2002. This demonstrates a significant failure in weed control for the island as future weed impacts will be dependant on both the magnitude and type of weeds that are brought to Lord Howe Island. Simberloff (2000) suggests two key outcomes that would significantly improve the conservation of island floras: 1) less habitat loss (currently occurring on Lord Howe Island, see below); and 2) a decline in the rate of introductions of non indigenous species (not occurring at present).

On Lord Howe Island, 17 introduced species are listed as Noxious weeds under the NSW *Noxious Weeds Act 1983*, and a further 36 species may be considered environmental weeds that are either slowly becoming established in the natural vegetation, or are weedy elsewhere and should be removed. Weeds of particular concern at present are *Psidium cattleianum, Pittosporum undulatum, Chrysanthemoides monilifera, Ageratina adenophora, Asparagus aethiopicum, Asparagus plumosus* and *Lilium formosanum.*

*Psidium cattleianum* is a serious woody weed of subtropical island ecosystems in the world (Lowe et al. 2000). It is the major woody weed on the Galapagos Islands, Mauritius, Seychelles, Hawaii, Norfolk Island, and Lord Howe Island. More urgent attention to eradication/control of this plant on Lord Howe Island is needed. At the same time, the relative impact of some weeds has changed over the last 30 years. For example, Pickard and Clark (1974) suggested that the *Asparagus* spp. were rare in undisturbed vegetation and that there was doubt as to the 'seriousness of these plants'. Currently, these weeds collectively represent one of the most significant threats to the vegetation of Lord Howe Island. *Pittosporum undulatum* was introduced in 1898 and has spread slowly into undisturbed forest (Pickard 1984). Since 1984, it has continued to spread southward and has now reached Intermediate Hill (Hutton & Le Cussan 2001). Pickard (1984) warned of the potential spread of several weeds. This warning has not been heeded and several weeds that were brought to Lord Howe Island in the 1970–1980s are now becoming serious environmental weeds. For example, *Ochna serrulata* was introduced as an ornamental in 1980 (Pickard 1984) and has now spread to the north face of Mount Lidgbird in the southern mountains (Hutton & Le Cussan 2001).

The Lord Howe Island Board has an extensive weed control program (Lord Howe Island Board 2002b). This is combined with volunteer weeding programs. The current program is targeted, but may need some refinement to better focus on restricting the spread of serious weeds in the highest priority area (the southern mountains and Intermediate Hill) e.g. *Psidium cattleianum* and *Asparagus* spp. (see below).

*Loss and degradation of habitat.*

Most of the loss of vegetation has occurred in the settlement area and little further habitat loss is expected for urban development. About 15% of the island forest has been cleared for housing, gardens or grazing. Most of this is lowland forest of the type *Cryptocarya triplinervis/Drypetes deplanchei* closed forest (Pickard 1983a). This forest type is one of the habitats for two endangered animals (the Woodhen *Tricholimnas sylvestris* and the land snail *Placostylus bivaricosus*).

The impact of this clearing has gone beyond the removal of individual trees and understorey. The majority of the forest of the island is rainforest and when the natural border of hardy small trees and shrubs is removed the exposed trees are affected by the strong, salt laden winds that blow across the island, particularly during winter months (Pickard 1983a). The exposed trees gradually lose their leaves and may die over a period of some decades. This dieback has been noted by botanists before 1900 (Pickard 1983a). This dieback is exacerbated by the invasion into the forest by the pasture grasses *Pennisetum clandestinum* (Kikuyu) and *Stenotaphrum secundatum* (Buffalo) which grow over native trees and shrubs trying to establish on the forest edge. The Lord Howe Island board has developed a revegetation program (Lord Howe Island Board 2002a) to attempt some habitat restoration in areas affected by tree dieback due to exposure.

*Impacts of exotic animals*

There have been a number of introductions of animals to Lord Howe Island. Pigs and goats had locally significant impacts (Pickard 1976). Pigs were eradicated in 1979 and goats have been virtually eliminated from the island. Currently, the most serious exotic animals are likely to be rats and mice. These may consume fruits, seeds or vegetative material and hence limit reproduction, recruitment of new plants and plant vigour and competitive ability, but very little is known about their impact. Further study is required on those species that have been observed to suffer heavy predation e.g. loss of fruits and seeds (*Baloghia inophylla, Chionanthus quadristamineus, Drypetes deplanchei, Elaeodendron curtipendulum, Pandanus forsteri, Ochrosia elliptica*); loss of seedlings and stem damage (the four palm species, *Hedyscape canterburyana, Howea forsteriana, Howea belmoreana, Lepidorrhachis mooreana, Dietes robinsoniana* (Wedding Lily) and at least two fern species, *Asplenium milnei* and *Adiantum hispidulum*). The extinctions of two Lord Howe Island plant species, *Sicyos australis* and *Solanum bauerianum*, were most likely influenced by consumption of seeds and fruits by introduced animals.

There is the potential for rat and possibly mouse control on Lord Howe Island (Saunders & Brown 2001) but no assessment of the impact of rodents on the flora is currently available to inform control methodologies or to prioritize areas for control if eradication is not possible or not successful. This needs to be addressed in the lead up to the development of any rodent control strategy.

Two other threats have the potential to have a major impact on the flora, and preventative actions need to be taken to reduce potential impacts. These threats are:

*Climate change*

The summits and upper slopes of the southern mountains on Lord Howe Island contain unique assemblages of plants and animals, in particular in association with cloud forest vegetation. This vegetation is most extensive on the summit of Mount Gower (875 m) (Pickard 1983a). Moist air flowing across the summit is forced to rise, and the condensation results in semi permanent cloud shrouding the summits, particularly during the summer months. The resulting high humidity provides conditions for many unique species to exist. The cloud forest consists of dwarf rainforest trees about 5 metres high, with an abundance of mosses, ferns and liverworts covering the ground, tree trunks, branches and rocks. Approximately 86% of plant species on the summit are endemic.

One of the predictions arising from modelling the impacts of climate change is that there is likely to be upward altitudinal shifts in the areas that receive cloud formations (Still et al. 1999). If this prediction holds for Lord Howe Island, then there may be reduced formation of clouds on the southern mountains and reduced precipitation. This is likely to have negative impacts for species occupying both the cloud forests themselves and the associated mountain slopes.

At present, there are no active actions in relation to possible impacts of climate change on Lord Howe Island. At a minimum, investigations should be made into propagation and *ex situ* storage techniques for species restricted to the cloud forests (Harris et al. in press). This may include both seed banking and/or living collections.

*Exotic pathogens*

Exotic pathogens can drastically alter the vegetation composition and structure in habitats that are sensitive to these pathogens. In Australia, the exotic pathogen *Phytophthora cinnamomi* is widespread and has been shown to severely impact on certain species or plant communities across a range of environmental regions (Environment Australia 2001). This pathogen was recently identified as present on Lord Howe Island in 2003, where it was identified in a small orchard on cleared land at the southern end of the settlement area (B. Summerell pers. comm.). Unidentified species of *Phytophthora* were also found at several lowland sites in the settlement area. There are a number of plant taxa on Lord Howe Island that are closely related to taxa that have been severely impacted by *Phytophthora cinnamomi* in other parts of the world (Table 3). Such species are potentially susceptible to this pathogen; urgent action is required to quarantine the known infected area, carry out detailed surveys for the presence of *Phytophthora cinnamomi* around drainage lines in the known location and to test susceptibility of the species listed in Table 3. In addition, a set of phytosanitary guidelines is urgently needed to avoid any further importations of this pathogen and to prevent its spread to forested parts of Lord Howe Island.

## Priorities for conservation management

Here we propose an area-based classification scheme as a framework for dealing with current and future conservation management issues for vascular flora on Lord Howe Island. This should then be overlain on and integrated with issues for non-vascular flora, fungi and fauna, where such information is available. We identify six priority areas for management based on the overall conservation significance of the vascular flora of each area, in combination with the nature and degree of threats that are either currently impacting on the vegetation or may rapidly impact on the vegetation in the future. While there is clear overlap between vegetation across areas, each area stands as a unit that can be practically managed on the ground. It is also possible that subdivision of the suggested areas may be practical for management but here we simply present the overall broadscale priorities. A summary of the priority areas and major threats is contained in Table 1, while the key actions for management of vascular flora conservation are contained in Table 2.

### Priority 1. Southern Mountains and Intermediate Hill

This area covers some 65% of the main island and contains all vegetation in the Permanent Park Preserve south of the airstrip. Because of the connectivity of the vegetation, it is important to manage it as a single unit. Some of the area has been cleared (south end of Lagoon beach through to Salmon Beach), but most is rugged and uncleared. The area is of the highest priority in terms of conservation of vascular flora. It contains the majority of endemic species and significant endemic plant communities such as cloud forest, Mountain palm forest, *Chionanthus* closed forest and *Dracophyllum*/*Metrosideros* scrub (Pickard 1983a). The endangered species *Carmichaelia exsul, Coprosma inopinata, Geniostoma huttonii, Polystichum moorei* and *Xylosma parvifolium* are confined to this area, while three of the four known

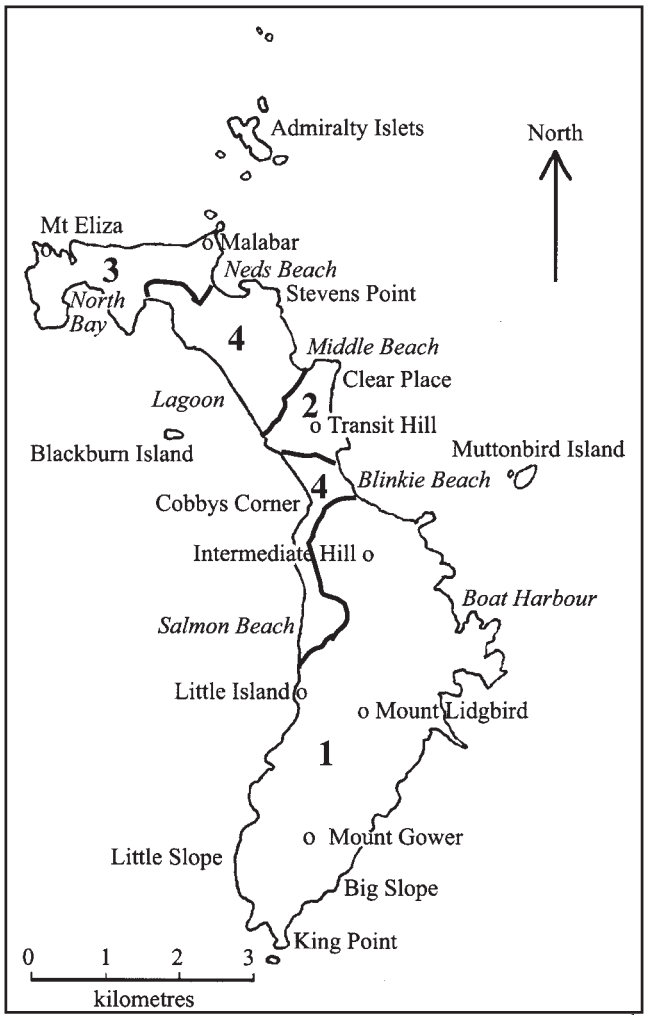


**Fig. 1.** Proposed Conservation Management Zones for Lord Howe Island

**Group**

1 Southern Mountains and Intermediate Hill

2 Transit Hill

3 Northern Hills

4 Settlement Area

5 Coastal dunes (including Neds Beach, North Bay, Lagoon Beach, Middle Beach, Blinky Beach, Salmon Beach)

6 Offshore Islets (including Admirality Islands, Blackburn (or Rabbit) Island, Gower Island, Mutton Bird Island, Balls Pyramid)

**Table 1. Priority Areas and Key Threats to conservation of vascular flora (see Fig. 1 for locations).**

| Priority | Area | Key Threats |
|---|---|---|
| 1 | Southern Mountains & Intermediate Hill | Weeds, climate change, *Phytophthora cinnamomi*, rodents |
| 2 | Transit Hill | Weeds, dieback of forest edges |
| 3 | Northern Hills | Weeds, dieback of forest edges |
| 4 | Settlement Area | Weeds, edge disturbances, *Phytophthora cinnamomi*, degradation and loss of *Lagunaria* swamp forest, genetic pollution |
| 5 | Coastal Dunes | Weeds |
| 6 | Offshore Islets | Weeds on Blackburn Island |

populations of the endangered *Calystegia affinis* occur here. Several rare species or species of conservation significance also occur here (Pickard 1983b, Hutton 2001, unpubl., Harris et al. in press). There are also a number of significant non-vascular plants, particularly on mountain summits, and a range of significant vertebrate and invertebrate species (Cassis et al. 2003). At present, this area is not as severely impacted as are the Transit and Northern Hills areas (priority areas 2 and 3), but it is essential that that degree of degradation is precluded from occurring in the southern mountains.

For the conservation of the flora, key issues are: weed encroachment, climate change, ensuring the habitat remains free of *Phytophthora cinnamomi*, maintenance of negative impacts of walking tracks and associated users, rodent impacts and rehabilitation of *Lagunaria* Swamp Forest at former locations.

*Weeds*

As the settlement is the source of weeds into this unit, the worst infestations of weeds are close to the disturbed areas. However, weeds will spread from this edge throughout the southern mountains if left unchecked. As well there are a number of weeds that can invade undisturbed native vegetation on Lord Howe Island (Pickard 1984). Already individuals of serious weeds such as *Psidium cattleianum* have been found on the upper slopes of both Mount Gower and Mount Lidgbird. Three main groups of weeds are serious problems for this area.

(1) *Fleshy-fruited weed species that have the ability to modify the understorey structure of the forests of the southern mountains*. Within this area there are several areas of land that are now part of the Permanent Park Preserve, but were cleared as leases in the 1950s. These contain many weed species including *Psidium cattleianum*, which are a source of weed invasion into the undisturbed forests. A belt of *Psidium cattleianum*, occurs all along the boundary of the settlement area here and already numerous individuals of *Psidium cattleianum* occur within the forest of the Permanent Park Preserve. There are scattered individuals occurring on remote north slopes of Mount Gower to 600 m elevation. Other fleshy-fruited weeds in this belt include *Cotoneaster glaucophyllus, Ochna serrulata, Chrysanthemoides monilifera* and *Asparagus aethiopicus.* If left unchecked, these species have the potential to dramatically reduce the conservation values of this, the highest priority area.

Two ways of dealing with weed invasions in these types of areas are:

(a) to treat mature fruiting individuals to prevent further seed dispersal; and

(b) the Bradley Method (Bradley 1988) i.e. to start at the farthest, sparsely separated individuals and work back to the worst areas near the source of infestation (usually settlement areas).

The most effective treatment may be to combine these methods. Any large stands of mature plants that are a seed source, and are easily accessible can be treated to prevent seeds being available for further spread. When planning long term works programs it may be effective to divide the area into a grid, and to start treatment of grids at the extreme ends of weed infestation, working back to the centre of most dense infestations.

Low numbers of fruiting *Psidium cattleianum* have already been removed from the remote slopes of Mount Gower and Mount Lidgbird to 600 m altititude. A surveillance program needs to be introduced to search the most likely remote areas for these weeds and remove them. If left, they become a source to develop into major remote infestations. The sites most likely to have these weeds are open, sunny areas (but they can also recruit into undisturbed forest). These areas include the boundary of the vertical cliffs and heavily forested slopes at around 400 m, open slopes with low sparse scrub, and land-slips. The north and west faces with more sun are more prone to weed invasion.

The areas of worst weed infestation have been mapped to identify areas for treatment (Lord Howe Island Board 2002b, Le Cussan 2003). As weed control work is done, this work should also be mapped to evaluate treatment programs as they proceed.

(2) *Wind-dispersed weed species*. Currently these are a major problem on the exposed edges of the rocky slopes of the southern mountains and habitat in areas at the base of the major cliffs where torrents of water from creeks, flowing during heavy rainfall, scour native vegetation. This distribution probably results from past goat activity and on-going high level of environmental disturbance due to the exposed nature of such sites. Major problem species are *Ageratina adenophora* (Crofton weed) and *Lilium formosanum*. Such species tend to locally dominate the exposed sites and exclude natives. *Ageratina adenophora* has probably been on Lord Howe Island since the 1920s (Pickard 1984). It occurs at many areas around the whole of Mount Lidgbird and Mount Gower at about 400m in elevation. From these dense, almost monoculture areas it is spreading into other exposed mountain slopes, particularly on Mount Gower.

**Table 2. Key actions for conservation management of vascular plants on Lord Howe Island.**

| Issue | Action |
|---|---|
| Weed control | Focus resources on highest priority conservation areas, independent of current magnitude of weed problem. This may involve some modification to existing weed eradication/control programs. |
| | A 'surveillance program' and a 'rapid response' program should be developed to quickly identify and treat any new weed incursions into the island. Early detection and treatment have been identified as the number one factor in successful eradication of weeds. Involve the community in this program. This is essential to reduce the rate of new weed introductions. |
| | Removal of potential environmental weeds from Settlement area in co-operation with community. |
| | Continue support for volunteer program for assisting with weed eradication. |
| | Monitor walking tracks for weed incursions. |
| | Treat weed control as one component of habitat restoration. |
| Public awareness | Continuing public awareness program about the need to protect the forests. This is for the integrity of the islands ecosystems and to maintain the island as a high quality ecotourism destination. This includes treating weeds on leases and removal of garden plants that are potential weedy species. Removal of exotic species that may pollute the genetic diversity of endemic species. |
| | Continuing public awareness program about not bringing foreign plants and animals to the island. |
| | Continue to supply Lord Howe Island native plants to residents for landscaping and gardens. Consider expanding the range of plants available, to also include native ferns and ground cover such as native grasses. |
| Quarantine | Develop and implement strategy for control of spread of *Phytophthora cinnamomi*. |
| | Implementation of the quarantine strategy adopted by the Lord Howe Island Board. |
| Rehabilitation | Focus on dieback areas and *Lagunaria* swamp forest. |
| | Continue rehabilitation programs already in place. |
| Research | Priority areas being weed control, restoration, conservation assessment, rodent impacts, population dynamics, *ex situ* conservation of endemic cloud forest species. |
| | Continual research into up to date treatment methods of all weeds where they occur in other parts of the world, particularly islands. Introduce staff to these latest methods. |
| | Support investigation into biology and ecology of major weed species to aid an understanding of potential spread and possible control strategies. |
| | Investigate current research into biological control of all weed species. Research possible sources of funding into biological control of all weeds, in particular Crofton weed *Ageratina adnenophora*. |
| | Monitor effectiveness of current weed program and methods. |
| | Continue research into rodent eradication, but quantify vegetation impacts and prioritise species and areas for control prior to eradication. |
| Funding | Continue to seek long term funding for a range of projects. |
| | Encourage collaborate research through ARC linkage grants for particular issues. |

The location of these wind-dispersed weed species makes manual control largely impossible. At the same time they are having a serious impact on the World Heritage Values of Lord Howe Island and seriously impact on threatened plant species including the endangered *Carmichaelia exsul* and *Calystegia affinis*. Biological control may be a future option for control of some of these weeds and given the high number of Lord Howe Island endemic species, research into such control should be a national priority.

(3) *Weeds recently carried into the southern mountains area along walking tracks*. These are currently only very localised and are having a minor impact, but their removal would be simple and cheap now; delaying any action will make control more expensive and perhaps impossible. Examples include *Paspalum wettsteinii* which occurs in about four places on the Muttonbird Point-Rocky Run- Boat Harbour track and at one place in Erskine Valley on the Mount Gower track. Kikuyu grass, *Pennisetum clandestinum*, occurs at only one place near the start of the Muttonbird Point Track, but also occurs on the Mount Gower walking track below Mount Lidgbird and at 700m in elevation. Treatment and removal of these weeds now will maximise the environmental benefit and be the most cost effective way to deal with them.

Weed control is just one component to the final outcome which should be habitat restoration. When a weed is treated or removed, other weeds may invade the area; it may be necessary to monitor the site and undertake other actions. Many weed species grow best in sunny open conditions, and are suppressed in shade so effective restoration may require mulching and/or planting native species to provide shade and inhibit weed species. Other species can invade and persist in shaded habitats or undisturbed forests (Pickard 1984) and ongoing control will be needed.

**Table 3. Species from Lord Howe Island with conspecifics elsewhere in the world that have been impacted by *Phytophthora cinnamomi*.**

| Lord Howe Island Species | Importance on Lord Howe Island | Conspecific affected elsewhere |
|---|---|---|
| *Cassinia tenuifolia* | Widespread shrub of lowlands. Major recolonising species | *C. aculeata* eastern Aust. (Taylor 1974) |
| *Coprosma huttoniana* | Endemic shrub of upper southern mountains | *C. australis* in New Zealand (McKenzie et al. 2002) |
| *Coprosma inopinata* | Endangered endemic shrub of upper mountains | *C. australis* in New Zealand (McKenzie et al. 2002) |
| *Coprosma lanceolaris* | Endemic shrub of upper southern mountains | *C. australis* in New Zealand (McKenzie et al. 2002) |
| *Coprosma prisca* | Endemic lowland shrub | *C. australis* in New Zealand (McKenzie et al. 2002) |
| *Coprosma putida* | Endemic small tree of lowlands to mountains | *C. australis* in New Zealand (McKenzie et al. 2002) |
| *Cryptocarya gregsonii* | Endemic tree of southern mountains | *C. cinnamomifolia, C. corrugata, C. glaucescens* Tropical Queensland (Brown 1999) |
| *C. triplinervis* | Major dominant tree on lowland forests | *C. cinnamomifolia , C. corrugata, C. glaucescens* Tropical Queensland (Brown 1999) |
| *Dodonaea viscosa* | Widespread shrub to small tree of lowlands | *D. viscosa* eastern Aust. (Taylor 1974) |
| *Drachophyllum fitzgeraldii* | Endemic tree, major structural component in southern mountains | A range of Epacridaceae |
| *Exocarpus homalocladus* | Widespread endemic shrub to tree | *E. cupressiformis* eastern Aust. (Taylor 1974) |
| *Gahnia howeana* | Endemic shrub from lowlands to mountains | *G. xanthocarpa* in New Zealand (McKenzie et al. 2002) |
| *Gonocarpus* sp. | Confined to ridge of Mt Gower | *Gonocarpus teucrioides* (Pratt & Heather 1973) |
| *Leptospermum polygalifolium* spp. *howense* | Endemic subspecies of shrub or small tree important structural component of cloud forest | *L.* spp. eastern Aust. (Taylor 1974, Weste 1974, Podger & Brown 1989) |
| *Leucopogon parviflorus* | Lowland shrub | *L.* spp. eastern Aust. (Pratt & Heather 1973, Taylor 1974, Barker & Wardlaw 1995) |
| *Metrosideros nervulosa* | Endemic small tree of southern mountains | *M. collina* in Hawaii (Kliejunas and Ko 1976) |
| *M. sclerocarpa* | Endemic tree of southern mountains | *M. collina* in Hawaii (Kliejunas and Ko 1976) |
| *Olearia ballii* | Shrub of southern mountains | *O. oppositifolia* Barrington Tops (McDougall & Summerell unpubl.) |
| *Olearia elliptica* ssp. *praetermissa* | Endemic subspecies of shrub from southern mountains | *O. oppositifolia* Barrington Tops (McDougall & Summerell unpubl.) |
| *Olearia mooneyi* | Endemic small tree of southern mountain tops | *O. oppositifolia* Barrington Tops (McDougall & Summerell unpubl.) |
| *Syzygium fullageri* | Major structural endemic tree of lowlands and southern mountains | *S. erythrodoxa, S. wesa* Tropical Queensland (Brown 1999) |
| *Symplocos candelabrum* | Endemic tree of southern mountains | *S. stawellii* Tropical Queensland (Brown 1999) |

### *Exclusion of pathogen* Phytophthora cinnamomi

This pathogen has recently been identified as occurring in an avocado orchard on the island. A number of taxa from the southern mountains are potentially susceptible to this pathogen, based on related species elsewhere. These include major structural dominants such as *Syzygium, Dracophyllum, Metrosideros, Leptospermum* and *Cryptocarya* (Table 3). The pathogen could devastate the vegetation. Currently, a precautionary approach should be taken and protocols for prevention of the pathogen from reaching the southern mountains should be developed, along with testing of potentially susceptible taxa in Table 3.

With human visitation increasing, the possibility of this pathogen (or others) being introduced on walking boots is increasing. Visitors to Lord Howe Island should be advised to clean and treat their walking shoes and boots before travelling to the Island. A treatment station at the starting points to walking tracks in this area is needed to prevent pathogens being carried into vegetated areas.

### *Climate change*

The most likely impact of climate change will be on the cloud forest and associated vegetation and fauna of the southern mountains. While control of the issue is not relevant for Lord Howe Island, it may be possible to reduce the potential impacts of climate change. This would require ensuring species confined to the cloud forest and upper mountain slopes have representative samples in *ex situ* conservation, including seedbanks and living collections.

### *Rodent control*

A number of plants in this area have seeds, fruits or vegetative material that are consumed by introduced rodents. For example, observations on Mount Gower have suggested that recruitment of *Lepidorrachis moorei* (Small Mountain Palm) has been limited by rodents and that effective recruitment only occurs in areas subject to rodent poisoning.

A quantitative assessment of the standing size structure of the population on Mount Gower is needed. This should include a comparison across baited and non-baited areas as well as assessing the survival of tagged seedlings and juvenile plants. This will demonstrate the importance of rodent control for the small mountain palm.

The extent of impact of rodents on other species is poorly known and research in this area should be encouraged. It is possible that rodents may be eating fruits of *Passiflora herbertiana* ssp. *insulae-howei*, a species that is highly restricted and declining on Lord Howe Island (Pickard 1983b, Hutton unpubl.).

**Priority 2 Transit Hill**

This area is crown land that is proposed for addition to the Permanent Park Preserve. It contains both *Drypetes*/*Cryptocarya* closed forest, *Howea forsteriana* palm forest and mixed forest (Pickard 1983a). The area is largely intact but, being close to the settlement area, has been subject to weed invasion (Le Cussan 2002) and edge disturbances in particular. This is a second priority area as mature individuals of weed species in this area are a potential source of seeds that birds may carry into the southern mountains. Weed eradication should start from the southern end of this area and work north. The proposal to reconstruct a narrow vegetation corridor between Transit Hill and Intermediate Hill (to the south) (Lord Howe Island Board 2002a) should consider the possible negative impacts of the increased access of weed seeds to the southern mountains by dispersal from birds. Simberloff and Cox (1987) and Simberloff et al. (1992) have highlighted the need to consider a range of issues that may degrade the areas linked by corridors. The possibility of increased weed invasion is one such issue. Given that the highest conservation value area on Lord Howe Island is the southern mountains and that bird dispersed weeds are a major threat to this area, a quantitative assessment of the potential impact of such a corridor is needed before it proceeds.

*Weeds*

A number of weed species are a major concern in this area (Pickard 1984, Le Cussan 2002) including bird-dispersed *Psidium cattleianum, Cotoneaster glaucophyllus, Pittosporum undulatum, Asparagus aethiopicus* and *Asparagus plumosus.*

Since 2000, staff from the Lord Howe Island Board have been treating the major woody weeds in this area. Since 1998 volunteer teams from mainland Australia have been assisting the Lord Howe Island Board with treatment and removal of *Asparagus aethiopicus* and *Asparagus plumosus.* A group of 20 volunteers usually contribute around 400 hours per week, and now each year six groups participate. These groups of volunteers are an important resource for readily accessible weed-infested areas.

*Dieback of forest edges*

Restoration trials and research into dealing with edge effects on the boundary of pasture and forest should be undertaken.

**Priority 3 Northern Hills**

The northern hills contain a number of species and communities largely restricted to the northern end of Lord Howe Island. Vegetation is a mixture of *Drypetes*/*Cryptocarya* closed forest, *Howea belmoreana* and *Howea forsteriana* palm forests, *Syzygium fullageri* closed forest and small areas of scrub and *Atriplex* dwarf scrub (Pickard 1983a). A number of rare or threatened plants occur in this area (Pickard 1983b). The rare orchids *Plectrorrhiza erecta* (an endemic) and *Corybas barbarae* (an outlier also occurring in eastern Australia) are confined to this area (Hutton 2001). A population of the endangered *Calystegia affinis* occurs on the boundary of the northern hills and the settlement area, as does the endangered ecological community *Lagunaria* swamp forest. However, the floristic diversity and habitat complexity of the area is not as great as the southern mountains and there is greater degradation of the area due to weeds, and hence, the lower relative priority of this area. The main threats in this area are weeds and dieback along pasture/forest edges.

*Weeds*

The northern hills have been invaded by weeds that have escaped from the settlement area, mainly *Chrysanthemoides monilifera*, *Asparagus aethiopicus* and *Asparagus myrsiphyllum.* Some weeds are still escaping (*Ligustrum sinense, Cotoneaster glaucophyllus, Grevillea robusta*). Since about 1985 there have been periodic sweeps through this area by Lord Howe Island Board staff for eradication of *Asparagus aethiopicus.* More recently work has been done on *Asparagus myrsiphyllum* near Kims Lookout, including release of a biological control agent (a rust). Two infestations of *Pennisetum clandestinum* (Kikuyu grass) occur in this northern section of the Permanent Park Preserve and should be removed as they continue to spread each year (Dawsons Point and the west end of North Beach). Control of garden plants escaping into this forest and becoming the environmental weeds of the future is essential. There needs to be a program for removal of potential environmental weeds from the adjacent settlement area.

*Dieback of forest edges*

Restoration trials and research into dealing with edge effects on the boundary of pasture and forest should be undertaken.

**Priority 4 Settlement Area**

The settlement area has been extensively cleared and the remaining vegetation is severely fragmented and disturbed with large edge effects. The NSW endangered plant *Caesalpinia bonduc* is known from this area. Major threats include weeds, edge-related habitat disturbances, maintenance and restoration of the endangered *Lagunaria* swamp forest ecological community, *Phytophthora cinnamomi*, and genetic pollution.

*Weeds*

This area is the source of most weed species and the exponential increase in exotic introductions to Lord Howe Island (Pickard 1984) is continuing (Hutton & Auld unpubl.). This demonstrates a failure to deal with the major problem of importation of exotics to Lord Howe Island. As well as the 17 species of plants listed by the Lord Howe Island Board as noxious weeds under NSW legislation, Hutton and Le Cussan (2001) identified a further 36 plant species in the settlement that are already on the way to being, or could already be, environmental weeds. Continued degradation of the World Heritage Values of Lord Howe Island will occur unless this rate of introduction of weeds is greatly reduced.

A program is needed to make residents aware of the potential threat of weed species and seek the removal of potential environmental weeds in the settlement area (Table 2). This could include continuing public awareness campaigns, Lord Howe Island Board staff removing such species from crown land, Board staff assisting with removal from private leases, and the Board providing native Lord Howe Island plants to replace those removed.

Recent years have seen attempts to make the resident community more aware of the weed problem but more work needs to be done to promote awareness of weed threats to the integrity of the Island's forests, and its future as a prime ecotourism destination. Staff of the Lord Howe Island Board conduct regular lease inspections and advise leaseholders of problems and responsibilities. Good relations in this area have seen progress in cooperation with residents for removal of noxious weeds. This needs to continue.

One weed which should be taken more seriously in the settlement area is *Anredera cordifolia* (Madiera vine). Only introduced in the 1970s, some control was started on this in 1980 by the Lord Howe Island Board (Hutton pers. comm.) and it could have been eradicated by now, if the effort had continued. This is one of the worst environmental weeds on Raoul Island (Kermadec group), an island with similar climate and geology to Lord Howe Island. *Anredera cordifolia* is such a potential threat to Lord Howe Island's forest ecosystems that the Lord Howe Island Board should take responsibility for its eradication, rather than leaving control to leaseholders.

*Edge-related habitat disturbances*

It is still necessary to protect and revegetate edges of remnants in the settlement area to prevent continual degradation along edges as suggested over 20 years ago by Pickard (1983a).

*Maintenance and restoration of* Lagunaria *swamp forest*

This ecological community is listed as endangered on the NSW *Threatened Species Conservation Act*. The community is largely confined to the Settlement area (see Pickard 1983a). Much of the community has been cleared and only a few highly disturbed remnants remain, many of which are on the boundary of the former community distribution. Threats to the community are clearing, grazing, weeds and alterations to water regimes. Some restoration of this community will be needed to ensure the tiny remnants can persist. This may involve weed control and rehabilitation plantings using local stock from remnants of this ecological community. The progress of establishment of any plantings will need to be monitored. Some exclusion fencing to reduce stock grazing impacts on rehabilitation will also be needed.

*Genetic pollution of endemics*

The settlement area contains a number of introduced ornamental plant species that have endemic species from the same genus. For example *Metrosideros excelsa* on lagoon foreshore and at Neds Beach; *Dietes* sp. from Southern Africa in gardens, *Coprosma repens* in gardens and at Neds Beach. These introduced plants should be removed to prevent cross pollination and dilution of the genetic integrity of endemic species.

*The pathogen* Phytophthora cinnamomi

This pathogen has recently been identified (B. Summerell pers. comm.) as occurring in an avocado orchard on the settlement area of the island. Active quarantine measures are needed to ensure that it does not spread to other parts of Lord Howe Island.

**Priority 5 Coastal dunes**

The coastal dunes on Lord Howe Island are a relatively homogenous vegetation type that occur in several different parts of Lord Howe Island (Pickard 1983a). The NSW *TSC Act* listed endangered plant *Chamaesyce psammogeton* occurs on these coastal dunes. The major threat to these dunes is weed invasion.

*Weeds*

The dune areas at many locations around the settlement have been severely invaded by introduced grass species, mainly *Stenotaphrum secundatum* (Buffalo Grass) and some areas of dunes could be targeted in future rehabilitation programs to restore to natural systems.

The beach dunes can be invaded by weeds that have recently arrived on the mainland Australia and float to Lord Howe Island. Three weed species that have probably arrived this way are *Ipomoea cairica*, *Cakile edentula* and *Euphorbia paralias*; the latter is only occurring on a small area of Lagoon Beach at present and every effort should be made to eradicate it now. Regular inspection of dunes should be part of the weed program, and early detection and treatment of new arrivals can be carried out. The condition of the dunes varies across Lord Howe Island, with a number of dunes degraded by weeds. Some weed control is needed. Any re-planting to replace weeds in restoration programs must use local stock to maintain local genetic integrity, as there is

evidence of species being imported to Lord Howe Island from mainland NSW in previous restoration works on the dune near the airport.

**Priority 6 Offshore islets**

These islets are an important part of the landscape of Lord Howe Island but because of their relative isolation from the main island, and difficulty of access, they are generally free from major weed species and rodents, and threats are minimal. However monitoring of weed species should be carried out.

The exception is Blackburn (or Rabbit) Island in the lagoon which has been grazed by introduced animals in the past and is now largely covered by the introduced *Chloris gayana* (Rhodes Grass). It is an important seabird breeding island (Wedge-tailed Shearwaters) and a refuge for a several of Lord Howe's endemic animals that have been lost or greatly reduced on the main island. These include the two lizard species *Christinus guentheri* and *Pseudomia lichenigerum* and the endangered *Panesthesia lata* (Lord Howe Island Bush Cockroach).

The original vegetation of Blackburn Island may have included some tree or shrub species, but probably had similar plant species to that found on the offshore islets such as Roach Island. Careful treatment and monitoring of the introduced Rhodes grass may allow native species such as *Commelina cyanea, Acaranthes aspera* and *Canavalia rosea* to establish and provide ground cover to exclude weeds, and allow protection for the seabirds to breed. In time, seeds of trees or shrubs from those still remaining on the island may colonise parts of this island.

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