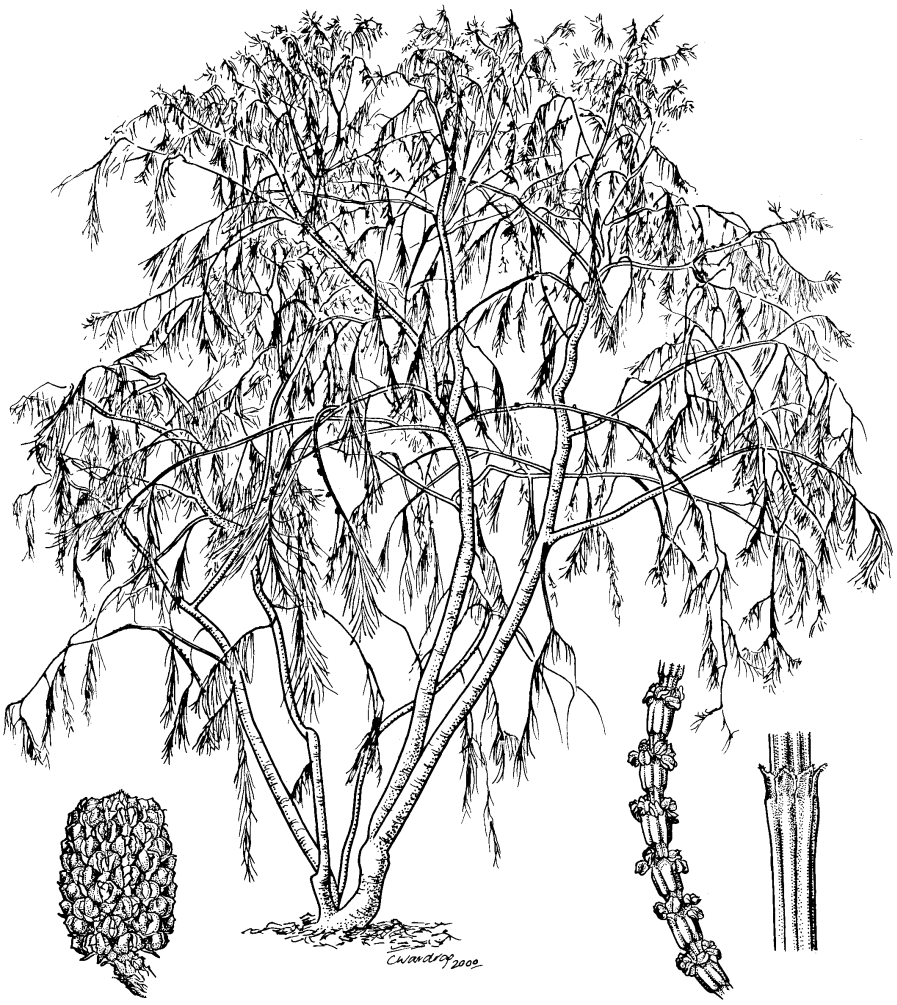
**Approved Recovery Plan**

# *Allocasuarina portuensis*
# Recovery Plan



**June 2000**

Natural Heritage Trust
*Helping Communities Helping Australia*

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NSW National Parks and Wildlife Service Recovery Planning Program

# *Allocasuarina portuensis* Recovery Plan

**Prepared in accordance with the New South Wales *Threatened Species Conservation Act 1995* and the Commonwealth *Endangered Species Protection Act* 1992**

**June 2000**

# Acknowledgments

This plan is largely based on the Conservation Research Statement and Recovery Plan for *Allocasuarina portuensis* (1994) prepared by Maria Matthes & Sharon Nash under the Commonwealth *Endangered Species Protection Act* (1992) (ESP Act).

Recovery team members Maria Matthes, Bronwyn Conyers and Tony Prior (from NPWS), Cathy Offord and Graeme Errington (from Mt Annan Botanic Gardens) and Katrina Jensz from Environment Australia for their contribution to the recovery plan.

Environment Australia through the National Heritage Trust, Endangered Species Program, has provided funding for the preparation of the original recovery plan (prepared under the ESP Act) and has provided resources to implement components of this original plan.

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David Keith and Mark Tozer (both NPWS) provided useful discussion about the ecology and biology of the species.

Harbour South Area Staff (NPWS) provided field assistance and background information to the preparation of both the original plan and this version of the recovery plan.

Mount Annan Botanic Garden and the Australian National Botanic Gardens provided information regarding the propagation of *A. portuensis*.

The National Herbarium of New South Wales gave permission to reproduce figures from the Flora of New South Wales (Harden 1990).

# Foreword

The conservation of threatened species, populations and ecological communities is crucial for the maintenance of this State's unique biodiversity. In NSW, the *Threatened Species Conservation Act 1995* (TSC Act) provides the framework to conserve and recover threatened species, populations and ecological communities through the preparation and implementation of recovery plans.

The preparation and implementation of recovery plans is identified by both the National Strategy for the Conservation of Australia's Biological Diversity and the NSW Biodiversity Strategy as a key strategy for the conservation of threatened flora, fauna and invertebrates. The object of a recovery plan is to document the research and management actions required to promote the recovery of a threatened species, population or ecological community and to ensure its ongoing viability in nature.

This plan describes our current understanding of *Allocasuarina portuensis*, documents the research and management actions undertaken to date, and identifies the actions required and parties responsible to ensure the ongoing viability of the species in the wild.

The *Allocasuarina portuensis* Recovery Plan was prepared with the assistance of a recovery team comprising relevant land management and other government interests, and was placed on exhibition during June-July 1999. I thank these people for their efforts to date and I look forward to their continued involvement in the implementation of recovery actions identified in this plan.

**BOB DEBUS MP**

**Minister for the Environment**

# Executive Summary

## Introduction

*Allocasuarina portuensis* L.A.S. Johnson, Casuarinaceae, is a slender shrub, 3-5 m high with branchlets drooping to spreading and dark green in colour. It is a dioecious species; that is, it has separate male and female plants, with the female plants bearing the characteristic fruit-bearing cones. *A. portuensis* occurs in foreshore vegetation within Nielsen Park, which is part of Sydney Harbour National Park, NSW.

## Current Conservation Status

*A. portuensis* is listed as an endangered species on Schedule 1 of the New South Wales *Threatened Species Conservation Act 1995* (TSC Act). The species is also listed as a nationally endangered species on Schedule 1 of the *Commonwealth Endangered Species Protection Act 1992*.

A single population of only ten *A. portuensis* was discovered in 1986. Since then, the population has diminished to only two female plants. Over 100 cultivated *A. portuensis* plants have been planted in nine localities throughout the park. Fifty-four plants still remain.

## Legislative Context

The TSC Act is NSW's legislative framework to protect and encourage the recovery of threatened species, populations and communities. Under the TSC Act, the Director-General of National Parks and Wildlife has certain responsibilities including the preparation of recovery plans for threatened species, populations and ecological communities. This Recovery Plan has been prepared in accordance with the provisions of the TSC Act.

## Preparation of Plan

This Recovery Plan has been prepared with the assistance of a recovery team, a non-statutory group of interested parties with relevant expertise, established to discuss issues relating to the plan. Components within the plan do not necessarily represent the views nor the official positions of all the individuals or agencies represented on the recovery team. The information in this Recovery Plan is accurate to the best knowledge of the NPWS.

A draft of this Recovery Plan was placed on public exhibition from 28 June to 30 July 1999. Two public submissions were received. The comments of the Scientific Committee were also sought and this plan was finalised in view of these comments.

The plan will be reviewed and updated 10 years from the date of publication with an internal review after 5 years.

## Implementation of Plan

The TSC Act requires that a government agency must not undertake actions inconsistent with an approved recovery plan. The two government agencies relevant to this plan are the NPWS and the Royal Botanic Gardens, Sydney (RBG). The NPWS must, as the only land manager, manage *A. portuensis* within Sydney Harbour National Park in accordance with this plan. Relevant land management issues include weed control and habitat restoration. Likewise, the RBG, will participate in the establishment and maintenance of the *ex situ* collection of *A. portuensis*.

## Recovery Objectives

### Overall Objective

The overall objective is to recover *A. portuensis* through actively seeking to increase the number of known individuals in the wild, and so prevent the extinction of the species.

Specific objectives of the plan are:

- to protect, restore and maintain the original habitat of *A. portuensis* and the planted locations;
- to establish the distribution of *A. portuensis*;
- to ensure that the recovery program is focused toward the recovery of a population of 'pure' (non-hybrid) *A. portuensis*;
- to store a representative collection of *A. portuensis ex situ* during the recovery process and to enhance the known population of *A. portuensis* in Sydney Harbour National Park through translocation if no additional viable populations of *A. portuensis* are found during a targeted survey; and
- to enhance future management of *A. portuensis* by furthering our understanding of essential aspects of the biology and ecology of the species relating to seed ecology, population dynamics and response to fire.

## Recovery Criteria

### Overall Recovery Criteria

The overall performance criteria of the recovery plan is that the risk of extinction of *A. portuensis* is reduced, through the implementation of recovery actions to protect and enhance the known population.

Specific performance criteria are that:

- buffer zones are created around each of the locations of *A. portuensis* and these will be maintained in good condition with a minimum of weeds;
- the original habitat and the planted locations of *A. portuensis* are not diminished through human induced disturbance;

- the original habitat is restored to a more suitable state for the recovery of *A. portuensis*, i.e. open woodland/heath containing sclerophyllous species and minimal weeds;
- potential habitat is identified and surveyed for the presence or absence of additional populations of *A. portuensis*;
- *in situ* and *ex situ* material contains no hybrid material, so that the genetic integrity of *A. portuensis* is maintained;
- a representative *ex situ* collection suitable for a translocation program is established and maintained;
- the number of individuals within the population of *A. portuensis* in Sydney Harbour National Park is increased to between 30-60 individuals in at least one sub-population. The plants within these enhanced sub-populations should be fertile and produce non-hybrid seed from which new individuals establish under natural conditions; and
- a greater understanding of *A. portuensis* biology and ecology is achieved and applied to management.

## Recovery Actions

The plan consists of ten recovery actions which aim at the overall objective. These actions include to:

- create and manage buffer zones to protect *A. portuensis* in Sydney Harbour National Park;
- undertake monitoring program;
- assess impacts of any activities;
- undertake habitat restoration and weed management in the original habitat of *A. portuensis* and in the buffer zones established around the planted locations;
- undertake weed management at the planted locations;
- undertake a targeted survey for *A. portuensis;*
- undertake ongoing assessment of the hybridity status of individuals of *A. portuensis in situ* and *ex situ* by an expert in the plant family Casuarinaceae and discontinue any hybrid plant material;
- establish and maintain a representative collection of *A. portuensis ex situ* during the recovery process;
- establish a translocation trial; and
- investigate the biology and ecology of *A. portuensis*.

## Estimated Cost of Recovery

A summary of the funds required to implement this recovery plan is identified below. This recovery plan will be implemented over a ten-year period. Average implementation cost per year will be approximately $10,315.

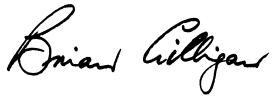
All actions have secured funding, except actions 13.3.1 and 14.3.1 after the second year of implementation.

| Action | Description | Source of Funding ($) | |
|---|---|---|---|
| | | NPWS | RBG |
| 11.3.1 | Create and manage buffer zones | 1,000 | |
| 11.3.2 | Undertake monitoring program | 3,500 | |
| 11.3.3 | Assess impacts of any activities | - | |
| 11.3.4 | Restoration and maintenance of the original habitat | 31,500 | |
| 11.3.5 | Weed management of the planted locations | 11,000 | |
| 12.3.1 | Targeted survey | 3000 | |
| 13.3.1 | Ongoing assessment of hybridity | | 3,000 |
| 14.3.1 | Maintenance of *ex situ* collection | 4,900 | 17,900 |
| 14.3.2 | Establish a translocation trial | 12,950 | |
| 15.3.1 | Investigate biology and ecology | 14,400 | |
| **TOTAL ($103,150)** | | 82,250 | 20,900 |

**NPWS -** The National Parks and Wildlife Service; **RBG-** The Royal Botanic Gardens Sydney.

## Biodiversity Benefits

The discovery of *A. portuensis* highlights the importance of habitat conservation. The conservation of the habitat occupied by *A. portuensis* is important for the conservation of all species that occur there. Restoration of the original habitat in Nielsen Park will also provide for the conservation of the harbour side vegetation, which has been otherwise cleared or degraded.



**BRIAN GILLIGAN**

**Director-General**

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# 1. Introduction

*Allocasuarina portuensis* L.A.S. Johnson, Casuarinaceae, is a slender shrub, 3-5 m high with branchlets drooping to spreading and dark green in colour. It is a dioecious species; that is, it has separate male and female plants, with the female plants bearing the characteristic fruit-bearing cones.

*A. portuensis* occurs in foreshore vegetation within Nielsen Park, part of Sydney Harbour National Park.

# 2. Legislative Context

## 2.1 Legal Status

Due to its small population size and restricted distribution, *A. portuensis* is considered endangered in NSW and is listed on Schedule 1 of the TSC Act. The effect of the State listing is that a recovery plan must be prepared and that consideration is given to the species in assessing the impacts of developments and activities with the aim of minimising adverse impacts.

*A. portuensis* is listed as a nationally endangered species on Schedule 1 of the Commonwealth *Endangered Species Protection Act 1992* (ESP Act). The schedules in the ESP Act are based on the lists complied by the Australian and New Zealand Environment Conservation Council. Being listed nationally, the species has been eligible for funding under the Commonwealth Natural Heritage Trust, Endangered Species Program and is protected under Commonwealth legislation.

## 2.2 Recovery Plan Preparation

The TSC Act requires the Director-General of National Parks and Wildlife to prepare recovery plans for all species, populations and ecological communities listed as endangered or vulnerable on the TSC Act schedules. The TSC Act includes specific requirements for both the matters to be addressed by recovery plans and the process for preparing recovery plans. This plan satisfies these provisions. As *A. portuensis* is also listed nationally, this plan will also meet the requirements of the Commonwealth ESP Act, so that there will only be one recovery plan operating for *A. portuensis*.

## 2.3 Recovery Plan Implementation

The TSC Act requires that a government agency must not undertake actions inconsistent with an approved recovery plan. The two government agencies relevant to this plan are the NPWS and the Royal Botanic Gardens, Sydney (RBG). Consequently, the NPWS must, as the relevant land manager, manage *A. portuensis* within Sydney Harbour National Park in accordance with this plan. Relevant land management issues include weed control and habitat restoration. Likewise, the RBG must participate in the establishment and maintenance of the *ex situ* collection of *A. portuensis*.

## 2.4 Critical Habitat

The TSC Act makes provision for the identification and declaration of critical habitat for species, populations and ecological communities listed as endangered. Once declared, it becomes an offence to damage critical habitat (unless the TSC Act specifically exempts the action). A species impact statement is mandatory for all developments and activities proposed within critical habitat. In effect, critical habitat is a flag for a higher level of impact assessment.

To date, critical habitat has not been declared for *A. portuensis* under the TSC Act. The declaration of critical habitat is not considered to be a priority for this species, as other assessment mechanisms provide for the protection of this species. As the habitat of *A. portuensis* is only known to occur on land managed by the National Parks and Wildlife Service, the type of developments or activities which are likely to occur are limited by the provisions of the *National Parks and Wildlife Act* (1974).

Action 11.3.3 of this plan emphasises the need for environmental assessment of activities undertaken for park management purposes, to prevent adverse impacts on *A. portuensis.* In accordance with Part 5 of the *Environmental Planning and Assessment Act* 1979, the NPWS will conduct a Review of Environmental Factors (REF) for any activities proposed in Sydney Harbour National Park which may affect *A. portuensis* and its habitat. Examples of such activities include construction/maintenance of tracks, building and hazard reduction burning. If, in the REF, the impacts of the activity on *A. portuensis* are seen to be significant, then a species impact statement will be prepared. As a general rule the NPWS will avoid approving or implementing activities which are likely to significantly affect this species.

## 2.5 Key Threatening Processes

There are currently no key threatening processes listed in Schedule 3 of the TSC Act which have been identified as adversely affecting *A. portuensis*.

## 2.6 Environmental Assessment

The TSC Act amendments to the environmental assessment provisions of the *Environmental Planning and Assessment Act* 1979 (EP&A Act), requires consent and determining authorities to consider relevant recovery plans when exercising a decision making function under Parts 4 & 5 of that Act. In the context of this plan, the NPWS is a determining authority and will carry out environment assessment as described above in section 2.4.

# 3. Conservation Status

Two naturally occurring *Allocasuarina portuensis* (commonly known as the Nielsen Park She-oak) plants are known from Nielsen Park, Sydney. Over 100 cultivated plants have been planted at 9 locations at Nielsen Park, Gap Bluff and near Hermitage Point, all within Sydney Harbour National Park, of which 54 still survive.

Given its extremely small population size and decline in numbers since its discovery in 1986, *A. portuensis* is listed as endangered in New South Wales (Schedule 1 of the TSC Act 1995) and Australia-wide (Schedule 1 of the Commonwealth ESP Act 1992).

*A. portuensis* is listed as 2ECit on the Rare or Threatened Australian Plants (ROTAP) listing (Briggs and Leigh 1996). This code means that: the species has a geographic range of less than 100 kilometres; the taxon is in serious risk of disappearing from the wild within 10-20 years; and that less than 100 plants are known, all occurring within a conservation reserve.

# 4. Description

## 4.1 Scientific Description

*Allocasuarina portuensis* belongs to the family Casuarinaceae. Plants in this family are distinctive in that they possess modified leaves and secondary stems, and have unique flowers and fruit (modified from Wilson & Johnson 1990).

Species in the family Casuarinaceae have wiry branchlets and leaves reduced to whorls of small triangular teeth which occur at regular intervals along the branchlets. Regions of branchlets called articles separate the leaf whorls. These articles are composed of longitudinal ridges separated by furrows. There is always the same number of ridges as there are teeth. Inflorescences consist of alternating whorls of tooth-like bracts. Within each bract are 2 lateral scale-like bracteoles and a single unisexual flower. Male inflorescences are short to elongated catkin-like spikes. Female inflorescences are small globose or ovoid heads on short lateral branchlets. The female inflorescence develops into a woody cone in which the 2 enlarged bracteoles of each flower form lateral valves and open to release the fruit (samara). The samara is a winged nut and appears like a seed. Figures 1 and 2 illustrate these characters.

The following description of *A. portuensis* is modified from Wilson & Johnson (1989, 1990). *A. portuensis* is a slender dioecious shrub, that is, having separate male and female plants. It is 3-5 m high, with branchlets drooping to spreading, up to 27 cm long and dark blue-green in colour. Teeth are 7 or 8 per whorl, spreading to recurved, 0.7-1.1 mm long. Branchlet articles are terete, usually with a faint waxy bloom, glabrous, 13-20 mm long and 0.8-1.0 mm in diameter. Male spikes are 5-10 cm long. Cones are cylindrical and borne on peduncles 2-15 mm long. The cone body varies from 12-15 mm long and 8-10 mm diameter. The fruiting

bracteoles are obtuse, pyramidal with a protuberance shorter than the bracteole body. The samara are 4-5 mm long and dark brown in colour.

## 4.2 Distinguishing Features

The difference between *A. portuensis* and other similar species is also described by Wilson & Johnson (1989). The most similar of the *Allocasuarina* species to *A. portuensis* are *A. rigida* and *A. diminuta*. *A. portuensis* differs from these species by its strongly moniliform male inflorescences (moniliform refers to the way in which the inflorescence constricts so as to resemble a necklace of beads). From *A. rigida* subsp. *exsul* it differs in its generally longer articles and often longer, broader teeth. It further differs from *A. rigida* in its more rounded ridges and generally more slender articles. From *A. diminuta* it differs in its spreading and mostly slightly overlapping teeth, its longer articles and its longer, less dense male spikes.

*A. littoralis* and *A. distyla* occur in the same habitat as *A. portuensis.* Table 1 summarises the differences between them (Karen Wilson, Royal Botanic Gardens Sydney, pers. comm.).

**Table 1. Distinguishing between *A. portuensis* and two common species: *A. distyla* and *A. littoralis*.**

| Character | *A. portuensis* | *A. distyla* | *A. littoralis* |
|---|---|---|---|
| Habit | shrub 3-5 m | shrub 1-3 m | tree 5- 15 m |
| Bark | smooth | smooth | fissured |
| Branchlets | usually middling in size | usually rather coarse | slender compared to the other two species |
| Articles | ridges without strong longitudinal mid-line; furrows without obvious hairs | ridges with yellowish longitudinal midline; furrows with obvious hairs | with longitudinal mid-line; furrows with obvious hairs |
| Teeth | 7-8 per whorl, shape - spreading to recurved at tip | 6-8 per whorl, shape - broad triangular | (rarely 5)6-8(9) per whorl, shape - narrow triangular |
| Male spike moniliform? | yes | rarely | no |

**Figure 1.** **General features of the Casuarinaceae: wiry branchlets with whorls of teeth at regular intervals separated by articles. The fruiting cone is also shown. (Source: Harden 1990)**

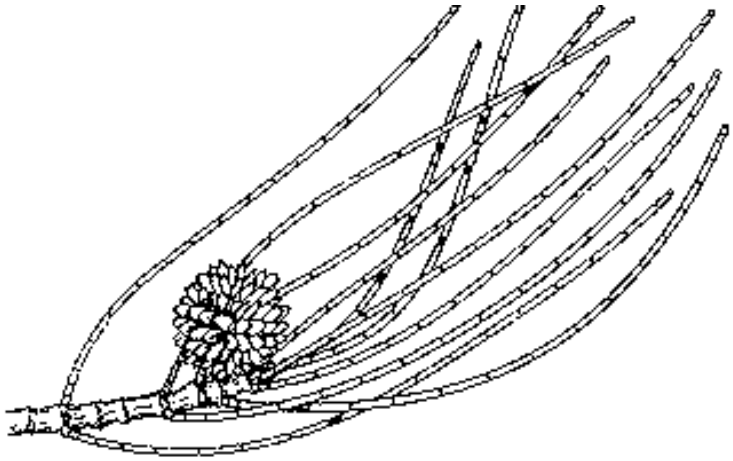


**Figure 2.** **General features of the Casuarinaceae: A) portion of branchlet showing leaf teeth and article; B, C & D) male inflorescences; E) female inflorescence; F) portion of cone showing woody bracteoles, bracts and protuberances; G) samara (fruit). (Source: Harden 1990)**

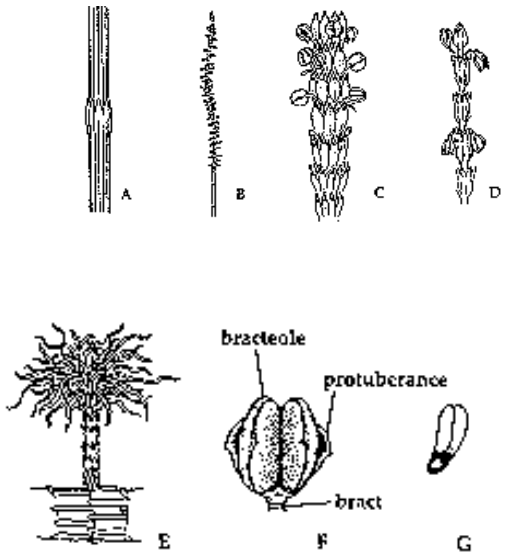


**Figure 3.** **General habit of *A. portuensis* (cultivated plant, Nielsen Park). Photo: M. Matthes.**

**Figure 4.** **Male inflorescence of *A. portuensis.* Photo: M. Matthes.**

**Figure 5. Cones of *A. portuensis.* Photo: M. Matthes.**

# 5. Distribution

## 5.1 Current Distribution and Tenure

The current known habitat of *A. portuensis* occurs wholly within Nielsen Park, part of Sydney Harbour National Park (Figure 6). Nielsen Park is within Woollahra local government area.

*A. portuensis* was discovered in 1986. At the time of discovery there was a total population of ten plants, with two male and eight females at six positions, found within 100 m of each other (Brookhouse 1986). These plants were located in the south-eastern part of Nielsen Park. Since discovery, the number of individuals has decreased, so that as of February 1998, only two original plants remain, both females. The location where these plants were discovered is referred to in this plan as the *original habitat.*

## 5.2 Historic Distribution and Potential Habitat

It is highly likely that *A. portuensis* once had a broader distribution along the foreshore of this part of Sydney Harbour. Extensive land clearing has taken place, and loss of habitat is likely to be a factor contributing to the decline of this species.

Benson and Howell (1990) in their account of the historic distribution of vegetation of the Sydney region include a description of the vegetation communities in the Woollahra area at the time of European settlement. The vegetation of Nielsen Park consisted of both heath and woodland communities on sandstone. These types of vegetation communities do not occur exclusively in this area. Thus it is possible that the distribution of *A. portuensis* was not restricted to this area.

Action 12.3.1 of this plan investigates the distribution of *A. portuensis* and will involve, to some extent, understanding the historic distribution of these plant communities in this part of Sydney. This will assist in determining areas of potential habitat suitable for targeted survey.

## 5.3 *In situ* Plantings of Cultivated Stock

Since 1986, over 100 cultivated individuals have been raised in pots from seed collected from the original wild population in Sydney Harbour National Park. As of February 2000, 54 survive in 9 locations, one of which is the original habitat. These locations are referred to in the plan as the *planted locations*. Details of the number and probable dates of planting are provided in Table 2. It is unknown whether the seeds from which these plants were grown were sourced from more than one of the original female plants. Thus the extent of genetic variation expressed in the current *in situ* material is unknown.

Prior to 1998, there has been some doubt over the genetic purity of the *in situ* plantings of *A. portuensis*. It had been suspected that some of the planted individuals were hybrids with other *Allocasuarina* species growing nearby. This

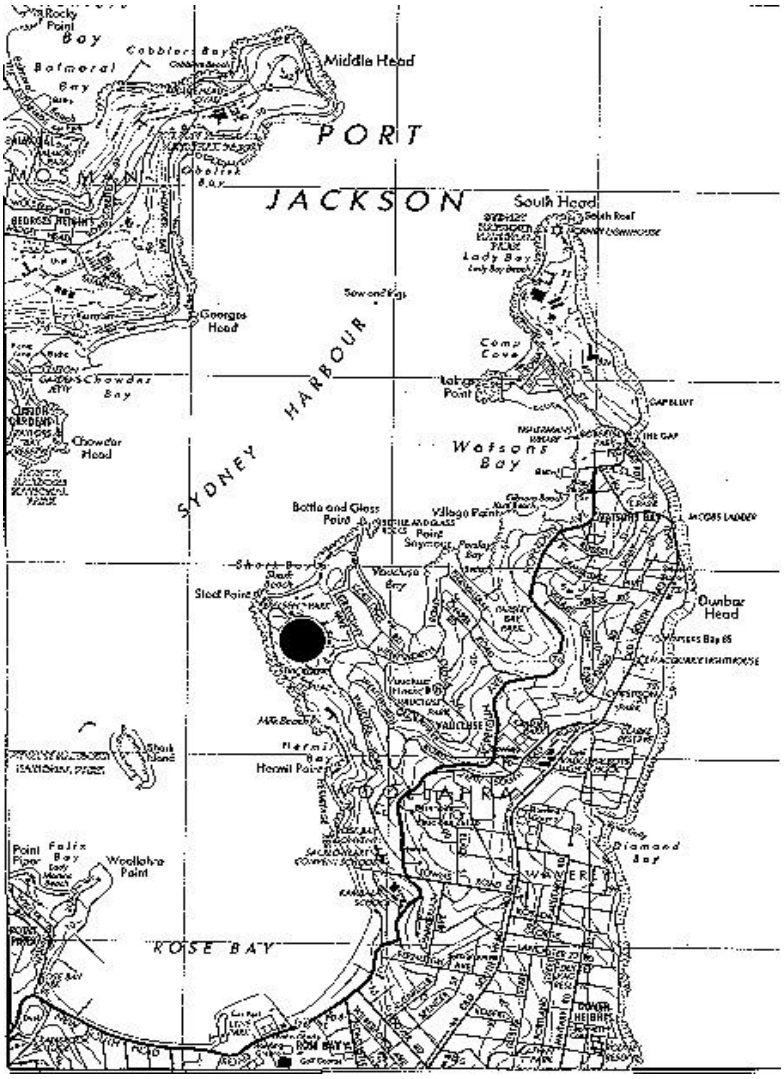
prompted the initiation of a preliminary genetic study, the results of which indicate that the majority of the planted individuals are true *A. portuensis* and not of hybrid stock. The genetic status of 5 plants remains uncertain. This genetic investigation is described in more detail in section 7.4.

**Table 2. Sites of *in situ* plantings in Sydney Harbour National Park and the approximate number of plants at each site in February 1998.**

| Planted Location | Date of plantings | Number of plants |
|---|---|---|
| **1** *The original habitat* - Nielsen Park | 1991/1987 | 2 female, 5 male, 3 immature |
| **2** Nielsen Park | 1991 | 3 female, 4 male |
| **3** Nielsen Park | 1987 | 5 female, 2 male |
| **4** Nielsen Park | 1987 | 4 male |
| **5** Nielsen Park | ?1994 | 2 male, 6 immature |
| **6** Nielsen Park | ?1994 | 3 male, 2 female, *1 multi stemmed clump with stem varying in sex |
| **7** Gap Bluff | 1995 | 1 male, 1 female, 1 immature |
| **8** Gap Bluff | 1995 | 1 male, 1 female, 2 unknown |
| **9** Hermit Point | 1995 | 2 females, 1 male |

***** These plants may indicate that this species is not truly dioecious, as it shows signs of being monoecious (that is flowers of both sex on the same plant) or that the seed used in the plantings is of hybrid origin.

**Figure 6. General Locality of Sydney Harbour National Park and the habitat of *Allocasuarina portuensis* in Nielsen Park (Central Mapping Authority, Sydney Heads 1:25 000).**



# 6. Habitat

## 6.1 The Original Habitat

The *original habitat* is the most significant site for *A. portuensis*, because it is the only site where *A. portuensis* has been known to occur naturally. The presence of naturally established plants usually indicates that local environmental conditions are suitable for maintaining the population dynamics of this species through all life history stages (ie. from fruit production to seedling establishment and maturation etc.). Or it may at least indicate that conditions have been most suitable in recent times. However, there is some evidence to suggest that the original habitat has been greatly modified over, at least, the last 50 years and its current state may not exactly reflect the conditions under which previous generations of *A. portuensis* were dispersed (discussed in more detail in section 5.2). Nevertheless, the original habitat is the best representation of the physical environment in which populations of *A. portuensis* are known to naturally exist.

## 6.2 The Planted Locations

The distinction between *original habitat* and the *planted locations* was alluded to in sections 5.1 and 5.3. There are several reasons why it is important to highlight and maintain this distinction during the implementation of this recovery plan.

The planted locations hold less importance than the original habitat. Cultivated plants have been planted in a variety of habitats throughout Sydney Harbour National Park. These differ from the original habitat in vegetation type, slope, aspect, soil depth, drainage and landscape position. These planted locations may or may not represent areas where *A. portuensis* occurred previously, and there is less certainty about the ability of the species to carry out its whole lifecycle in these locations. Nevertheless, since the original habitat is degraded, the planted locations still hold some importance due to the continuing survival of the *in situ* cultivated plants. They are also sites where supplementary translocation can be trialed (as described in action 14.3.2 of this recovery plan). Some cultivated plants have also been replanted into the original habitat after the original plants died in the early 1990s.

## 6.3 Vegetation

The remaining wild population of *A. portuensis* occurs in tall closed woodland. Canopy species include: *Ficus rubiginosa*, *Angophora costata*, *Elaeocarpus reticulatus* and *Gloichidion ferdinandi* with a shrub layer of *Pittosporum revolutum*, **Lantana camara*, *Kunzea ambigua*, and *Monotoca elliptica*. Ground covers include: *Lomandra longifolia*, *Dianella caerulea*, **Protasparagus densiflorus*, **Tradescantia albiflora*, *Pteridium esculentum*, *Entolasia* sp. and a climber *Billardiera scandens* (Matthes & Nash 1994). (* = introduced species).

The original habitat has been severely degraded by weeds (Matthes & Nash 1994). Species such as *Protasparagus densiflorus* (Asparagus "fern"), *Tradescantia*

*albiflora* (Wandering Jew) and *Lantana camara* were dominating the understorey before the ongoing weed program was initiated. Other species in the immediate area that could become a threat are *Delairea odorata* (Cape Ivy), *Acetosa sagittata* (Rambling Dock) and *Anredera cordifolia* (Madeira Vine).

The floristic composition of the *A. portuensis* habitat is likely to have changed due to the absence of fire (Matthes & Nash 1994). The original habitat was last thought to have been burnt around 30 years ago. The absence of fire during this period may have promoted the growth and dominance of mesophyllic species such as *Pittosporum revolutum* and *Gloichidion ferdinandi*. It is probable that under a more frequent fire regime, sclerophyllous species, which occur adjacent to the site, would be more dominant in this habitat.

## 6.4 Landform and Soils

The original habitat of *A. portuensis* occurs above a sandstone shelf approximately 20 m above the harbour. The shallow sandy soils are highly siliceous, coarsely textured and devoid of a soil profile (Matthes and Nash 1994).

## 6.5 Fire History

It is thought that the last fire in this part of Nielsen Park was about 30 years ago (Matthes & Nash 1994). This is a long period for vegetation of the Sydney region not to have experienced fire. The fire regime prior to this is unknown.

## 6.6 Climate

The climate experienced in the Sydney area is subject to coastal influences, which are variable from year to year. Details of the climate have been extracted from Matthes & Nash (1994). The climate is generally warm, with wet-summer-autumns, followed by cool, drier winter-springs. The annual average rainfall is over 1200 mm with the wettest period in autumn and the driest in spring. The average minimum and maximum temperatures (degrees Celsius) for the Sydney area in January are 18.5-25.7, and in July are 7.9-16.0.

# 7. Biology and Ecology

## 7.1 The Distinction between Original Plants and the *in situ* Cultivated Plantings

Just as it is important to maintain the distinction between the original and planted locations, it is also important to maintain the distinction between the original wild plants and cultivated stock. This distinction will be maintained throughout this recovery plan.

In general, plants growing in the wild under natural conditions hold greater importance for the survival of a species because they have been 'naturally selected' for that habitat. Under natural conditions, these wild plants germinated from seed to survive to maturity in the conditions exhibited by their original habitat. The genotype exhibited by these plants is that which is 'fit' for the conditions that are present at that time. In contrast, cultivated plants by-pass the filter of natural selection by being grown in less stressful conditions. These plants are watered regularly, raised in potting mix, sheltered from adverse weather conditions and protected from disease. In reality, if these same seeds were released into the natural environment, only the most 'fit' genotypes for that environment would have survived.

In addition, the cultivated plants of *A. portuensis* were not established in the Sydney Harbour National Park by natural means. In sclerophyllous habitats, such as the likely original habitat of *A. portuensis*, the regeneration of most species is cued by the occurrence of fire. Cultivated *A. portuensis* individuals were planted into the ground during the inter-fire period when other plants in the habitat were long established. The plants were watered, some fertilised and given the best chance of surviving. We have no certainty as to whether these plants would have survived during the immediate post-fire period in competition with other regenerating species. Under these circumstances, the apparent success of these cultivated individuals (in terms of plant size and fruit production) does not necessarily indicate that these individuals are most fit for survival at other stages of the lifecycle under natural conditions.

Although the original wild plants in the original habitat of *A. portuensis* are the most important remaining material of *A. portuensis*, the importance of the cultivated plants should also not be underestimated. The non-cultivated material consists of only two senescent female plants. These two plants are no longer producing fruit, and the small quantity of fruit from previous years has been removed. Thus, it is not possible to recover the species from these original plants. The cultivated individuals provide more genetic variability than is available from the remaining wild plants. Without this cultivated material, extinction of *A. portuensis* would be imminent.

The *in situ* plantings also provide an opportunity to gain some understanding of the biology of the species, as many of these plants are reproductively mature and producing flowers and seed cones. However, it must be kept in mind that cultivated

plants do not necessarily behave the same as wild plants. The plantings also provide some indication of the likely success of supplementary plantings as part of a translocation trial. However, as stated earlier, long-term survival can only be assessed if these plants can complete their whole lifecycle. This will involve providing conditions appropriate for regeneration. Appropriate conditions will include the use of fire to kill adult plants and allow seed to be released from cones.

### 7.1.1 Practicalities - tagged plants

To assist distinguishing between wild and cultivated plants, all *in situ* cultivated plants and the original plants have been tagged with unique numbers. The date and source of all *in situ* and *ex situ* cultivated material has been investigated and recorded (to the best of available knowledge). All future plantings carried out in conjunction with the implementation of the recovery plan of *A. portuensis* will be tagged in the same way.

## 7.2 Growth Rate and Longevity

The growth rate and longevity of *A. portuensis* is unknown. The age of the original plants is most likely linked to the time of the last known fire, which occurred at least 30 years ago. The two remaining plants appear very old and are senescing. Therefore, the longevity of the plants may be around 30 years.

## 7.3 Vegetative Reproduction

The two original plants of *A. portuensis* do not show signs of clonality. However, one of the *in situ* cultivated plants is multi-stemmed arising from one base, which may indicate clonal tendencies. Other species of *Allocasuarina*, such as *A. glareicola*, exhibit a clonal growth habit, whereby multi-stems are connected by an underground root system. There are no sign of other forms of vegetative reproduction in *A. portuensis*.

## 7.4 Reproductive Biology

### 7.4.1 Breeding system

*A. portuensis* is dominantly dioecious, having separate male and female plants. However, some of the cultivated plants have been observed to have both male and female flowers (particularly at planted location 6). Exhibiting both monoecy and dioecy is common in *Allocasuarina* spp. (K. Wilson, Royal Botanic Gardens Sydney, pers. comm.). Other species in the Casuarinaceae such as *A. glareicola*, *A. defungens* and *Casuarina pauper* exhibit both dioecy and monoecy.

### 7.4.2 Flowering and pollination

Observations of the flowering period of *A. portuensis* indicates that flowering occurs throughout the winter months (April-August)(Brookhouse 1986, Matthes & Nash 1994). Many of the *in situ* plantings were also flowering during January and

March 1998 (M.E. Tozer, NPWS, pers. obs.). It is likely that this species has a dominant flowering period with a smaller reproductive effort throughout the whole year, which is dependent on climatic conditions. *A. portuensis* is probably wind pollinated like other members of the Casuarinaceae.

### 7.4.3 Cone production

Little information is available about the quantity and timing of cone production in the wild population of *A. portuensis.* Observations of the original population were that cone production was low which may have related to the age of the plants. Since the discovery of the species, only 10 cones have been observed on the wild plants (Matthes & Nash 1994).

The *in situ* cultivated plants exhibit varying levels of fruit production. The number of cones being produced is dependent on the number of female plants present (to produce fruit), and also the source of pollen (ie. the number of male *A. portuensis* or other *Allocasuarina* species nearby). At several of the planted locations, it is highly likely that the seed will be not be pure *A. portuensis* as there is either little or no source *A. portuensis* pollen available. Nevertheless, the plants have still produced a significant number of fruit (M.E. Tozer, NPWS, pers. obs.). It is also interesting to note that the cultivated *in situ* plantings in the original habitat have not produced any fruit.

Although predators have not been observed interfering with fruit, cone damage was observed on the original plants in 1994 (Matthes & Nash 1994). No damage to cones on the *in situ* plantings has been observed (M.E. Tozer, NPWS, pers. obs.).

### 7.4.4 Samara (seed) production

Fruit of the Casuarinaceae are referred to as samaras (winged nut-fruits). Due to their seed-like appearance, these will be referred to as seed throughout this plan. In the genus *Allocasuarina,* seed is produced inside the woody cone and is held there by woody valves. In general, most of the seed is released after the parent plant dies from old age, disease or from the effects of fire. A small proportion of seed may be continuously released from the canopy (seed rain) during the life of the plant.

Thus, given these characteristics of the genus *Allocasuarina,* we can assume that *A. portuensis* has a canopy stored seed bank which is released on death of the parent plant. There is little evidence of seed rain (M.E. Tozer, NPWS, pers. obs.).

### 7.4.5 Seed longevity and viability

There is no empirical information about seed longevity and viability of *A. portuensis*. Seed in the genus *Allocasuarina* is generally long lived (K. Wilson, Royal Botanic Gardens Sydney, pers. comm.). Seed in cones removed from the original plants in 1987 germinated readily in pots, which suggests high levels of viability (Matthes & Nash 1994). Information about seed viability in the *in situ* plants of *A. portuensis* is prioritised in action 15.3.1 of this plan. As described in

section 7.4.3, there is a strong likelihood that some of the seed produced by the *in situ* plantings is hybrid and this will also be investigated.

### 7.4.6 Response to fire

Species in the Casuarinaceae are generally obligate seed regenerators. Most species are killed by fire, although some species can resprout. It is most conservative to assume that *A. portuensis* is killed by fire unless otherwise shown. Appropriate fire regimes for *A. portuensis* should incorporate a consideration of the time taken to accumulate a seedbank and to maintain its habitat.

### 7.4.7 The seed bank

Although we have no information about the dynamics of the seed bank of *A. portuensis*, studies on two other species of *Allocasuarina* in the Sydney Region, *A. distyla* and *A. nana* by Pannell (1990), could offer some insight into the seed bank of *A. portuensis*.

In general, the seed bank size is determined by the rate of seed production and the rate of seed loss from the system (Pannell & Myerscough 1993). In a maturing population, the accumulation of seed appears to be exponential. Although some losses occur through seed death or fungal attack, it makes little impact on the increasing size of the seed bank (Pannell 1990). In *A. distyla* about 60% of recently set seeds were found to germinate, however, the viability of the seed was lost with time since seed set and models suggest that all seed produced within one year loses its viability after 13 years. A similar pattern was exhibited by *A. nana*.

In an aging population, where individuals are senescing, the rate of seed production declines and the rate of seed attrition increases to equal or exceed seed production (Pannell 1990). This scenario is particularly relevant to the original population of *A. portuensis*. It is a senescing population in which there has been no addition to the seedbank since its discovery in 1986. All seed cones that were present on the original plants at the time of discovery have been removed and there is currently no seed production on the remaining plants. It is highly probable that no wild seed bank exists for *A. portuensis* in the original habitat.

Many of the *in situ* planted individuals have produced cones. Most of the fertile plants possess over 100 cones, and two have over 500. However, as described earlier the genetic status (ie. hybrid or pure bred) remains uncertain.

### 7.4.8 Germination factors

In the genus *Allocasuarina,* fire kills adult plants causing the cones to release seed into the post-fire environment. These seeds have no effective dormancy and will germinate when sufficient moisture is available and temperature is suitable (Pannell 1990). Using fire to promote germination to regenerate *A. portuensis* will only be effective if there are stores of seed in cones in the canopy.

### 7.4.9 Seed dispersal

As most of the seeds of *Allocasuarina* species are stored in cones in the canopy, large-scale dispersal of seed only occurs on death of the adult. The agent of dispersal is unknown, as is the distance over which seed may be carried. Outside of fire events, a small proportion of the seeds is gradually released from the cones as has been observed in *A. nana* and *A. distyla* (Pannell 1990). However, observations of seed release from the cones of *in situ A. portuensis* plantings suggest this is probably insignificant for this species.

### 7.4.10 Seedling establishment and survival

There have been no seedlings observed in the original habitat of *A. portuensis*, nor beneath the cultivated individuals. There is no information as to the conditions, or requirement for seedling establishment and survival of this species.

Pannell (1990) identified factors that are important in the establishment of *A. nana* and *A. distyla* seedlings and these could apply to *A. portuensis*. Seedling establishment was higher in areas that had higher soil moisture levels and at sites that had been recently burnt. Seedling establishment was not observed in areas which had not been burnt recently. The reasons for this are probably associated with the conditions that are present after fire eg increased light, increase in organic and inorganic nutrients and higher available soil moisture due to reduced competition.

It is highly probable that *A. portuensis* requires disturbance of some nature (such as fire) for seedling recruitment and establishment to occur. As described earlier, the canopy stored seed bank needs to be released from the cones. However, if a fire was to occur now in the original habitat, it is highly unlikely that recruitment would occur. The rationale being that a viable soil stored seed bank associated with the original plants is unlikely to remain (for reasons described in 7.4.7) and the cultivated *in situ* plants in the original habitat are yet to produce fruit.

## 7.5 Gall infection

The remaining original plants have stem and leaf she-oak galls (*Cylindrococcus spiniferus*). Most of the original population also had them before they died (Matthes & Nash 1994). Although these galls may not be the primary cause of death, they probably affect growth of the plants in the long term (K. Wilson Royal Botanic Gardens Sydney, pers. comm.).

## 7.6 Summary of known biology and ecology

We know little information about the biology and ecology of *A. portuensis*. Our knowledge is limited to the small amount of information collected from the 10 original plants (now reduced to only 2) since the discovery of *A. portuensis* in 1986. Some information has been gathered from the *in situ* cultivated plants although this cannot necessarily be assumed to be characteristic of the species. However, in the

absence of other wild plants and the fact that recovery of *A. portuensis* is dependent on these cultivated plants, this information is useful.

Until more information is known the following assumptions can be made:

- *A. portuensis* is a shrub species with a life span greater than 10 years, and possibly up to 30 years;
- recruitment of new individuals is most likely linked to fire when adult plants are killed and the canopy stored seed bank is released from female plants into the resource rich post-fire environment; and
- *A. portuensis* is dioecious with reproductive success dependent on the availability of pollen.

# 8. Previous Management Actions

## 8.1 Previous Recovery Plans and Implementation

In 1994, a Conservation Research Statement and Recovery Plan was prepared for the then Commonwealth Australian Nature Conservation Agency (Matthes & Nash 1994). This recovery plan prepared under the TSC Act is based on that plan. The implementation of the Commonwealth Recovery Plan was funded during 1997-1999 and focused on the preparation of a representative *ex situ* collection and gathering information about the biology and ecology of the species (including information about its habitat). Information gathered during 1997/99 has been incorporated into this plan.

## 8.2 Recovery Team

A recovery team was formalised in 1997 and includes members from NPWS (Central CPPD and Harbour South Area) and Mount Annan Botanic Garden. A recovery team is a non-statutory group of interested parties with relevant expertise, established to discuss issues relating to the formulation and implementation of the plan. Components within the plan do not necessarily represent the views or the official position of all the individuals or agencies represented on the recovery team.

## 8.3 Propagation

Plants of *A. portuensis* have been propagated from seed collected from the original plants. Seedlings and juveniles derived from seed have been planted in 9 locations in Sydney Harbour National Park. This *ad hoc* program has highlighted the need for a controlled and well-documented approach to supplementary plantings. In order to maintain the genetic integrity of the species, particularly in future translocation activities, it is essential that the source and parentage of seed is known, and that hybrid material is not maintained.

Since the discovery of *A. portuensis*, it has been successfully cultivated by seed at the Royal Botanic Gardens Sydney (RBG), Australian National Botanic Gardens (ANBG), Mt Annan Botanic Garden (MABG), as well as the local National Parks and Wildlife Service Nursery (NPWS). Approximately 30 plants grown by the various botanic gardens have been planted in their own garden beds. About 100 plants were donated by the ANBG back to Nielsen Park, and less than half still survive. Those grown by NPWS have been planted in Nielsen Park.

Earlier in 1997, a method for obtaining tissue culture was established by Mt Annan Botanic Garden. However, the long-term viability of the tissue-cultured material has not been tested.

Mt Annan Botanic Garden started the preparation of a representative *ex situ* collection of cuttings in potted stock during January 1998. The aims are to reserve a representative collection off-site (which will be suitable for a translocation trial) and also as a conserved store of genetic material while a viable population is being

established. The current *ex situ* collection held at Mt Annan Botanic Garden consists of 42 putative genotypes (Errington and Offord 1998). Mt Annan Botanic Gardens also holds the remaining seed from the original plants.

## 8.4 Genetic Studies

Species in the Casuarinaceae are wind pollinated and their ability to hybridise has been observed in species such as *Allocasuarina littoralis* and *A. distyla*. The seedlings of *A. portuensis* which were grown from seed collected from the original plants of *A. portuensis* have been treated with caution as it has long been suspected that these may be hybrids with *A. littoralis* or *A. distyla* which also occur in Nielsen Park.

During 1997, Mt Annan Botanic Garden carried out preliminary investigations into the genetic variation within *A. portuensis* (Porter & Offord 1997). Their investigation consisted of the comparison of the DNA of some of the remaining *A. portuensis* material using electrophoresis (the 'RAPD' technique of Williams *et al.* (1990)). The results of their investigation indicated that *A. portuensis* was capable of hybridising with other *Allocasuarina* spp. The hybrids identified in this analysis were able to be identified as distinct from pure *A. portuensis* through morphological examination by Karen Wilson (Royal Botanic Gardens Sydney), a taxonomic expert in the Casuarinaceae.

## 8.5 Verification of Non-Hybrid Status

In December 1997, following the results of the genetic study, Karen Wilson examined all the known plants of *A. portuensis* planted in Sydney Harbour National Park. Except for five plants whose status is uncertain, 54 plants have been verified as pure *A. portuensis* (ie. they are not hybrids).

## 8.6 Fencing

In the 1990's the habitat where most of the original plants were found was fenced to redirect people who were walking through the area. Although these original plants have since died, several other cultivated plants are now growing there. The fence continues to help maintain the habitat by dissuading walkers from moving through the area.

## 8.7 Habitat Restoration Plan

In April 1996, NPWS contracted the National Trust of New South Wales to write a Bushland Restoration Plan for *A. portuensis* habitat in Nielsen Park. This plan aimed to conserve the existing *A. portuensis* population and its habitat, by developing an on-site strategy for the management of weeds and the regeneration of a sclerophyllous community.

The plan identifies zones of habitat within Nielsen Park and details restoration actions. Zone 1 contains the only two living *A. portuensis* plants. The plan recommends comprehensive removal of weeds from this area and thinning of the overstorey. Zone 2 contains original habitat where plants have since died. The objectives and aims of habitat restoration plan are described in Appendix 1.

## 8.8 Weed Removal

Weed removal activities have been initiated in the original habitat. Professional bush regenerators completed the first stage of this work in June 1997 with follow up weeding in June 1998. This work has contributed in part to the actions outlined in the Habitat Restoration Plan (as described above).

# 9. Management Issues

This section describes our current understanding and/or limitations of the biology and ecology of *A. portuensis*, the current threats operating on the population and a consideration of the social and economic factors that have an ability to affect the success of the recovery program. Translocation is another issue which is often raised in relation to the management of threatened species and is particularly relevant to the management of *A. portuensis*.

## 9.1 Level of Current Understanding

At present, a number of assumptions have been made about the biology and ecology of *A. portuensis*. An increased understanding of these aspects of *A. portuensis* will improve the finer scale approach to the recovery of the species. A greater understanding of its habitat requirements and its lifecycle processes (most particularly seed ecology, the conditions needed for recruitment and response to fire) will increase the likelihood of successful recovery of *A. portuensis* and our ability to manage the species in the future. Action 15.3.1 aims at investigating these essential aspects.

## 9.2 Threatening Processes

This section describes the current threats to the original habitat and planted locations of *A. portuensis*. The management and recovery of *A. portuensis* must address these threats.

Many of the threats listed below are a result of changing land use practices since the arrival of Europeans. Nielsen Park as a whole has suffered extensive disturbance. Development of Nielsen Park began in 1793 with extensive clearing for cropping and grazing (Wellham in Matthes and Nash 1994). The area was resumed in 1911 for public recreation and managed by a Trust, and later by Woollahra Council. In 1980, Nielsen Park was gazetted as part of Sydney Harbour National Park. It is currently managed by NPWS Harbour South Area.

The current threats to *A. portuensis* include inappropriate fire regimes, weed invasion, contamination from landfill, degradation from park management activities and recreational use of the park. More details are provided below.

### 9.2.1 Inappropriate fire regime

Fire has been excluded from the original habitat of *A. portuensis* in Nielsen Park for about 30 years (Matthes & Nash 1994). The prior fire regime is not known. However, the proliferation of mesic species indicates a long, fire-free interval. The lack of fire may have had a detrimental effect by not providing post-fire conditions needed for the recruitment of *A. portuensis* and the component species of its sclerophyllous habitat. Fire is assumed to play an essential role in the life cycle of *A. portuensis*. Therefore the use of fire as a management tool will be essential for the recovery of this species and is covered in actions 11.3.4 and 14.3.2 of the plan.

### 9.2.2 Weed invasion

Weed invasion is a problem in the original habitat of *A. portuensis* (Matthes & Nash 1994). The main species which have been dominating the understorey and altering the habitat are *Protasparagus densiflorus*, *Tradescantia albiflora*, *Lantana camara*, *Delairea odorata*, *Acetosa sagittata* and *Anredera cordifolia*.

During early 1998, Mt Annan Botanic Garden carried out a small investigation into the soil seed bank of the original habitat (Errington and Offord 1998). The results of this study indicate that the soil seed bank in this area is largely composed of weed seeds of the plants listed above. This has implications for the long-term maintenance of this site.

There are also weed species present at the various planted locations of *A. portuensis* within Sydney Harbour National Park. Grass and vine species have been found climbing the planted individuals. These weeds should be removed so that they do not cause harm to the *in situ* plantings. The ground cover beneath the *in situ* plantings may impact on their ability to set seed and reproduce.

Weed invasion is addressed in section 11.3 of the plan.

### 9.2.3 Degradation through park management activities or recreational usage

Some park management activities may have an affect on the *in situ* planted individuals. Some of these sites (sites 2, 3, 6, 7) occur next to tracks, and mowing and slashing in these areas may cause harm to these plants. Recreational usage of the park may lead to the creation of unofficial tracks, the degradation of vegetation or the accumulation of litter. These threats are addressed in section 11 of the plan.

### 9.2.4 Contamination by landfill

The area up-slope from original habitat of *A. portuensis* was used to deposit landfill from nearby building sites between 1975 and 1979. It is unknown if individual *A. portuensis* have been affected by this activity. There is concern that water runoff from this area of fill may have contaminated the soil with additional nutrients or pollutants, which may have affected the biological function of the species. It is not possible to remove the landfill from the site, however a monitoring program as part of action 11.3.2 will assist in detecting impacts if they are occurring.

## 9.3 Social and Economic Issues

### 9.3.1 Intrinsic ecological value

*A. portuensis* has intrinsic ecological value. The discovery of *A. portuensis* in 1986 highlights the importance of conserving remnant bushland to protect biodiversity values.

### 9.3.2 Scientific value

As a member of a large genus, *A. portuensis* has helped taxonomists to understand the evolutionary relationships between other members of its genus and family.

Research on the biology of this species will increase understanding of the way in which species function. It will also enhance understanding of the processes required to recover species that are close to extinction.

### 9.3.3 Biodiversity value

The 1986 discovery of this species within a highly developed part of Sydney highlights the importance of managing small bushland remnants. In the case of Nielsen Park, its chief value was considered to be recreational, scenic and historical. Now this area has an important conservation role as the sole location for an endangered species of plant (Brookhouse 1986).

No other nationally or state listed threatened species are known to occur in this habitat. The habitat in which *A. portuensis* occurs is not an endangered community. However, it is a valuable refuge for biodiversity in a highly developed part of Sydney.

A number of actions in this plan target the restoration and management of vegetation in Sydney Harbour National Park (see section 11.3). Weed removal and habitat regeneration involving fire will provide improved habitat for *A. portuensis* and all other native species that are struggling to survive in the scarce areas of native vegetation, which remain in Sydney Harbour. Weed invasion is a dominant threatening process in urban bushland, and thus weed management in Sydney Harbour National Park will assist in conserving the biodiversity of this part of New South Wales.

Biodiversity values can be decreased by site degradation caused by public access. The monitoring program associated with action 11.3.2 will also assist in preventing this type of degradation. Parkland is frequently degraded from unofficial tracks, litter and rubbish dumping and the monitoring program will highlight these problems and prompt remedial action.

### 9.3.4 Social effects

As *A. portuensis* is only known to occur on land managed by the NPWS there are no other affected land holders who may be affected by the implementation of the recovery plan. The original habitat of *A. portuensis* does not occur immediately adjacent to neighbouring property. Thus there are no immediate neighbours who will be directly affected by the plan.

The restoration of the *A. portuensis* habitat will provide an area of scenic value that will contribute to the recreational value of Nielsen Park and of Sydney Harbour. Access to these areas by the general public may need to be regulated due to the

possible adverse impacts of walkers on the vegetation of the area (eg. through trampling).

Control burning will be necessary to restore the habitat of *A. portuensis.* This use of fire, causing smoke, may be met with opposition by local residents.

### 9.3.5 Economic consequences

The economic consequences of the recovery of *A. portuensis* are those direct costs associated with the implementation of this plan. These include the restoration of the habitat of *A. portuensis, ex situ* cultivation, and biological and ecological studies.

## 9.4 Translocation

Translocation, "the deliberate transfer of plants or regenerative plant material" (ANPC 1997), is often raised in conjunction with the process of recovering endangered species. Translocation is a lengthy process involving long term commitment and should only be attempted when it is seen as necessary to achieve a long-term conservation outcome. In the case of *A. portuensis* where only two individuals of the species remain, a translocation program which aims at increasing the numbers of plants is the only likely way to recover this species and is described in action 14.3.2 of the plan. Guidelines detailing the issues associated with translocation have been published by the ANPC (1997). Translocation trials associated with this plan will follow these guidelines.

## 9.5 Species Ability to Recover

### 9.5.1 Species rarity

*A. portuensis* is considered to be a threatened species, as it is known from a single population consisting of 2 individuals. Although we cannot be certain, it is likely that *A. portuensis* had a wider distribution before the development of the foreshore of Sydney Harbour. The clearance or degradation of native vegetation in that part of Sydney is the most likely cause of decline in *A. portuensis*.

### 9.5.2 Species viability

As *A. portuensis* is a species that is very close to extinction, a lengthy recovery process is necessary to 'recover' the species to the extent that it is viable. Broadly speaking a viable species is one that is self-maintaining in the wild. That is, for *A. portuensis* it consists of reproductive individuals which successfully produce viable and non-hybrid seed, that seedlings establish from this seed under natural conditions, and that these seedlings mature to reproductive adults which produce viable and non-hybrid seed, and so on into the future.

### 9.5.3 Likelihood of recovery

The overall objective of this recovery plan is to recover the species so that a viable population of *A. portuensis* is self-maintaining in the wild.

In its current condition, *A. portuensis* is not likely to be a viable species in the long term. Thus, in order to increase the likelihood of *A. portuensis* surviving into the future this recovery plan recommends a series of recovery actions focused at:

- restoring and maintaining the original known habitat of *A. portuensis*;
- protecting and managing the *in situ* planted *A. portuensis*;
- searching for new populations;
- maintaining a representative *ex situ* collection; and
- undertaking a translocation program.

Locating new populations of *A. portuensis* through survey would greatly increase the options available for recovering this species. However, the likelihood of locating new populations is low, as there are few areas of this habitat type remaining in this part of Sydney. If new populations are located, the necessity for translocation will be determined by the number of populations found, the number of individuals within each population and the condition of the habitat.

Given that the original known population of *A. portuensis* has diminished to 2 individuals, if no new populations are found it is highly unlikely that the species will be able to recover from this single wild population. The species is also unlikely to recover to form a viable population from the current *in situ* plantings as they are planted in small groups scattered around Sydney Harbour National Park. Nevertheless, these *in situ* plantings indicate that a translocation program is likely to be successful in increasing the actual number of individuals *in situ*. Supplementary plantings in a translocation trial will provide the best opportunity to establish viable sub-populations of *A. portuensis*. Habitat maintenance involving weed removal and fire will provide an appropriate environment for this to occur.

The success of translocation in terms of establishing a viable population, is assessable at key stages of the life history of the species (described under action 14.3.2) including, most importantly, the establishment of a second generation. Assessing the viability will involve an assessment of the degree to which viability is achieved, rather than a comparison of viability versus inviability. It is clear from the current *in situ* cultivated individuals that *A. portuensis* is able to survive and produce fruit. However, to what degree it is producing viable non-hybrid fruit and its ability to re-establish itself into the second generation is unknown.

Although it is not possible to estimate what the size of a viable population[1] of *A. portuensis* would be, an achievable goal is between 30 and 60 individuals within a single sub-population, with approximately half consisting of reproductive females. Although there is no scientific rationale to base these numbers, given the resources available (to propagate enough stock and to monitor the program), and the extent of

[1] A population is defined using the "rule of thumb: by Keith *et al.* (1997) as "geographic discontinuity of more than 1 km". Sub-populations are groups of plants not separated by an effective barrier by more than 1 km.

available habitat, this size of the population is seen as achievable. The even ratio of male to female plants is assumed until more information is available.

The consequence of not implementing this recovery program will be the extinction of this species in the wild. As stated above, in its current state *A. portuensis* is of doubtful viability. Based on the available information, *A. portuensis* does have the ability to recover. However, it will most likely remain an endangered species with a very restricted distribution of only one population consisting of more than one sub-population.

# 10. Overall Recovery Aim and Recovery Strategy

## 10.1 Overall Recovery Objective

The overall objective is to recover *A. portuensis* through actively seeking to increase the number of known individuals in the wild, and so prevent the extinction of the species.

## 10.2 Overall Recovery Performance Criteria

The overall performance criteria of the recovery plan is that the risk of extinction of *A. portuensis* is reduced, through the implementation of recovery actions to protect and enhance the known population.

## 10.3 Individual Objectives, Actions and Criteria

**Recovery Objectives**

Specific objectives of the recovery plan are:

- to protect, restore and maintain the original habitat of *A. portuensis* and the planted locations;
- to establish the distribution of *A. portuensis*;
- to ensure that the recovery program is focused toward the recovery of a population of 'pure' (non-hybrid) *A. portuensis*;
- to store a representative collection of *A. portuensis ex situ* during the recovery process and to enhance the known population of *A. portuensis* in Sydney Harbour National Park through translocation if no additional viable populations of *A. portuensis* are found during a targeted survey; and
- to enhance future management of *A. portuensis* by furthering our understanding of essential aspects of the biology and ecology of the species relating to seed ecology, population dynamics and response to fire.

**Performance criteria**

Performance criteria are that:

- buffer zones are created around each of the locations of *A. portuensis* and these will be maintained in good condition with a minimum of weeds;
- the original habitat and the planted locations of *A. portuensis* are not diminished through human induced disturbance;
- the original habitat is restored to a more suitable state for the recovery of *A. portuensis*, i.e. open woodland/heath containing sclerophyllous species and minimal weeds;
- potential habitat is identified and surveyed for the presence or absence of additional populations of *A. portuensis*;

- *in situ* and *ex situ* material contains no hybrid material, so that the genetic integrity of *A. portuensis* is maintained;
- a representative *ex situ* collection suitable for a translocation program is established and maintained;
- the number of individuals within the population of *A. portuensis* in Sydney Harbour National Park is increased to between 30-60 individuals in at least one sub-population. The plants within these enhanced sub-populations should be fertile and produce non-hybrid seed from which new individuals establish under natural conditions; and
- a greater understanding of *A. portuensis* biology and ecology is achieved and applied to management.

**Recovery Actions**

The plan consists of ten recovery actions which aim at the overall objective. These actions include to:

- create and manage buffer zones to protect *A. portuensis* in Sydney Harbour National Park;
- undertake monitoring program;
- assess impacts of any activities;
- undertake habitat restoration and weed management in the original habitat of *A. portuensis* and in the buffer zones established around the planted locations;
- undertake weed management at the planted locations;
- undertake a targeted survey for *A. portuensis;*
- undertake ongoing assessment of the hybridity status of individuals of *A. portuensis in situ* and *ex situ* by an expert in the plant family Casuarinaceae and discontinue any hybrid plant material;
- establish and maintain a representative collection of *A. portuensis ex situ* during the recovery process;
- establish a translocation trial; and
- investigate the biology and ecology of *A. portuensis.*

These are explained in more detail in sections 11-15 below.

# 11. Site Management

## 11.1 Objective

To protect, restore and maintain the original habitat of *A. portuensis* and the planted locations.

## 11.2 Criteria

The criteria for success of this action are that:

- buffer zones are created around each of the locations of *A. portuensis* and these will be maintained in good condition with a minimum of weeds;

- the original habitat and the planted locations of *A. portuensis* are not diminished through human induced disturbance; and
- the original habitat is restored to a more suitable state for the recovery of *A. portuensis*, i.e. open woodland/heath containing sclerophyllous species and minimal weeds.

## 11.3 Recovery Actions

### 11.3.1 Create and manage buffer zones to protect *A. portuensis* in Sydney Harbour National Park

The remaining original plants and the *in situ* cultivated individuals are vulnerable to harm caused by recreational use of Sydney Harbour National Park and park management activities. To prevent this, the NPWS will establish a buffer zone around each of the locations in which activities such as mowing, hazard reduction burning and bush regeneration activities should not take place unless in accordance with this recovery plan.

### 11.3.2 Undertake monitoring program

The NPWS will implement a monitoring program (Appendix 2) to be undertaken at six monthly intervals, whereby the condition of each of the sites and the individual plants are checked for damage and disturbance from visitation pressure (such as rubbish dumping or unofficial tracks). If degradation is occurring then remedial action will be taken.

This is an on-going action throughout the life of the plan. It will be carried out in conjunction with the restoration of the original habitat and weed management of the planted locations (outlined in Actions 11.3.4 and 11.3.5).

### 11.3.3 Assess impacts of any activities

To ensure those activities undertaken for park management purposes (both within and outside the buffer zones) do not adversely impact *A. portuensis*, the NPWS will assess the impact of any activities on *A. portuensis* and its habitat. Examples of such activities include track and building construction and hazard reduction burning. The NPWS will conduct (if necessary) a Review of Environmental Factors (REF), in accordance with part 5 of the *Environmental Planning and Assessment Act (1979),* for any activities proposed in Sydney Harbour National Park that might affect *A. portuensis* and its habitat.

### 11.3.4 Undertake habitat restoration and weed management in the original habitat of *A. portuensis* and in the buffer zones established around the planted locations as per action 11.3.1.

The original habitat of *A. portuensis* is degraded from weed invasion and inappropriate fire regimes. The aim here is to restore the original habitat in accordance with the 'Bushland Restoration Plan for *A. portuensis* habitat in Nielsen

Park' (prepared by the National Trust in 1996). The aims and objectives of the habitat restoration plan are provided in Appendix 1.

The Restoration Plan divides Nielsen Park into five zones in which the original habitat of *A. portuensis* is found in both Zones 1 and 2. It details activities to be carried out over a three-year period and highlights the necessity for ongoing weed management into the future.

The use of fire in the original habitat is likely to be essential and is recommended in the Restoration Plan. The timing of fire will depend on the success of weed removal from the site and the timing of activities within a translocation trial (action 14.3.2).

Fire can assist regeneration by opening up the canopy to provide more light for seedling growth. It also stimulates the regeneration of sclerophyllous species, which have largely dormant seeds that are often stimulated to germinate through the effects of fire and smoke. The regeneration of a more open, sclerophyllous habitat will provide more suitable conditions for *A. portuensis* to recover. In addition, once a population of *A. portuensis* has been established in this site, a fire regime will need to be established to maintain the integrity of the restored habitat.

The use of fire in the restoration of the original habitat may lead to the death of the two remaining individuals (that is, unless *A. portuensis* is able to resprout, which is doubtful at present). Measures can be taken to protect the two original plants during the implementation of a control burn. A back-up *ex situ* collection of *A. portuensis* suitable for translocation will also be established before the habitat is burned (see action 14.3.1). Weeding should continue after burning has taken place.

The NPWS will implement the major restoration activities (as detailed in the Habitat Restoration Plan) during the first three years of the plan with ongoing maintenance throughout the life of the plan. In the fourth year of implementation the success of restoration will be assessed and future management of the site will be refined. Six monthly monitoring (as described in action 11.3.2) will assist in the assessment of the success of the restoration activities.

### 11.3.5 Undertake weed management at the planted locations

There are nine planted locations occurring in Sydney Harbour National Park. Most of the planted locations contain weed species, which are climbing on the plants themselves and/or are forming dense ground cover. The longevity of the cultivated *in situ* plants and their ability to re-establish themselves in these locations is likely to be inhibited by the weed species present. Given that the original habitat has been degraded, the planted locations hold some importance to the recovery of the species (as described in section 6.1 and 6.2).

Planted locations 1, 2, 3 and 4 are included in zone 4 and 5 in the 'Bushland Restoration Plan for *A. portuensis* habitat in Nielsen Park' (prepared by the National Trust in 1996). As Zone 4 and 5 in the Restoration Plan are of lower priority than the original habitat of *A. portuensis* (Zones 1 and 2) only a broad scale

strategy has been described. However, given the importance of the *in situ* cultivated individuals, management of weed species on and beneath the *in situ* plants is required to enhance their long-term survival. Weed management is also required at planted location 6 and 7, and perhaps at location 8 and 9 which are within active bush regeneration areas. Planted location 5 is within a garden bed, and the identity of these plants remains uncertain, thus no active management of these areas is required. These sites may require fire management if a translocation trial takes place in any of these areas (see action 14.3.2).

The NPWS will manage weed species within the buffer zone surrounding the planted locations. Six monthly monitoring (as described in action 11.3.2) will allow an assessment of habitat condition. Weeding will take place at appropriate intervals so that the *in situ* cultivated plants are not adversely affected.

This is an on-going action throughout the life of the plan.

# 12. Survey

## 12.1 Objective

To establish the distribution of *A. portuensis.*

## 12.2 Criteria

Potential habitat is identified and surveyed for the presence or absence of additional populations of *A. portuensis.*

## 12.3 Recovery Action

### 12.3.1 Undertake a targeted survey for *A. portuensis*

There has not been a systematic targeted survey for *A. portuensis.* Areas of potential habitat will be surveyed for other populations of *A. portuensis* and in particular areas of remnant vegetation along the shores of Sydney Harbour.

It is not possible to determine the past distribution of *A. portuensis* as this part of Sydney has been extensively cleared and developed since the arrival of Europeans. It is likely that *A. portuensis* had a broader distribution, which has been reduced due to habitat loss.

The identification of suitable areas for survey will involve the investigation of the extent of suitable remaining habitat through aerial photograph interpretation. Given that *A. portuensis* was originally located in areas of largely degraded bushland, these areas should not be excluded from survey. Landscape position, soil type and aspect will largely assist in locating areas of potential habitat. Floristic information will be of limited assistance as remnant vegetation in suburban areas is generally degraded from weed invasion and inappropriate fire regimes.

The NPWS will coordinate this survey both on and off National Park. The involvement of community groups will be encouraged.

This action is scheduled for the first year of the plan. The results of this plan will determine the extent to which later actions are implemented.

# 13. Maintenance of a 'pure' population

## 13.1 Objective

To ensure that the recovery program is focused toward the recovery of a population of 'pure' (non-hybrid) *A. portuensis*.

## 13.2 Criteria

*In situ* and *ex situ* material contains no hybrid material, so that the genetic integrity of *A. portuensis* is maintained.

## 13.3 Recovery Action

### 13.3.1 Undertake ongoing assessment of the hybridity status of individuals of *A. portuensis in situ* and *ex situ* by an expert in the plant family Casuarinaceae and discontinue any hybrid plant material.

The genetic integrity of *A. portuensis* material planted in Sydney Harbour National Park has been confirmed as pure *A. portuensis*. However, as additional plants are cultivated and as seeds are germinated from the planted individuals, their hybrid status requires assessment. If seedlings emerge at the planted locations where cultivated *A. portuensis* are growing, then their hybrid status requires assessment. Confirmed *A. portuensis* hybrid material will be removed from Sydney Harbour National Park and from *ex situ* collections held at Mount Annan Botanic Garden.

The status of all material to be used for long term germplasm storage has been confirmed by an expert in the Casuarinaceae (Karen Wilson of the National Herbarium of NSW). Any *A. portuensis* material to be translocated will also be assessed immediately prior to translocation.

This action will be carried out by the Royal Botanic Gardens, Sydney in conjunction with the NPWS.

This is an ongoing action throughout the life of the plan.

# 14. Re-establishment

## 14.1 Objective

To store a representative collection of *A. portuensis ex situ* during the recovery process and to enhance the known population of *A. portuensis* in Sydney Harbour National Park through translocation if no additional viable populations of *A. portuensis* are found during a targeted survey.

## 14.2 Criteria

The criteria for success of this action are that:

- a representative *ex situ* collection suitable for a translocation program is established and maintained; and
- the number of individuals within the population of *A. portuensis* in Sydney Harbour National Park is increased to between 30-60 individuals in at least one sub-population. The plants within these enhanced sub-populations should be fertile and produce non-hybrid seed from which new individuals establish under natural conditions.

## 14.3 Recovery Actions

### 14.3.1 Establish and maintain a representative collection of *A. portuensis ex situ* during the recovery process.

As described in section 8.3 of this plan, a representative *ex situ* collection of cutting material has been established at Mount Annan Botanic Garden. This collection is an important store of genetic material while the recovery plan is in progress. An *ex situ* store of genetic material will need to be maintained, at least, until a viable population is found through survey, or one is established through translocation.

If no other populations of *A. portuensis* are found, then enhancement of the population of *A. portuensis* in Sydney Harbour National Park will be required to recover the species. Enhancement (translocation) will only occur through a properly managed translocation program following the ANPC (1997) guidelines. The representative *ex situ* collection will be used for this purpose. Adequate stock will need to be replicated at appropriate times so that adequate material is available for a translocation program and to maintain a store of material *ex situ*.

Now that the current *in situ* plants have been verified as pure *A. portuensis*, it is likely that an *ex situ* collection can be maintained using seed. However, before seed storage can be relied upon for *ex situ* storage, the capability of the seed requires investigation. This will include assessing its hybridity and viability status.

The need for germplasm storage will require reassessment during the life of the plan according to the results of the targeted survey and the success of translocation activities.

This action will be carried out by Mount Annan Botanic Garden in conjunction with the NPWS.

### 14.3.2 Establish a translocation trial

The objective of this action is to enhance the population of *A. portuensis* in Sydney Harbour National Park. A translocation trial will need to be established if no significant additional populations of *A. portuensis* are located through systematic field surveys. The number of populations found will determine the importance of the original site and thus the need for or the extent of a translocation trial. If no additional populations are found, it will not be possible for *A. portuensis* to recover from its current state, to that of a viable population in the wild, without assistance from translocation. Translocation will follow the ANPC (1997) guidelines.

**Pre-translocation**

Once the need for a translocation trial is established, the following factors should be considered for the design of the trial.

- ***The extent to which threatening processes been removed from each site.***

The extent to which the original habitat has been restored will determine the suitability of this site for additional plantings (refer to actions 11.3.4 and 11.3.5). Before translocation is initiated in this site, minimal weeds should be present, an increase in the number of sclerophyllous species should be observed and the canopy layer should be less dense. At the planted locations, weed management as outlined in Action 11.3.4 should have removed immediate threats to the *in situ* cultivated individuals.

- ***The most appropriate sites for translocation to occur.***

The original habitat is the most important site for the recovery of *A. portuensis* (for reasons discussed in section 6.1). Translocation should therefore take place in this site. Some cultivated individuals have already been planted there and these should be enhanced. As the condition of the original habitat is probably quite different to the conditions under which *A. portuensis* was naturally established, there is less certainty that *A. portuensis* will be able to re-establish in that site. Thus, the *in situ* locations provide some options as to where additional plantings may be successful. Translocating into more than one site will increase the chance of success. Additional sites chosen should be based on site condition (including naturalness), the apparent success of each of the current plantings and the extent to which the site can be appropriately managed in the future i.e. the ease to which weed and fire management can be implemented and areas which are less likely to be impacted by park activities. Care should be taken to choose sites which are not in close proximity to other *Allocasuarina* species which *A. portuensis* is known to hybridise with.

- ***The scale of translocation***

The success of the targeted survey will initially determine the extent to which translocation should occur. If several populations are found, then it may be more useful to allocate resources to the management of these new sites. If only one other population is found with no conservation security then the translocation trial should still be implemented. At the current level of knowledge regarding the distribution of *A. portuensis* and the resources available, the scale of translocation aims at increasing the number of individuals within three sub-populations of *A. portuensis* in Sydney Harbour National Park to between 30-60 individuals in each.

- ***Site preparation***

Some consideration should be made as to both continued maintenance of the each site and preparations for translocation. The buffer zones established in action 11.3.1 will ensure that the sites chosen are in good condition. The buffer zones encompassing the sites chosen for translocation will need to be increased to accommodate new plantings. Some consideration should also be made to the control of rabbits, as it is likely that they will graze on the young plants used in the translocation trial.

**The Translocation Process**

Three attempts will be required to achieve the target number of individuals within each of the three sub-populations. An assessment of the success and failure of the trial will follow each attempt so as to refine future translocations. Plantings have been timetabled for year 2, year 4 and year 6.

**Assessment**

The success of this translocation trial will be assessed over the life of the plan. Assessment is needed to both evaluate and modify the actual translocation process (as described above) and to monitor the success of the translocation towards the objective of this action i.e. to establish a viable population.

The overall objective of this action is to establish a viable population, which means measuring success at all stages of the life cycle and into the next generation. Outright success will not be assessable during the life of this plan due to the expected life span of the species. However, monitoring may indicate the failure of the trial at various stages, for example translocated individuals may fail to establish, or fail to produce flowers or fruits. Monitoring will initially occur at monthly intervals until translocated plants appear to have established and the death rate has decreased. Monitoring will then take place at 6 monthly intervals (as in action 11.3.2). Each new planting will be tagged and the source of material recorded.

The following factors will be considered when assessing the success of the trial:

- number of plants which survive translocation at each site;
- general health of the translocated plants (monitored six-monthly);
- number of plants producing flowers;

- number of female plants developing fruit;
- genetic status of this fruit (hybrid or pure);
- *natural establishment of seedlings within a location;
- survival of seedlings to maturity;
- production of flowers and fruit in the second generation; and,
- production of viable fruit in the second generation.

* It is essential that seedlings in the second generation be observed to establish by natural means. It is only through this that we can determine whether or not a naturally viable population is being established. Appropriate conditions will need to be provided for seedlings to establish. This will include the use of fire to kill adult plants and allow seed to be released from cones. The seed release and establishment trial will assist in refining the approach to this and additional experiments. One planted location may be burnt as a trial to observe natural recruitment. Expert advice will be sought.

On success of this action (beyond the life of this plan), long term site management guidelines will be formulated.

This action will be carried out by NPWS in conjunction with Mt Annan Botanic Garden.

If no additional populations are located and the original habitat and the planted locations are in good condition, then this translocation trial will commence during year 2 of the plan. Seedling establishment trials, incorporating the artificial release of seeds and/or the use of fire, should be implemented when the translocated individual have been producing significant numbers of fruit for more than 1 year. Monitoring of all translocated plants and seedlings will continue throughout the life of the plan.

# 15. Research

As summarised in section 7.6, little is known about the biology and ecology of *A. portuensis*. Future management of the original population and the *in situ* cultivated plantings, would greatly benefit from a better understanding of the biology and ecology of the species, particularly if a translocation trial is to be implemented. Currently we can only make a number of assumptions.

Some information can be gathered from the *in situ* cultivated plants although this cannot necessarily be assumed to be characteristic of the species. However, in the absence of other wild plants and the fact that recovery of *A. portuensis* is dependent on these and additional cultivated plants, this information is useful.

## 15.1 Objective

To enhance future management of *A. portuensis* by furthering our understanding of essential aspects of the biology and ecology of the species relating to seed ecology, population dynamics and response to fire.

## 15.2 Criteria

A greater understanding of *A. portuensis* biology and ecology is achieved and applied to management.

## 15.3 Recovery Action

### 15.3.1 Investigate the biology and ecology of *A. portuensis*

Essential aspects of the biology and ecology of *A. portuensis* requiring investigation include seed ecology, recruitment and response to fire. This includes:

- understanding seed dynamics, particularly of the cultivated individuals, will enable an assessment of the likely long-term viability of current *in situ* plantings and the likelihood of success of translocation;
- investigating population dynamics and recruitment are also high priority, as they will enable assessment of the success of management strategies and likely future translocation trials. This may involve an experimental approach, involving the removal of seed cones and the artificial sowing of seeds at a site within Nielsen Park to observe recruitment and seedling survival; and
- the response of *A. portuensis* to fire will also determine future management of these sites. Experimental plants from the seed recruitment trials will be available to test fire response.

Other aspects of the biology and ecology of *A. portuensis* may increase in importance with the progress of the implementation of the recovery plan. Experimental approaches may be employed. The recovery team during the progress of implementation will discuss prioritisation of future research.

This work will be coordinated by the NPWS. Universities or other research institutes or trained members of the community will be encouraged to participate in this component of the recovery program.

Investigations into seedbank ecology and recruitment will be initiated in the first year of the plan. Response to fire will be investigated in or after year 3. These investigations may be incorporated into the monitoring associated with the translocation trial (refer to section 14.3.2).

# 16. Implementation and Costs

## 16.1 Implementation Schedule

Table 3 allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies. Operational details regarding the implementation of this plan are held on file with the NPWS.

**Table 3**. **Implementation schedule for recovery plan actions.**

| Action | Description | Respon-sibility | Year of Implementation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11.3.1 | Create and manage buffer zones | NPWS | ✓ | | | | | | | | | |
| 11.3.2 | Undertake monitoring program | NPWS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 11.3.3 | Assess impacts of activities (as necessary) | NPWS | | | | | | | | | | |
| 11.3.4 | Habitat restoration and weed mgmt of original population<br>- implement habitat restoration plan<br>- assess success and refine management<br>- maintain and monitor | NPWS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 11.3.5 | Weed management at planted locations<br>- remove weeds in buffer zones<br>- maintain and monitor buffer zones | NPWS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 12.3.1 | Targeted survey | NPWS | ✓ | | | | | | | | | |
| 13.3.1 | Assessment of hybridity | RBG & NPWS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 14.3.1 | *Ex situ* collection<br>- maintain collection<br>- collect seed for storage and test for viability at set periods<br>- assess appropriateness of cutting collection and repropagate as necess. | RBG | ✓<br>✓ | ✓<br>✓ | ✓<br>✓ | ✓ | ✓<br>✓<br>✓ | ✓<br>✓ | ✓ | ✓ | ✓<br>✓ | ✓<br>✓ |
| 14.3.2 | Translocation trial<br>- establish need for trial<br>- choose and prepare sites<br>- replicate plants (spring)<br>- translocate plants (autumn)<br>- assess success of plantings<br>- provide conditions for regeneration | NPWS & RBG | | ✓<br>✓<br>✓<br>✓ | ✓ | ✓<br>✓ | ✓ | ✓<br>✓ | ✓ | ✓ | | |
| 15.3.1 | Investigate biology and ecology<br>- seed ecology<br>- population dynamics<br>- response to fire | NPWS | ✓<br>✓ | ✓<br>✓ | ✓ | ✓ | ✓ | | | | | |

## 16.2 Implementation Costs

Table 4 identifies the costs required to implement actions which require funding for implementation.

**Table 4. Implementation costs for recovery plan actions.**

| Action | Description | Year of Implementation | | | | | | | | | | | Source of funding | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total | NPWS[1] | RBG |
| 11.3.1 | Create and manage buffer zones | 1 000 | - | - | - | - | - | - | - | - | - | 1 000 | 1 000 | |
| 11.3.2 | Undertake monitoring program | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 3 500 | 3 500 | |
| 11.3.3 | Assess impacts of activities | - | - | - | - | - | - | - | - | - | - | - | - | |
| 11.3.4 | Habitat restoration and weed management of original population | | | | | | | | | | | | | |
| | - implement habitat restoration plan | 4 500 | 2 500 | 2 500 | - | - | - | - | - | - | - | 9 500 | 9 500 | |
| | - assess success and refine management | - | - | - | 1 000 | - | - | - | - | - | - | 1 000 | 1 000 | |
| | - maintain and monitor | - | - | - | 3 000 | 3 000 | 3 000 | 3 000 | 3 000 | 3 000 | 3 000 | 21 000 | 21 000 | |
| 11.3.5 | Weed management at planted locations | | | | | | | | | | | | | |
| | - remove weeds in buffer zones | 2 000 | - | - | - | - | - | - | - | - | - | 2 000 | 2 000 | |
| | - maintain and monitor buffer zones | - | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 9 000 | 9 000 | |
| 12.3.1 | Targeted survey | 3 000 | - | - | - | - | - | - | - | - | - | 3 000 | 3 000 | |
| 13.3.1 | Assessment of hybridity | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 3 000 | | 3 000 |
| 14.3.1 | *Ex situ* collection | | | | | | | | | | | | | |
| | - maintain collection | 1 600 | 1 600 | 1 600 | 1 600 | 1 600 | 1 600 | 1 600 | 1 600 | 1 600 | 1 600 | 16 000 | 3 200 | 12 800 |
| | - collect seed for storage and test for viability at set periods | 1 100 | 600 | - | - | 600 | - | - | - | - | 600 | 2 900 | 1 700 | 1 200 |
| | - assess appropriateness of cutting collection and repropagate as necessary | - | - | 1 300 | - | - | 1 300 | - | - | 1 300 | - | 3 900 | | 3 900 |
| 14.3.2 | Translocation trial | | | | | | | | | | | | | |
| | - establish need for trial | - | 350 | - | - | - | - | - | - | - | - | 350 | 350 | |
| | - choose and prepare sites | - | 1 000 | - | - | - | - | - | - | - | - | 1 000 | 1 000 | |
| | - replicate plants | - | 900 | - | 900 | - | 450 | - | - | - | - | 2 250 | 2 250 | |
| | - translocate plants | - | 2 000 | - | 2 000 | - | 2 000 | - | - | - | - | 6 000 | 6 000 | |
| | - assess success of plantings | - | - | 350 | - | 350 | - | 350 | - | - | - | 1 050 | 1 050 | |
| | - provide conditions for regeneration | - | - | - | - | - | - | - | 2 300 | - | - | 2 300 | 2 300 | |
| 15.3.1 | Investigate biology and ecology | | | | | | | | | | | | | |
| | - seed ecology | 3 000 | 3 000 | - | - | - | - | - | - | - | - | 6 000 | 6 000 | |
| | - population dynamics | 2 500 | 2 700 | - | - | - | - | - | - | - | - | 5 200 | 5 200 | |
| | - response to fire | - | - | 2 300 | 450 | 450 | - | - | - | - | - | 3 200 | 3 200 | |
| **OVERALL TOTAL /YR & PER AGENCY** | | **19 350** | **16 300** | **9 700** | **10 600** | **7 650** | **10 000** | **6 600** | **8 550** | **7 550** | **6 850** | **103 150** | **82 250** | **20 900** |

[1]implemented and funded by NPWS Central CPPD and Harbour South Area

# 17. Preparation Details

This recovery plan was largely prepared by Merrin Tozer, with final proofs and editing by Ron Haering and Sarah Burke.

## 17.1 Date of Last Amendment

No amendments have been made to date.

## 17.2 Review Date

This recovery plan will be reviewed ten years after the date of publication. A small internal review will occur after 5 years. The recovery plan will be reviewed by the NPWS in consultation with the *A. portuensis* threatened species recovery team.

# 18. Contacts

## 18.1 Threatened Species Recovery Team

The Threatened Species Recovery Team for *A. portuensis* is coordinated by Threatened Species Unit, Central Directorate, National Parks and Wildlife Service, PO 1967, Hurstville, 2220. Telephone (02) 9585 6678.

## 18.2 Other Useful Addresses

**NPWS**
A copy of this recovery plan will be available for inspection at the NPWS Head Office Information Centre and NPWS Harbour South Area Office, or on the Internet during the period of exhibition (address www.npws.nsw.gov.au). A copy can also be purchased for $7.50 plus postage. Other relevant display points include:

**NPWS Harbour South Area Office (at Nielsen Park)**
PO Box 461, ROSE BAY NSW 2029 (02) 9337 5511

**Mt Annan Botanic Garden**
Mt Annan Drive, MT ANNAN NSW 2567 (02) 46482 477

**National Herbarium of NSW**
Royal Botanic Gardens Sydney, Mrs Macquarie's Rd, SYDNEY 2000 (02) 9231 8111

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# Appendix 1: Habitat Restoration Plan

**Aims and objectives of the bushland restoration plan for *Allocasuarina portuensis* habitat in Nielsen Park (National Trust 1996).**

Given the limitations regarding natural regeneration of *Allocasuarina portuensis*, the aims of the restoration plan are:

- to restore the bushland area to a healthy ecosystem in which plants of *Allocasuarina portuensis* can survive, once established at the site, by natural regeneration or by the use of propagated plant stock; and
- to allow survival of the existing plants as long as possible, to enable the production of viable seed, the collection of genetic material and of material for propagation to take place over as long a period as possible.

Objectives of the plan are:

- removal of weed growth within the mapped area;
- promotion of natural regeneration of a diversity of native species; and,
- restoration of areas unable to regenerate naturally using tube stock propagated from material collected in the area.

# Appendix 2: Monitoring Program for *Allocasuarina portuensis* in Sydney Harbour National Park

## Aim

The monitoring program is integral to two of the objectives of the recovery plan and aims at providing feedback on the ongoing condition of 'sub-populations'[2] of *A. portuensis* and its habitat in Sydney Harbour National Park.

## Relationship to Recovery Plan Objectives

***Recovery Plan Objective 1:*** *To protect, restore and maintain the original habitat of A. portuensis and the planted locations.*

The actions associated with this objective are focussed at restoring the original habitat and maintaining weed free buffer zones. Buffer zones will be established around eight of the nine current sites (the garden bed (site 5) near the change sheds will be excluded as the genetic status of the individuals is uncertain). This monitoring program will provide feedback on the success of these restoration activities, the status of weeds in buffer zones and provide an adaptive response to the future management of each site.

*Recovery Plan Objective 5: To enhance the known population of A. portuensis through translocation if no additional viable populations of A. portuensis are found during a targeted survey.*

This action involves a structured approach to the planting of new individuals into three of the planted locations in Sydney Harbour National Park. Mt Annan Botanic Garden have been approached and are currently seeking endorsement to store and replicate material for this trial. It is likely that three attempts at planting will be required to achieve the goal of 30-60 plants in three sub-populations. More intensive monitoring must take place at monthly intervals after the trial has commenced to identify problems and refine the process for the next stage. The monitoring program described here will have to be upgraded to collect more information for the assessment of the success of each subsequent planting.

## Responsibility

An appropriately skilled or trained NPWS officer will coordinate the monitoring program. The NPWS officer must be able to recognise *A. portuensis* and be competent in making general observations of habitat condition.

## Material Required to Undertake Monitoring

- clip board and pencils;

[2] The sub-populations include naturally occurring and planted individuals.

- new data sheets, copy of the notes for completing the data sheet;
- photocopies of the last two data sheets and the condition reports including photos;
- site maps to locate individual *A. portuensis*;
- camera and film (at least 9 photos will be taken per monitoring episode);
- spare plant tags (Central CPPD and BRMD will supply the small amount needed for this task;
- ruler and callipers.

**Procedures**

1. At six monthly intervals (January and July) an officer of the NPWS will visit and record information at each of the eight sites being monitored;
2. Recording sheets should be completed for each of the sites (as per instructions provided below);
3. A condition report should be completed and the need for ameliorative work at any of the sites should be forwarded onto the Area Manager for follow up action.

## *Allocasuarina portuensis* Monitoring Program: Instructions for data sheet completion (as provided in Attachment 1)

## Notes on site condition:

Describe any qualitative changes to the site such as:

- *Weed infestation*: note any weed species present;
- *Ground cover*: presence of forbs, herbs, bare ground;
- *Canopy cover*: approximate percentage visual canopy cover;
- *Tracks*: has there been any new or eroded tracks, where are they located;
- *Rubbish*: note presence of any sort of rubbish from litter to large objects;

Also note any damage from park maintenance activities.

Information recorded from the last two monitoring periods will need to be read prior to undertaking the next monitoring episode. In addition check to see if restoration work identified after the last monitoring period has been carried out.

**Photopoint:**

Establish a position where a photo can be taken each time of monitoring. The photopoint will then be set and reused for each monitoring period. Attach the photo to the data sheet for future reference.

**Map recording:**

It may be useful to draw a sketch map of the site indicating the extent of any problems (eg disturbance) observed on the site. This may help in identifying if tracks or weeds are encroaching. Draw the map on the back of the recording sheet.

**Check for seedlings:**

Record yes or no. Make a note, if for some reason seedlings have not been checked. On each occasion, check on the ground underneath the adult plants for seedlings.

**Identity of seedlings confirmed:**

Record yes or no.

If you find some new seedlings, tag them using numbered brass tags attached to a stick ring placed close to the eastern side of the plant (if the distance from the plant is >10cm, then record that distance). Contact NPWS Central CPPD or the National Herbarium of NSW regarding identification.

Seedlings are vulnerable to grazing from rabbits so some measures may be taken (such as grow bags or tree guards) to protect any new seedlings from harm.

**Number of new plants and their tag number:**

If you found seedlings and have tagged them with official tags then record their tag number. Record the height and stem diameter of seedlings. Identify location of new tags on the map once confirmed as *A. portuensis*.

**Tags:**

Each plant has been tagged with a small metal stake that has a small ring attached. Each ring has been punched with a number. See the site maps and the recording sheets for these numbers.

**Measurements:**

For each plant measure the following:

- ***Stem width at 15 cm*:** Measure stem width at a height of 15 cm above the ground. If there is more than one main stem - choose the largest. This measurement will give an indication of the growth rate of each the plant;
- ***# stems at base***: Count the number of stems emerging from the base (ie. from lower then 15 cm);
- ***Approximate height:*** Approximate the height of the shrub - some of them are greater than 3 m therefore it will be difficult to measure the change in height. A best guesstimate will suffice;
- ***Upright/leaning*:** The plants are either leaning or upright. Some are starting to lean. This parameter may help to estimate the health of the plants;
- ***Fruiting cones*:** This can only be done for female plants. For those with lots of cones (eg >100), estimate the number by counting the number on one main stem and extrapolating it to the whole plant (multiply by number of main stems);
- ***Flowers:*** Are there any male/female flowers present at the time of monitoring? Are they new flowers or just grey old ones;
- ***Seed released from cones?:*** Is there much visual evidence that the cones have released seed? This can be identified by open valves on the cones. Note Yes or No;
- ***Cone damage:*** Identify any evidence that the cones have been chewed by birds or mammals. Note Yes or No and if yes specify in comments section what may have caused damage;
- ***Other comments:*** Note anything of interest about the plant, including anything which may be indicative of the health of the plants.

Make sure that the last recording page is photocopied before commencing the next monitoring episode.

A data sheet for monthly monitoring of plantings (as per action 14.3.2) is provided in Attachment 2. This monitoring will be undertaken only after all surveys have been completed, habitat restored and translocations successfully established.

# Attachment 1: Allocasuarina portuensis Monitoring Sheet 1

**(six monthly intervals July and January)**

**Site 1 (original habitat)**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish etc) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Y461 | | | | | | | | | | |
| Y467 | | | | | | | | | | |
| Y466 | | | | | | | | | | |
| Z433 | | | | | | | | | | |
| Y468 | | | | | | | | | | |
| Y458 | | | | | | | | | | |
| Y471 | | | | | | | | | | |
| Y470 | | | | | | | | | | |
| D043 | | | | | | | | | | |
| Z235 | | | | | | | | | | |
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# *Allocasuarina portuensis* Monitoring Sheet 1

**(six monthly intervals July and January)**

**Site 2 (Behind workshop)**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Y451 | | | | | | | | | | |
| Y456 | | | | | | | | | | |
| Y452 | | | | | | | | | | |
| Z210 | | | | | | | | | | |
| Y469 | | | | | | | | | | |
| Y462 | | | | | | | | | | |
| Y453 | | | | | | | | | | |
| Y474 | | | | | | | | | | |
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# *Allocasuarina portuensis* Monitoring Sheet 1

**(six monthly intervals July and January)**

**Site 3 (Below Mt Trefle)**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Y459 | | | | | | | | | | |
| Y491 | | | | | | | | | | |
| Y493 | | | | | | | | | | |
| Y465 | | | | | | | | | | |
| Y473 | | | | | | | | | | |
| Y494 | | | | | | | | | | |
| Y492 | | | | | | | | | | |
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# *Allocasuarina portuensis* Monitoring Sheet 1
**(six monthly intervals July and January)**

**Site 4 (Below Mt Trefle in Leptospermum scrub)**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

NB: Y476, Y489, Y464, Y497, Y490, Y496, Y488, Y454, Y493, Y499, Y457 are NOT *A. portuensis*

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Y478 | | | | | | | | | | |
| Y495 | | | | | | | | | | |
| Y498 | | | | | | | | | | |
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# *Allocasuarina portuensis* Monitoring Sheet 1

**(six monthly intervals July and January)**

**Site 6 - E of Greycliffs House**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Z282 | | | | | | | | | | |
| Z220 | | | | | | | | | | |
| M100 | | | | | | | | | | |
| Z080 | | | | | | | | | | |
| M111 | | | | | | | | | | |
| Z303 | | | | | | | | | | |
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# *Allocasuarina portuensis* Monitoring Sheet 1

**(six monthly intervals July and January)**

**Site 7 - Gap Bluff below carpark**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Z428 | | | | | | | | | | |
| W133 | | | | | | | | | | |
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# *Allocasuarina portuensis* Monitoring Sheet 1

**(six monthly intervals July and January)**

**Site 8 - Gap Bluff in Bushland**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Z426 | | | | | | | | | | |
| Z284 | | | | | | | | | | |
| Z085 | | | | | | | | | | |
| Y483 | | | | | | | | | | |
| L109 | | | | | | | | | | |
| W136 | | | | | | | | | | |
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# *Allocasuarina portuensis* Monitoring Sheet 1

**(six monthly intervals July and January)**

**Site 9 - Hermitage Foreshore near Hermit point**
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....
.....

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers:
Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Z426 | | | | | | | | | | |
| Y475 | | | | | | | | | | |
| Z292 | | | | | | | | | | |
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**Attachment 2: Format for monitoring *Allocasuarina portuensis* translocation trial (monthly intervals initially)**

Site Number:
Date:
Recorder:

Notes on site condition (weeds, ground cover, canopy, tracks, rubbish) ..... .....
.....

**Translocation Details**

Number of individuals; Source of Material
Size of material; Date of Planting
Treatment of plant (watering, fertiliser, bagging to prevent rabbit damage)

Photopoint (Photo attached) Map recording (draw on back) Checked for seedlings: Y/N
Number of new plants and their tag numbers: Identity of seedlings confirmed with herbarium? Y/N

| Tag number | Stem width at 15 cm | # stems at base | approx. height | upright/ leaning? | evidence of dieback | # fruiting cones | flowers present | seed released from cones (yes/no) | cone damage (yes/no) | other comments |
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