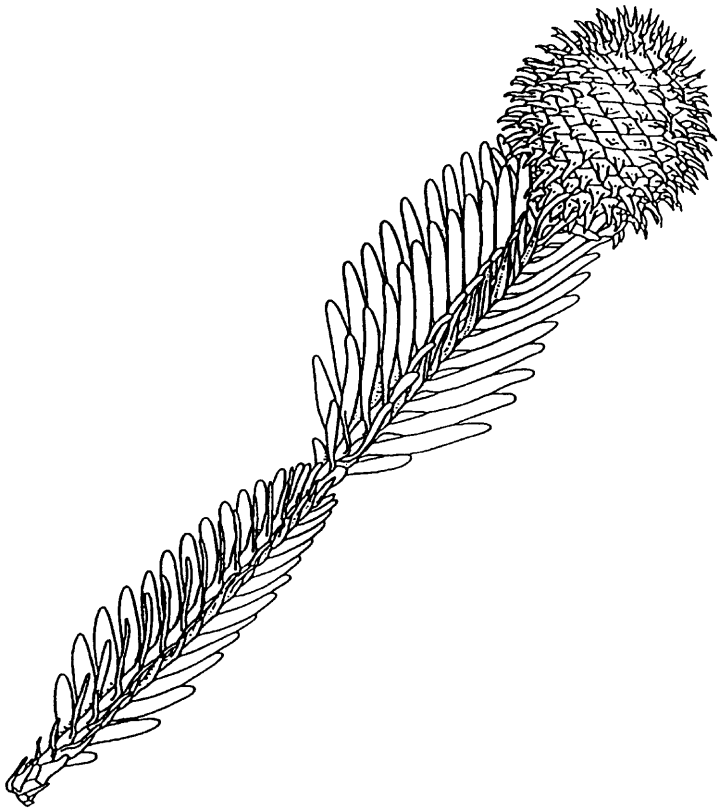
Recovery Plan Number 1

Wollemi Pine (*Wollemia nobilis*) Recovery Plan



September 1998

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Wollemi Pine (*Wollemia nobilis*) Recovery Plan

Prepared in accordance with the New South Wales
Threatened Species Conservation Act 1995

September 1998

Acknowledgments

The research into, and management of, the Wollemi Pine has been a joint effort of the NSW National Parks and Wildlife Service (NPWS) and the Royal Botanic Gardens, Sydney (RBG). This Recovery Plan has been the combined effort of many people who have contributed to the survey and research on the species. The NPWS would like to thank the following people;

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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 for conserving and recovering 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 draft 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 communities and to ensure its ongoing viability in nature.

The Wollemi Pine Recovery Plan is the first recovery plan approved under the TSC Act. This plan describes our current understanding of the Wollemi Pine, documents the research and management actions undertaken to date, and identifies the actions required and parties responsible for ensuring the ongoing viability of the species in the wild.

The Wollemi Pine represents a whole new genus belonging to an ancient family, the Araucariaceae. The discovery of the Wollemi Pine has generated enormous scientific and community interest throughout Australia and internationally due to the Pine's uniqueness, taxonomic significance and its aesthetic appeal.

The preparation of the Wollemi Pine Recovery Plan has been a joint effort of the NSW National Parks and Wildlife Service and the Royal Botanic Gardens and has been assisted by many people. I thank these people for their efforts to date and I look forward to their continued success.

Executive Summary

Introduction

The Wollemi Pine (*Wollemia nobilis* W.G. Jones, K.D. Hill & J.M. Allen) was discovered in Wollemi National Park in 1994 by David Noble, an officer of the NSW National Parks and Wildlife Service (NPWS). It represents a whole new genus belonging to an ancient family, the Araucariaceae (Jones *et al*. 1995).

This Recovery Plan describes our current understanding of the Wollemi Pine, documents the research and management actions undertaken to date, and identifies the actions required and parties responsible for ensuring the ongoing viability of the species in the wild.

Legislative context

The *Threatened Species Conservation Act* 1995 (TSC Act) is NSW's most comprehensive attempt at establishing a 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, which was established to discuss and resolve 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 was accurate to the best of the NPWS' knowledge on the date it was approved.

A draft of this Recovery Plan was placed on public exhibition from 7 July 1997 to 25 August 1997. Five 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 5 years from the date of publication.

Current species status

The Wollemi Pine is currently known from two sites consisting of a total of approximately 40 adult plants and 200 seedlings. The populations are separated by about 1 km in Wollemi National Park on the Central Tablelands of NSW.

The Wollemi Pine is considered endangered in NSW and is listed on Schedule 1 of the TSC Act. The directory of Rare or Threatened Australian Plants (RoTAP) also lists the species as endangered with a geographic range in Australia of less than 100 km and with its total population in reserve (Briggs and Leigh 1996). Populations within Wollemi National Park are potentially threatened by the introduction of pathogens, collectors and catastrophic fire events.

Recovery objectives

The overall objective of this Recovery Plan is to protect the known populations of the Wollemi Pine from decline induced by non-natural sources and to ensure that the wild populations of the Wollemi Pine remain viable in the long term.

Specific objectives of this Recovery Plan are to:

- protect and maintain the known populations and their habitat from human-induced threatening processes in the long term;
- understand the ecology of the species;
- determine the range of genetic variability of the known populations;
- establish representative *ex situ* populations in botanic gardens; and
- determine if further wild populations exist and to protect any new populations and their habitat.

Recovery criteria

Recovery criteria are that:

- wild populations do not suffer any net reduction in individuals due to human-induced causes;
- analysis of genetic variability of the wild populations is undertaken;
- genetically representative ex situ populations exist within botanic gardens; and
- wild populations are protected by appropriate mechanisms.

Recovery actions

Recovery actions will be directed towards:

- implementing a management program which ensures the security of populations in the wild;
- undertaking a program of ecological monitoring of known wild populations;
- undertaking a program of genetic variability analysis;
- establishing genetically representative ex situ collections within suitable botanic gardens; and
- systematically surveying likely habitat to locate any new populations.

Biodiversity benefits

The discovery of the Wollemi Pine highlights the importance of habitat conservation and the integral role that national parks play in the conservation of biodiversity. It also shows the importance of conserving areas of diverse vegetation types. The conservation and study of the Wollemi Pine will also benefit other species which share the same habitat.

Through awareness of the Wollemi Pine the profile of all threatened species is raised in the general community. This in turn leads to greater opportunities for the conservation of threatened species and increased protection of biodiversity.

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1 Current conservation status

The Wollemi Pine (*Wollemia nobilis* W.G. Jones, K.D. Hill & J.M. Allen) of the family Araucariaceae is currently known from two populations consisting of approximately 40 adult plants and about 200 juveniles/seedlings from within the Wollemi National Park. It is assumed that the current population of the Wollemi Pine has been relatively static over hundreds to thousands of years but may be in a very slow state of decline due to natural factors.

The Wollemi Pine is considered endangered in NSW and is listed on Schedule 1 of the *Threatened Species Conservation Act 1995* (TSC Act). The Wollemi Pine is also listed as endangered at the national level under the *Endangered Species Protection Act 1992* (ESP Act). The directory of Rare or Threatened Australian Plants (RoTAP) lists the species as endangered with a geographic range in Australia of less than 100 km^2 and with its total population in reserve (Briggs and Leigh 1996). Populations within Wollemi National Park are potentially threatened by the introduction of pathogens, collectors and catastrophic fire events.

2 Description

2.1 Taxonomic description

The Wollemi Pine is a monoecious tree which grows to 40 metres, frequently coppicing from the base (Figure 1). Trunks range up to 1.2 m in diameter and are broadest at about one-third the height of the tree. The crown is slender and columnar. The bark peels in thin, fragile, equidimensional dark red-brown scales on younger stems. On older trunks the bark becomes densely covered with soft and spongy nodules or tubercules to 10 mm diameter and 15 mm long which form a layer up to 20 mm deep (Jones et al. 1995). Successive whorls of primary branches arise from the vertical shoot. Subsidiary branches in older trees grow from epicormic shoots that develop from the trunk where lateral branches have fallen (Jones *et al.* 1995).

The adult lateral branches grow for three to eight years before being terminated by a male or female cone (strobili). Female cones are borne on branches above male cones. After bearing cones the tree sheds the branches at the basal abscission zone (Hill 1995).

There are three different kinds of shoots or branches produced according to the age and position of the branches. These are:

- adult vertically growing shoots (orthotropic), which have a helical arrangement of leaves. The leaves taper to an acute angle at the tip, have a sharp point, are narrowly triangular and 3-10 mm long and 2-4 mm wide at the base (Figure 2a);

- juvenile and lower canopy lateral shoots, which are horizontal, with leaves arranged in two opposite ranks. The leaves are twisted with the upper surface towards the sky and are linear to narrow triangular (Figure 2b);

- adult lateral shoots (plagiotropic), which are initially nearly vertical then become horizontal and later pendulous. Leaves are opposite or sub-opposite and present the upper surface to the sky (Figure 2c).

Seeds are flat, brown and papery with a single circumferential wing. Seeds are 7-11 mm long and 5-7 mm wide, and 5-9 mm wide with the wing (Jones *et al.* 1995) (Figure 3).

2.2 Taxonomic significance

Wollemia is a monotypic genus with only a single species known. The Wollemi Pine is of considerable significance in the study of the evolutionary relationships of early flora on the Gondwana continent. *Wollemia* is a new genus in the family Araucariaceae, and although it possesses morphological characteristics from the related genera *Agathis* and *Araucaria*, it also possesses unique features (Hill 1995). The evolutionary relationships within the Araucariaceae are unknown. There are no other species of *Wollemia*, either fossil or extant, and it is not possible to make any definitive statements at this stage. (K. Hill pers. comm.). One suggestion of the evolutionary relationships of the species is shown in Figure 4.

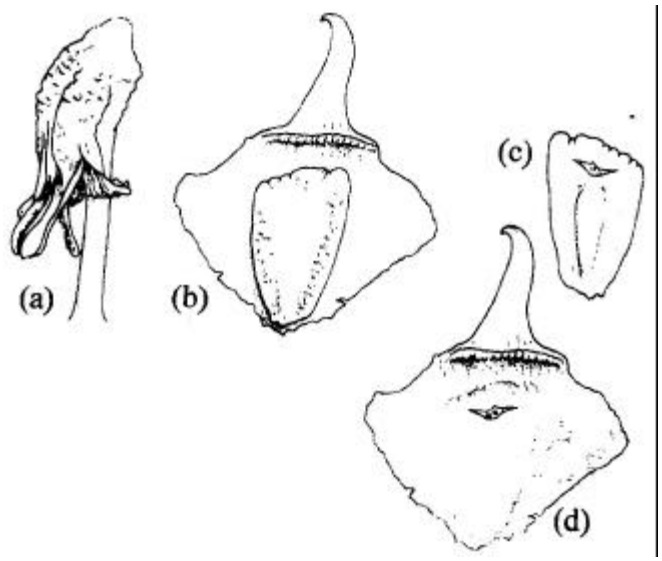
Figure 1. Habit of the Wollemi Pine (Photo Jaime Plaza)

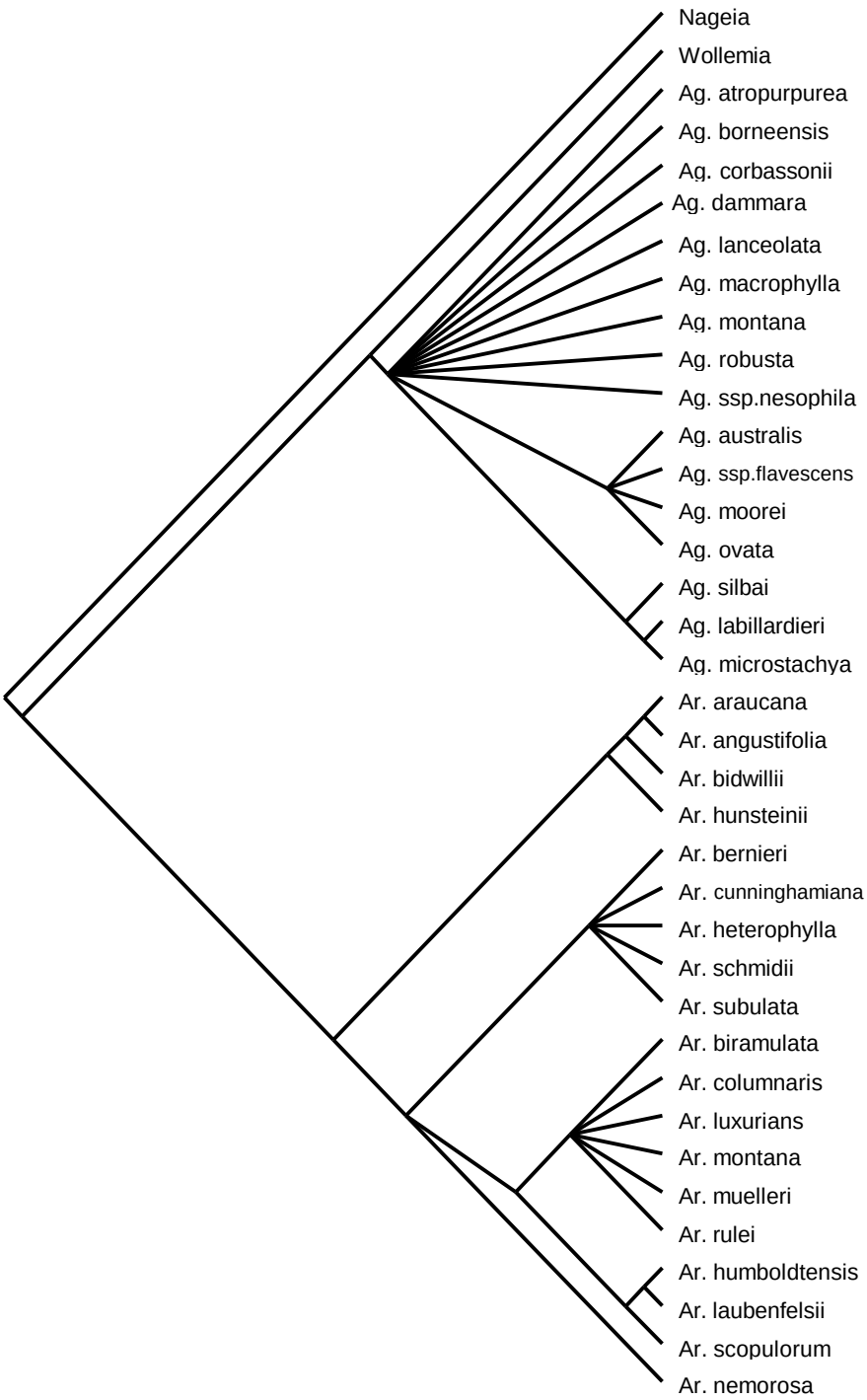
Figure 2a. Foliage of the Wollemi Pine - adultorthotropic (Photo Jaime Plaza)

Figure 2b. Foliage of the Wollemi Pine - juvenileplagiotropic (Photo Jaime Plaza)

Figure 2c. Foliage of the Wollemi Pine - adult plagiotropic (Photo Jaime Plaza)

Figure 3. Reproductive parts of the Wollemi Pine (Drawing by D. Mackay)
(a) microsporophyll, (b) female bract-scale complex with attached seed, (c) seed, (d) female bract-scale complex with seed detached.





Ag. = *Agathis*
Ar. = *Araucaria*

Figure 4. Evolutionary relationships of the Wollemi Pine (K. Hill pers. comm.)

3 Distribution

3.1 Current and historical distribution

The Wollemi Pine is a relict species currently known to occur in only two sites located about 1 km apart in Wollemi National Park on the Central Tablelands of New South Wales in south eastern Australia. (See Figure 5). The known sites (referred to as Site 1 and Site 2) are located in a deep sandstone gorge. The gorge walls are composed of Triassic sandstones from the Narrabeen Group.

Evidence suggests that major gymnospermous forests or woodland strata were once widespread in Australia, and Araucariaceae fossils have been found in every Australian state from the Tertiary period (Lange 1982). Studies of pollen deposits in north Queensland show a sharp and sustained decline in *Araucaria* forest and a concomitant increase in sclerophyll vegetation from 130 000 years BP to the present (Sluiter and Kershaw 1982). A decline in the distribution of *Araucaria* species appears to have taken place over millions of years through natural causes such as major climate changes, the evolution and dominance of the environment by angiosperms, and a probable severe reduction in numbers as a result of increasing fire frequency. Fire frequency over the last 130 000 years has greatly increased and this is suspected to be caused by human interference rather than climate change (Singh 1982). The distribution of the Wollemi Pine may have undergone a decline similar to that of other species of Araucariaceae. Its distribution is now an area of less than 1 hectare.

The Araucariaceae had a world-wide distribution in the Cretaceous. Fossil representation of the family is known from the Triassic period (c.200 million years BP). The distribution of the Araucariaceae contracted at the end of the Cretaceous (c.65 million years BP) when the species became extinct in the northern hemisphere. The genera in the southern hemisphere have slowly declined in distribution and diversity since that time (Hill 1995). Palaeobotanical analysis indicates that the pollen of the Wollemi Pine is similar to the fossil pollen of the species *Dillwynites,* which is known from the late Cretaceous (c.91 million years BP) (MacPhail *et al.* 1995). There is no conclusive fossil evidence to indicate when the Wollemi Pine evolved. It has a number of advanced morphological features, but its pollen matches that of more ancient species (Benson 1996). There is no evidence indicating knowledge of the Wollemi Pine in more recent times from either Aboriginal or European historic sources (W. Jones pers. comm.).

3.2 Tenure

The known populations of the Wollemi Pine occur within Wollemi National Park, which is managed by the NPWS. The security of this National Park tenure is governed by the provisions of the *National Parks and Wildlife Act, 1974* (NPW Act). The land is zoned 8a - National Park.

4 Ecology

4.1 Habit, growth rate and longevity

The typical form of the Wollemi Pine in the wild is a tall long-lived tree which has a coppicing habit (see Figure 6). Mature trees are usually multi-trunked with up to 100 stems of various size (Offord 1996). The habit of coppicing makes it difficult to identify which trunks represent an individual tree. The height of the largest trees are 25 to 40 metres (W. Jones, J. Allen, field obs.). When the primary branches have been shed from the trunk (after they have borne mature strobili), the trunk produces epicormic shoots with a juvenile leaf arrangement which create a second crown. These shoots eventually become mature branches and mature trees may have a branched crown (Hill 1995).

Adult trees have been observed to increase by one additional growth unit (referred to as stem segments) per year from orthotropic shoots (vertical growing shoots), and no more than one segment from plagiotropic reproductive shoots (lateral growing shoots) (C. Offord pers. comm.). The nature of the multi-trunk habit makes it difficult to measure growth rate in the short term.

Extrapolation from ring counts of a broken branch of 90 mm diameter indicates that the largest living trunks may be about 500 years old (J. Benson pers. comm.). Extrapolation from the fallen trunks of some of these trees indicate that the trees may be much older (W. Jones, J. Allen, field obs.). The current cohort of mature trees may have occupied its current site for more than 1 000 years.

4.2 Phenology

The Wollemi Pine is a monoecious species with the reproductive organs borne on specialised leaves called sporophylls. These are arranged in cones or cone-like structures called strobili (Harden 1990). The male strobili (Figure 7a) are located at the end of lateral growing shoots and are 109 mm long and 19 mm wide. The small dark red-brown scales of the male strobili are numerous (more than 500) and are helically arranged. Each has 4-9 elongated, drooping microsporangia in which the oval-shaped, granular, unwinged pollen is formed.

Female strobili (Figure 7b) are located at the end of leafy adult lateral growing (plagiotropic) shoots and are usually borne on ascending branches above the male strobili. They are globular to broadly egg-shaped, measuring up to 125 mm long and 100 mm in diameter. Each strobili has numerous bract-scales (between 250-300) flattened with a lateral wing. The female strobili are mid-green at first and then become brown and shed their individual bract-scales at maturity (Jones *et al.* 1995, C. Offord pers. comm.).

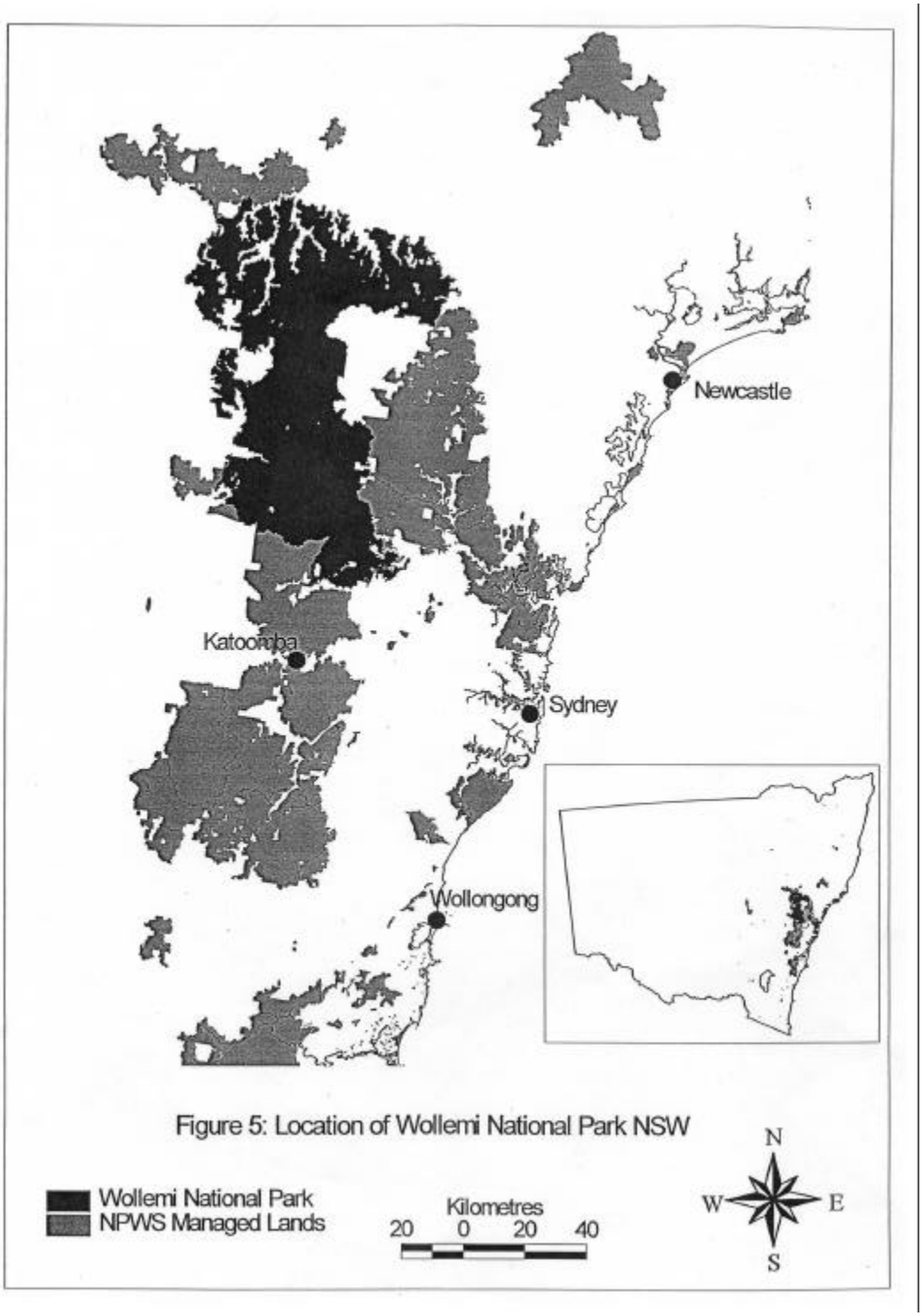


Figure 5. Location of Wollemi National Park, New South Wales

Figure 6. Coppicing habit of the Wollemi Pine (Photo Jaime Plaza)

Figure 7a. Male strobili of the Wollemi Pine (Photo Jaime Plaza)

Figure 7b. Female strobili of the Wollemi Pine (Photo Jaime Plaza)

4.3 Reproductive biology

4.3.1 Vegetative reproduction

The Wollemi Pine may be a clonal species. All but one of the adult trees appear to have a multi-trunked habit in the wild (W. Jones, J. Allen, field obs.). Vegetative reproduction occurs through rudimentary buds which are carried in the axils of leading vertical shoots. Initially, these buds can replace the leading shoot if it is damaged. If they do not replace the leading shoot they become buried under the thickening bark. These buds may remain dormant for long periods of time until they sprout from older trunks or from the base of the trunks (Hill 1995). This coppicing leads to a number of trunks of various ages in a mature tree. In the wild, most trunks arise from a common base but some may derive from a suckering of larger roots. Trunks have also developed from the epicormic shoots of fallen branches (W. Jones, J. Allen, field obs.).

4.3.2 Breeding system

The Wollemi Pine is probably wind-pollinated like other members of the Araucariaceae. Field observation indicates that only the largest (oldest) trunks on any one plant reproduce sexually. Secondary branching of the larger trunks appears to have created large side branches which also reproduce sexually (W. Jones, J. Allen, field obs.).

4.3.3 Fruiting

Observation in the field suggests that production of female strobili may occur year round at Site 1. Three ages of female strobili have been observed to occur at one time on the most fecund trees at this site. In contrast to Site 1, only one age of strobili has been recorded at any time on the trees at Site 2. Male strobili production is seasonal, with maturation occurring in late September and early October. The male strobili shed their pollen by late spring and early summer (November/December) (W. Jones, J. Allen, field obs.).

4.3.4 Seed production

After fertilisation the seed develops on the bract-scale of the female strobili and the seed and bract-scale are shed from the strobili at maturation (Jones *et al.* 1995). Seed is persistent in the canopy and most probably matures in autumn (C. Offord pers. comm.). At Site 1, trees have been observed to drop small amounts of seed almost year round although the main period of seed shed is late summer to early autumn (W. Jones, J. Allen, field obs.). Approximately 300 strobili matured and dropped seed in the 1996 season and produced an estimated 4000 seeds (Offord *et al*. 1996).

4.3.5 Seed viability and germination factors

Field observations of wild seedlings indicate germination of seed *in situ* (W. Jones, J. Allen, field obs.). Initial research into seed biology indicates that the number of viable seeds set is low (5%) (Offord 1996). Results of germination trials have confirmed that it is possible to judge germinable seed by eye (C. Offord pers. comm.). A high percentage germinability of all seed deemed viable (over 90%) has been obtained at 24°C by day, using a limited number of seeds and seed cones, but there is a considerable lag period (Figure 8) (C. Offord pers. comm.).

Optimal germination occurred between 25 and 30°C. Better rates of germination may be obtained by a period of stratification (C. Offord pers. comm.). Early findings suggest that seeds germinate steadily after a period of less than six months in storage and that there may be a short dormancy period which varies widely between seeds (C. Offord pers. comm.).

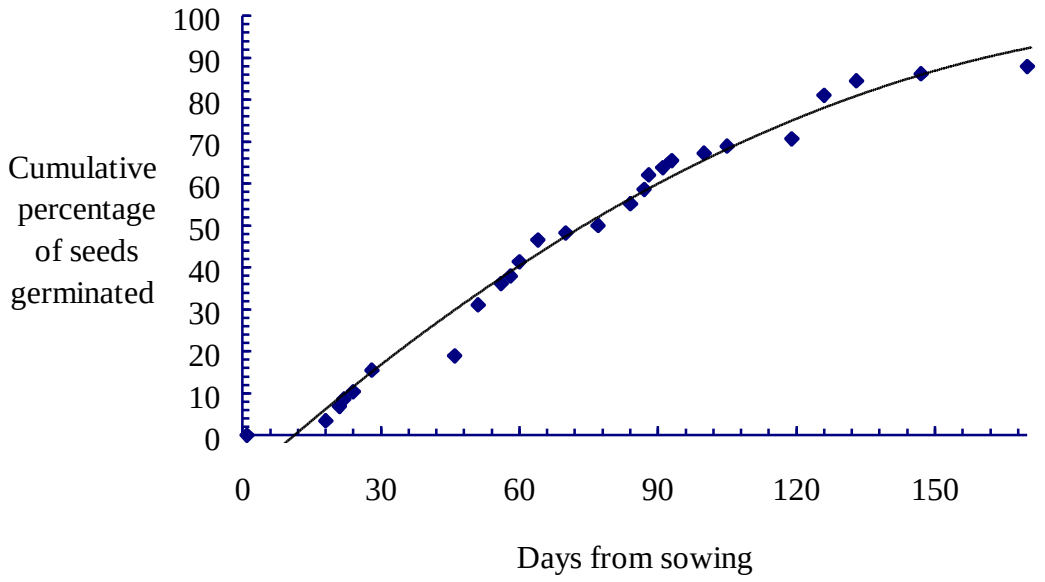


Figure 8. Germination (%) of the Wollemi Pine seed at 24°C day and 16°C at night (C. Offord pers. comm.)

4.3.6 Seed dispersal and seedling establishment

Seeds of the Wollemi Pine are light and winged and it is most probable that they are dispersed by wind. Aerial dispersal appears to be in a down-canyon direction as the seedlings occur up to 30 metres downslope of the nearest tree but do not occur upslope.

Seedlings have been identified in the wild population by the presence on the plants of cotyledons and cotyledon scars. They occur in the wild on a variety of substrates including rocks, logs, tree ferns and in the soil litter layer (W. Jones, J. Allen, field obs.). Seedling recruitment in the wild may be adversely affected by the extremely low pH of the soil and interactions with other factors such as low light availability. This will be examined by *ex situ* experimentation on seedlings (Offord *et al*. 1996).

4.3.7 Seedling growth

Growth of seedlings in the wild appears to be very slow (W. Jones, field obs.). An estimate of the growth rate of seedlings in the wild will be more reliable after their growth is recorded for a minimum of 5 years. From current observations they appear to increase by more than one growth segment per year, but this may depend on the site and season of germination (W. Jones field obs.). In cultivation growth is much faster. Two-year-old cultivated seedlings are nearly 1 m tall. Although mycorrhizal associations have been identified (B. Summerell pers. comm.), as yet no mycorrhizal association appears necessary for seedling growth and survival (C. Offord pers. comm).

4.4 Population structure

In all, there are approximately 40 adult plants and about 200 juveniles. Figure 9 shows the size distribution of the trees and seedlings within the population in the main gorge at Site 1. Adult trees may have up to 100 trunks (Offord 1996) which vary in diameter from a few centimetres to over 1 metre. The diameters of trunks show a highly skewed distribution with very few trunks between 25 mm and 200 mm (W. Jones, J. Allen, field data). This may indicate that the stands are slow in replacing cohorts of mature, cone-bearing trees or that at some time in the past a recruitment event occurred which has led to the population consisting of similar aged individuals. Alternatively, conditions may not have been favourable in the recent past for the establishment of new individuals.

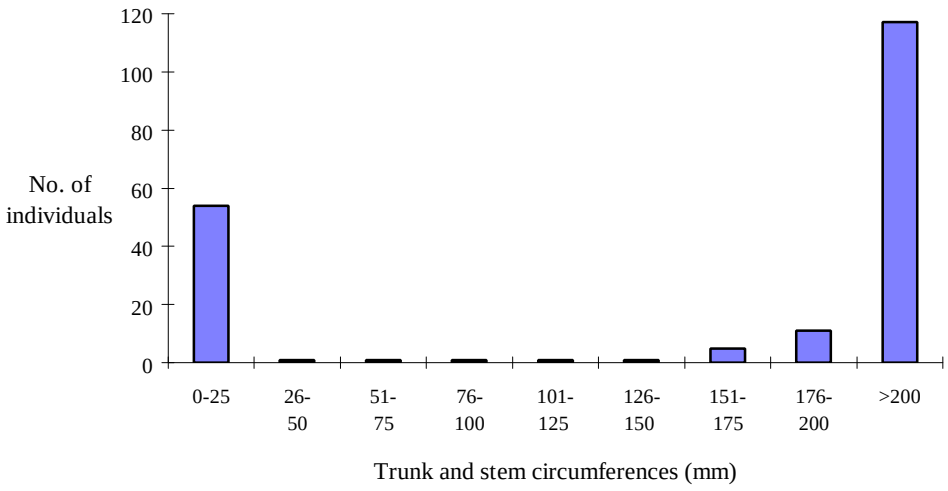


Figure 9: Size distribution of trees and seedlings at Site 1

All non-reproductive plants in the population which are below 3m in height and not identifiable as seedlings by the presence of cotyledons or cotyledon scars have been classified as juveniles. As the Wollemi Pine may be a clonal species, some of the plants classed as juveniles may in fact be suckers. Excavation of these plants and genetic analysis of these stems is necessary to determine their status. At Site 2 where there are fewer juveniles this class constitutes a smaller proportion of the total population than at Site 1. However this may be due to lack of survey as not all the potential areas for seedling establishment at Site 2 have yet been surveyed (W. Jones, J. Allen, field obs.).

5 Disturbance

5.1 Fire

The response of the Wollemi Pine to fire is unknown. It is assumed that intense fires will kill individuals of the Wollemi Pine and that catastrophic fire is a threat to the known populations. However, the population at Site 1 on the eastern side of the gorge has been exposed to a fire event in the past as evidenced by fire scars on the pines and a dead *Eucalyptus piperita* (Sydney Peppermint) on the eastern gorge wall (W. Jones, J. Allen, field obs.). An appropriate disturbance regime may be required to ensure the long-term viability of populations in the wild. Further *in situ* monitoring is required to assist with providing information on the role of fire in the survival of the Wollemi Pine.

5.2 Drought

The Wollemi Pine is restricted to specialised habitats in rainforest communities in deep sandstone gorges. These wet micro-habitats act as refugia for species which are not tolerant to drought or to high fire frequencies because they are sheltered from the hot, dry, fire-prone conditions of the surrounding forest and woodland. Conditions within these microhabitats have enabled the Wollemi Pine to survive and to share the habitat with other canopy species, particularly coachwood and eucalypt species. A regime of disturbance is operating within this habitat. It appears to consist of major events over a long time frame such as catastrophic events (fire events and rock falls) and individual tree deaths, which produce the canopy gaps that may be necessary for successful regeneration. More research is required before the precise nature of this disturbance regime is known (J. Benson pers. comm.).

5.3 Seed predation

Birds, mainly Crimson Rosellas (*Platycercus elegans*), have a significant impact on seed fall. Crimson rosellas have been observed in the field grazing along the leafy branches and disturbing the shattered strobili. Many seed coats falling into the seed traps have been neatly split and the contents removed. Rodent or marsupial toothmarks have also been found on viable looking seed. Predation from these sources appears to destroy at least 37% of putative viable seed (C. Offord pers. comm.).

6 Habitat

6.1 Vegetation

The Wollemi Pine occurs in the warm temperate rainforest and rainforest margins in a *Eucalyptus* spp. forest/woodland complex within the Sydney Sandstone Biome of the eastern coast and tablelands of New South Wales (Floyd 1984). This warm temperate rainforest habitat is dominated by coachwood *Ceratopetalum apetalum* and sassafras *Doryphora sassafras*. Most individuals of the Wollemi Pine occur on large ledges or are inserted in crevices in the cliffs. Species recorded in the vicinity of the Wollemi Pine are listed in Table 1.

Scientific Name	Common Name	Scientific Name	Common Name
Canopy Species		**Understorey Species**	
Ceratopetalum apetalum	Coachwood	*Dicksonia antarctica*	Soft tree fern
Doryphora sassafras	Sassafras	*Cyathea australis*	Rough tree fern
Acmena smithii	Lily pilly	*Eupomatia laurina*	Bolwarra
Quintinia sieberi	Possumwood	*Lepidosperma urophorum*	Sword sedge
		Sticherus flabellatus	Umbrella fern
		Todea barbara	King fern
Adjacent species		*Cissus hypoglauca*	Water vine
		Clematis aristata	Clematis
Eucalyptus piperita	Sydney peppermint	*Pandorea pandorana*	Wonga Vine
Angophora floribunda	Rough barked apple	*Parsonsia straminea*	Silkpod
E. punctata	Grey Gum		

(*W. Jones field obs.)

Table 1: Species recorded in the vicinity of the Wollemi Pine*

6.2 Soil characteristics

Soils are sandstone-derived boulder alluvium, with high organic matter, some shale component and a substantial basalt wash from the higher reaches of small tributary canyons (Jones *et al*. 1995). The soil is very shallow. In some areas there is little or no soil layer. Roots of the Wollemi Pine plants grow into rock fissures or extend for tens of metres away from the main groups of trunks. The soil has a poor structure and appears to have water-repelling qualities. Levels of nutrient are low and the soil is extremely acidic, often in the range 3-4 pH, with low levels of most elements although high in aluminium, sulphate and iron. There are patches of highly saline soil. Salt probably leaches from the parent material (Offord *et al*. 1996, C. Offord pers. comm.) (See Table 2).

Senescent branches fall and contribute substantially to the litter layer (Hill 1995). Decomposition of these fallen branches may contribute to the low pH of the soil and this acidity and lack of nutrients may contribute to the slow growth of mature trees and seedlings (Offord *et al.*1996).

Characteristic	**Range**	**Interpretation**
pH(inH_20)	3.8-4.6	strongly-extremely acidic
pH(in CaC12)	2.9-4.2	strongly - extremely acidic
Electrical Conductivity	0.1-1.9 mS/cm	low-highly saline
Sodium	0.0-0.14 meq%	good
Potassium	0.15-0.8 meq%	low-good
Calcium	0.3-2.9 meq%	very low - marginally good
Magnesium	0.5-2.24 meq%	low-high
Aluminium	0.1-4.9 meq%	trace-very high
Phosphorus	0-3.3 mg/kg	none - low
Ammonium	10-42 mg/kg	low
Nitrate	0.1-20.7 mg/kg	low-good
Iron	179-357 mg/kg	high - good
Sulphate	73-176 mg/kg	high - good
Zinc	1.6-2.6 mg/kg	low
Copper	0.6-2.3 mg/kg	low
Maganese	1.1-7.7 mg/kg	low

Table 2: Soil chemical characteristics of the Wollemi Pine at Site 1[1]

[1] Seven areas across the site were tested and fall within the range presented. Each characteristic is interpreted in terms of requirements for normal plant growth

6.3 Light intensity

Field recordings show that light on the canyon floor at Site 1 is very low, with less than 10% ambient light. Due to their orientation both Wollemi Pine sites receive only limited light at most times of the year. The amount of available light is further reduced at Site 1 by shading from competing flowering trees. Site 2 receives even less light than Site 1 due to aspect and the narrowness of the canyon. Some areas of Site 1 receive direct light in the middle of the day for a very short time, possibly less than one hour (Offord *et al*. 1996).

7 Relevant legislation

7.1 State and Commonwealth listing

Due to its small population size and restricted distribution, the Wollemi Pine is considered endangered in NSW and is listed on Schedule 1 of the TSC Act.

The Wollemi Pine is also 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 compiled by the Australian and New Zealand Environment Conservation Council. As a nationally listed species the Wollemi Pine is eligible for funding under the federal Endangered Species Program and is protected under Commonwealth legislation.

7.2 Recovery plan preparation and implementation

7.2.1 Recovery plan preparation

The TSC Act requires that the Director-General of National Parks and Wildlife 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.

A draft version of this plan was placed on public exhibition from 7 July 1997 to 25 August 1997. Five public submissions were received and subsequently considered by the NPWS and the Wollemi Pine Recovery Team. The comments of the Scientific Committee on the draft plan were considered in the finalisation of this plan. Amendments were made to the draft plan, where necessary, as a consequence of these submissions.

7.2.2 Recovery plan implementation

The TSC Act requires that a government agency must not undertake actions inconsistent with a 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 the Wollemi Pine within Wollemi National Park in accordance with this plan. Relevant land management issues include fire management and visitor access. Likewise, the RBG must undertake research in accordance with the priorities identified in this plan and subject to the controls outlined in this plan (eg the site hygiene protocols).

7.3 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 action is

specifically exempted by TSC Act) and a species impact statement is mandatory for all developments and activities proposed within critical habitat.

To date, critical habitat has not been declared for this species under the TSC Act. The identification of critical habitat is not considered to be a priority for this species as all known populations occur within a National Park and no demonstrable conservation outcome would accompany identification and declaration.

7.4 Environmental assessment

The TSC Act amendments to the environmental assessment provisions of the *Environmental Planning and Assessment Act 1979* (EP&A Act) require that consent and determining authorities consider relevant recovery plans when exercising a decision-making function under Parts 4 & 5 of the EP&A Act. As it is highly unlikely that new populations of the Wollemi Pine will be discovered outside Wollemi National Park, the only relevant determining authority for this plan is the NPWS. The NPWS, when considering any activity in Wollemi National Park which may affect the Wollemi Pine, must consider the conservation strategy outlined in this plan.

8 Management issues

8.1 Threats and reasons for decline

The Wollemi Pine may have been in a state of slow natural decline over hundreds of thousands of years and is now a relict species. The Wollemi Pine is considered to be an endangered species due to its extremely restricted distribution (1 km), the possibility of a very restricted number of genetic individuals, its seemingly slow rate of recruitment of new genetic individuals, its low level of seed set and the long time before sexual maturity. The species is considered to be threatened by unauthorised seed collection (this may impede the long-term replacement of reproductive plants and cause a loss of genetic diversity), catastrophic fire events, the introduction of pathogens, especially fungal species such as *Phytophthora cinnamomi,* and other impacts from unauthorised site visits such as trampling of seedlings, compaction of soil and the introduction of weeds.

8.2 Social and economic consequences

8.2.1 Intrinsic ecological value

The Wollemi Pine has the same right of existence as any other native species. It is likely that the species plays a crucial role in the ecology of its habitat and of the other species which may depend on it for any ecological function such as host, food or shelter. The discovery of the Wollemi Pine highlights the importance of conserving areas of undisturbed habitat which are large and diverse enough to provide species with opportunities for refuge from threatening processes and to allow evolutionary processes to occur in a geological time scale.

8.2.2 Scientific and taxonomic value

To the scientific community the Wollemi Pine is of very high scientific value as it is the sole living representative of an ancient genus which has survived to the present day. Study of this species will enable scientists to gain knowledge about the evolutionary relationships between species in the Araucariaceae and to get an insight into an ancient species which until now were known only from fossils.

8.2.3 Biodiversity value

As a monotypic genus the genetic diversity within this species constitutes the full genetic range of the genus. Therefore each genetic individual plays a key role in the future evolution of the genus. The microflora and other species associated with the microhabitats provided by the species are important and unique components of the biodiversity of Wollemi National Park and New South Wales and, indeed, the Australian continent.

8.2.4 Pharmaceutical value

The chemical properties of the Wollemi Pine and the microflora associated with it are unknown. Some preliminary work has been done on extracting a chemical named Taxol, which is a known anti-cancer agent. Future harvesting of the Wollemi Pine for chemical extraction is a possibility.

8.2.5 Social benefits

The species belongs to all people and as the known locations are protected within a National Park there is no cost incurred by private landholders in the management of the Wollemi Pine. *In situ* management costs are minimal and are borne by the whole community through the NPWS. The RBG will provide opportunities for the public to view the species by establishing groves in its gardens. All people will, therefore, benefit from the research and management of this species and future generations will continue to enjoy these benefits. Through awareness of the Wollemi Pine the profile of all threatened species is raised in the general community. This in turn leads to greater opportunities for the conservation of threatened species and increased protection of biodiversity.

8.2.6 Commercial value

The Wollemi Pine may be of immense horticultural value as both a rare and an attractive species (C. Offord, pers. comm.). There is potential for the commercial propagation of the Wollemi Pine to generate significant revenue. Revenue raised from the commercialisation of the Wollemi Pine will be directed to fund research into the Wollemi Pine and other threatened species. Commercialisation will allow members of the public to own a specimen of the Wollemi Pine with no threat to the wild populations. Tourism opportunities will be created through groves in botanic gardens and various installations such as "The Edge" theatre at Katoomba in the Blue Mountains of NSW. Opportunities to increase awareness of other threatened species are available through the sale of film, books and other merchandise about the Wollemi Pine and its habitat.

8.3 Biodiversity benefits

The discovery of the Wollemi Pine highlights the importance of habitat conservation and the integral role that national parks play in the conservation of biodiversity. It also shows the importance of conserving areas of diverse vegetation types. It outlines the crucial role that rainforests play in the environment in providing a relatively stable habitat through periods of great changes in other habitats. The rainforest habitat of the Wollemi Pine has provided a refuge for the species during the great climatic changes experienced in Australia (Hill 1995).

The conservation and study of the Wollemi Pine will also benefit the other species which share the same habitat. Field studies so far have resulted in the collection of a number of invertebrates from the seed traps and these have been passed on to the Australian Museum for identification. Several species of fungi have been collected

from the Wollemi Pine plants and from the soil and litter adjacent to the trees. These species and their relationship to the Wollemi Pine and its habitat are undergoing further research (Offord *et al*. 1996).

9 Previous actions undertaken

9.1 Wollemi Pine Recovery Team

The Wollemi Pine Conservation Team was convened by the NPWS and the RBG in 1994 to oversee the interim research and management of the Wollemi Pine. With the passing of the TSC Act and the legislative need for a recovery plan, the Wollemi Pine Recovery Team was formed to oversee the initial investigations (see below) and guide the NPWS preparation of the recovery plan.

9.2 Wollemi Pine Access Strategy

The RBG and NPWS have adhered to a policy of highly restricted access to the site for both staff and the public in an effort to minimise any risk to the *in situ* population. The Wollemi Pine Access Strategy outlines the protocols for site access and restricts access only to people authorised by the NPWS. These measures will be further codified in the Wollemi National Park Plan of Management (in prep.) and the Wollemi National Park Fire Management Plan (in prep.)

The location of the pines is to be kept secret, with only essential staff being made aware of the location of the natural population. Official visits to the sites for research purposes have also been monitored by the Wollemi Pine Recovery Team. Only essential on-site work has been authorised and all officer visits must be approved. Impact on the sites is minimised by programming the use of walking routes. Recording of the use of the routes will enable assessment of the impact of visitation in the future.

9.3 Wollemi Pine Community Relations Strategy

A draft community relations strategy has been developed by the NPWS. All community relations initiatives are linked to key management objectives. The major objectives of the strategy are to:

- discourage the general public and special interest groups from trying to find and visit the site within Wollemi National Park; and
- increase community awareness of the Wollemi Pine in an effort to encourage community support for the protection of the site and for research into the species.

A number of actions in the community relations strategy have already been undertaken, such as the production of a poster, contact with key park neighbours and regular media updates.

9.4 Site Hygiene Protocol

A threat to the known populations of the Wollemi Pine is the introduction to the site of pathogenic fungi, particularly *Phytophthora cinnamomi*. A Site Hygiene Protocol has been developed by the RBG (See Appendix 1). Strict quarantine measures have been enforced during all site visits by staff of the NPWS and the RBG. This protocol includes the use of clean clothes and sterilised footwear at all times on site. All equipment used for sampling is also sterilised before it is introduced into the site.

9.5 Fire Management Protocol

As part of the Wollemi National Park Fire Management Plan (in prep.), the NPWS has developed a protocol for fighting a fire which threatens a population of the Wollemi Pine. In addition, the fuel management plan for Wollemi National Park will include a hazard reduction strategy to protect the known habitat of the species in Wollemi National Park. These interim measures will provide a response specifically for the protection of the Wollemi Pine from fire and are designed to reduce the fire hazard, the intensity of any fire which is deemed to be a potential threat, the response time in the event of a direct threat, and to extinguish any fire at the sites with all due caution for the safety of the fire fighters.

9.6 Mycological research

Mycological research has been undertaken by the RBG to:

1. determine the presence or absence of the pathological fungus *Phytophthora cinnamomi* in soils associated with the Wollemi Pine; and
2. determine the fungal flora associated with the Wollemi Pine and associated soils.

In order to gain baseline data on the levels and types of fungal organisms present on site, samples of soil, litter, leaves, sterile seed and cone material were collected from Site 1 in 1995 by the RBG. The samples were plated on a variety of media for the isolation of fungi. In addition, tissue culture contaminants were plated for identification. Soil was also baited with the cotyledons of *E. sieberi* to isolate *P. cinnamomi* (B. Summerell pers. comm.).

P. cinnamomi was not isolated from any of the soil samples. This indicates that there is a high likelihood that the soil is presently free of this fungus (B. Summerell pers. comm.).

Approximately 50 species of fungi were recovered from the samples. The identification of many of these species is still in progress (B. Summerell pers. comm.).

The development of nodules in the bark has been observed on Wollemi Pine seedlings. Nodules on the stems appear from below the ground and are largest at or just above ground level. They disappear with height above the ground and, on adult

trees, are replaced by diamond-shaped scaly bark (W. Jones, J. Allen, field obs.). The microbiology of these nodules serves as an interesting point of research, and may indicate a symbiotic relationship with a specific micro-organism. The roots of the Wollemi Pine also contain a complex nodular structure. To date one species of mycorrhizal and three species of ecto-mycorrhizal fungi have been isolated from the roots. It remains to be determined whether these species are specific to the Wollemi Pine and its habitat (B. Summerell pers. comm. to J. Benson).

9.7 *In situ* ecological research and monitoring

An *in situ* ecological research program was initiated in mid-1995 under the guidance of the Recovery Team. This program of ecological research has provided the baseline information required for the formulation of the Recovery Plan. This program was carried out by officers of the NPWS and the RBG and is detailed below.

9.7.1 Description of the habit and habitat of the Wollemi Pine

Initial description of the growth habit and habitat of the Wollemi Pine was undertaken on site and material was collected for analysis of embryology, phenology, cuticle morphology and branching pattern studies. The main species associated with the Wollemi Pine were identified and recorded and a description of the general character of the habitat was recorded. This is discussed in Section 6. Readings of light intensity were taken using a Licor Instrument at Site 1.

9.7.2 A preliminary description of the population structure at both sites

The coppicing habit of the Wollemi Pine makes identification of individual trees difficult in the field. In order to undertake a preliminary description of the population structure putative individuals were identified and tagged (C. Offord 1996). The number of trunks of each putative individual was counted and the basal diameter of each trunk was measured (W. Jones, field data). These results are discussed in Section 4.4.

9.7.3 Mapping of the distribution of the individual trees on site

In order to map the distribution of the trees at Site 1, the position of tagged putative individuals was fixed using a tape and compass transect for an area of the gorge which extends beyond the limits of the populations. These locations were recorded onto a master map for future identification of individuals at the sites (W Jones survey data).

9.7.4 Tagging and measurement of seedlings for survivorship studies

Seedlings were identified *in situ* by the presence of cotyledons or cotyledon scars. The seedlings were tagged with permanent numbered metal stakes and tags (C. Offord pers. comm.). Approximately 200 seedlings have been tagged at Site 1. The location of these seedlings was noted on the master map by associating groups of seedlings with a tagged mature tree (W. Jones survey data). Measurements of seedling height and basal diameter and the number of leafy branches were recorded. Any damage to the growing tip and the condition of the foliage was assessed.

9.7.5 Preliminary assessment of the age of individual trunks

Ring counts of fallen branches were undertaken to give a preliminary assessment of the age of standing trunks. Results are discussed in Section 4.1.

9.7.6 Edaphic factors

Small soil samples were collected from the base of selected trees for physical and chemical analysis (Offord *et al.* 1996). Results are discussed in Section 6.

9.7.7 Cone counts, monitoring of pollen release and estimation of seedcrop

Cone (strobili) counts were carried out to provide an estimate of the fecundity of the population. Cones were counted on site and a photographic record of cone development was undertaken (W. Jones survey data).

Pollen development was assessed by examining male cones on site. Pollen fall was monitored by observing the site from the lower cliff. This enabled the season of pollen shedding to be recorded.

Counts of cone numbers and seeds allowed the estimation of standing seed crop. This information allowed the effect of the removal of seeds from the seedbank to be assessed and minimised (G. Errington pers. comm.).

9.8 Survey

In order to ascertain the full distribution of the Wollemi Pine, a strategic survey of suitable areas of Wollemi National Park was undertaken during 1995 and 1996. Areas of potential habitat, ie gorge country containing rainforest communities, were selected after aerial photo interpretation (W. Jones pers. comm.)

Survey was undertaken using low fly-overs in helicopters combined with ground searches. Ground searching is necessary for the detection of sub-canopy and juvenile pines. The area within 15 km of Site 1 was extensively ground searched and 300 km of gorge and canyons have been exhaustively searched by helicopter. Aerial searches have also been carried out in other parts of the Wollemi National Park. Several areas remote from the sites were ground searched after they were assessed

for suitable habitat. No further populations of the Wollemi Pine have been located (W. Jones survey data).

9.9 *Ex situ* propagation

Research into the *ex situ* propagation of the Wollemi Pine has been carried out by the RBG since February 1995**.** Cutting material has been collected from the majority of putative trees from both Sites. Thus a full representation of all putative individuals of both populations is maintained by the RBG to provide material for propagation and other analyses when required (C. Offord pers. comm.).

9.9.1 Seed collection

The Wollemi Pine produces numerous fruiting cones, but the position of these cones on the crown of the tree makes collection of seed difficult (Offord 1995). Low impact seed traps have been constructed by the RBG and the NPWS. These traps have been located at strategic points within Site 1 to capture fallen seed. Some seed has been collected from the ground at Site 2. Each seed collected is assigned a number and its progress is monitored at every stage of experimentation (Offord *et al*. 1996).

9.9.2 Propagation from seed

Viable seed has successfully been germinated and seedling growth appears to be faster *ex situ* than in the wild (Refer Section 4.3.7). However, the low percentage of viable seed produced (10%), the high predation rate and the low numbers of seed produced in the field, means that propagation from seed is not a viable option for *ex situ* propagation at the present time (C. Offord pers. comm.).

9.9.3 Vegetative propagation

Only one or two trunks have been sampled from each trunk group. Each trunk is tagged with a permanent marker to facilitate future identification in the field (Offord *et al.* 1996). Initial research has shown that the Wollemi Pine can be propagated from both juvenile and adult shoots. The natural coppicing habit of the Wollemi Pine may allow for a propagation system similar to that used for the commercial production of the related species *Araucaria cunninghamii* or Hoop Pine (Offord 1995).

For vegetative propagation, orthotropic shoots are the preferred material as they establish a seedling-like habit. There are a limited number of these shoots available on the trunks. Cuttings from the more numerous plagiotropic shoots (sideways growing shoots) produce prostate or decumbent plants and are of limited use although they are of horticultural interest (C. Offord pers. comm.).

Basic propagation requirements for the species have been established. Although seed is the preferred unit of propagation, it is difficult to obtain in large amounts. The current stock of plants is shown in Appendix 2.

9.10 Preliminary genetic variability analysis

The RBG has established a collaborative research program with the Australian National University (ANU) to undertake genetic variability analysis on the Wollemi Pine. These preliminary genetic studies commenced in March 1996 to develop and use the very latest DNA fingerprinting techniques. A program of genetic variability analysis investigating the variability between individuals and determining the number of individuals in the stands will require the characterisation of all individuals or potential individuals using DNA or isoenzymes.

10 Species' ability to recover

Species such as the Wollemi Pine are considered to have become "endangered" through natural factors. If the threatened status of a species is not due to factors which can be directly attributed to human interference, it may not be appropriate to "recover" the species in the sense that it can be managed to reverse the past decline it has experienced. However, as the Wollemi Pine is a great scientific and commercial discovery and may henceforth be under adverse pressure from human-induced threatening factors, it must be managed to protect it from any actions which will cause unnatural decline of the species in nature.

11 Recovery objectives and performance criteria

11.1 Objectives of the Recovery Plan

The overall objective of this Recovery Plan is to protect the known populations of the Wollemi Pine from decline induced by non-natural sources and to ensure that the wild populations of the Wollemi Pine remain viable in the long term.

Specific objectives of this Recovery Plan are to:

- protect and maintain the known populations and their habitat from human-induced threatening processes in the long term;
- understand the ecology of the species;
- determine the range of genetic variability of the known populations;
- establish representative *ex situ* populations in botanic gardens; and
- determine if further wild populations exist and to protect any new populations and their habitat.

11.2 Recovery performance criteria

Recovery criteria are that:

- wild populations do not suffer any net reduction in individuals due to human-induced causes;
- analysis of genetic variability of the wild populations is undertaken;
- genetically representative *ex situ* populations exist within botanic gardens;
- wild populations are protected by appropriate mechanisms.

12 Recovery actions

12.1 Management strategy

This action consists of five main tasks which are discussed below.

12.1.1 Wollemi Pine Access Strategy

All visits to the site by the NPWS and RBG employees, or by other approved persons, will be conducted in accordance with the Wollemi Pine Access Strategy (see Appendix 3). This strategy will be part of the Wollemi Pine National Park Plan of Management. A register of all people visiting the site will be maintained by the Upper Hunter District Office of the NPWS.

Outcome

The known sites of the Wollemi Pine will be protected from damage by unauthorised personnel entering the sites.

12.1.2 Wollemi Pine Community Relations Strategy

A number of actions in the community relations strategy have already been undertaken and other actions in the strategy will be undertaken as funds become available.

Sponsorship funds are being sought through the National Parks Foundation to enable additional community awareness and education materials to be produced. The Foundation has established a special Wollemi Pine fund for donations.

All funds raised from the sale or use of photographs, video and film footage and or any other fundraising activities associated with the Wollemi Pine will be deposited into a special fund to be used by NPWS and the RBG for research into, and conservation of, the Wollemi Pine and other rare and threatened flora.

Outcome

Community appreciation of and support for the conservation and protection of the Wollemi Pine is enhanced.

12.1.3 Wollemi National Park Reserve Fire Plan

The Wollemi National Park Fire Management Plan outlines fire hazard management policies and procedures for the area surrounding the Wollemi Pine sites. These management procedures will assist in the long-term protection of the species from potentially devastating fires. Fire management procedures are tailored to provide conservation of the habitat of the Wollemi Pine. It is currently assumed that intense fire events will lead to individual tree deaths and a reduction in the population.

Outcome

The risk of damage to Wollemi Pine populations from wildfire and bushfire management activities will be minimised.

12.1.4 Catchment management practices

The NPWS will ensure that the risk of pollution, flooding, weed infestation and sedimentation and other adverse changes to the hydrology of the catchment of the Wollemi Pine sites is minimised by implementing the following practices.

- The NPWS will not permit the storage or application of chemicals, oil or fuel within the upper catchment of the Wollemi Pine site.

- All chemical spills within the upper catchment of the Wollemi Pine site will be treated as emergencies.

- The NPWS will seek the co-operation of the Environmental Protection Authority, Local Councils, Park neighbours, bushfire authorities and owners of properties within the park, if appropriate, to minimise the risk of chemical, oil or fuel spills.

- Annual monitoring of blackberry and other woody weed incursions in the catchment of the Wollemi Pine sites will be carried out and treatment of infestations will occur when the NPWS, in consultation with the Recovery Team, concludes that the infestation could adversely affect the population of the Wollemi Pine.

- A weed control program for the Wollemi Pine sites using low-impact methods (cut stump and systemic herbicide application) will be formulated as part of the Wollemi National Park Plan of Management to ensure that blackberry and other woody weeds do not become a threat to Wollemi Pine populations.

Outcome

The risk of pollution, flooding, weed infestation and sedimentation and other adverse changes to the hydrology of the catchment of the Wollemi Pine sites is minimised.

12.1.5 Site hygiene protocol

This task involves the continuation of the protection of the wild populations of Wollemi Pine by the implementation of strict hygiene measures during all official site visits and the monitoring of soil for introduced pathogens. To protect the sites during official site visits, a protocol developed by the RBG has been adopted.

- All authorised personnel visiting the Wollemi Pine site will be required to sterilise all footwear and equipment in accordance with the approved protocol.

- Any outbreak of fungal pathogens at the site will be treated as an emergency and dealt with promptly and effectively using expert advice available through the RBG, Department of Agriculture and State Forests of NSW.

- Soil sterilants and systemic fungicides may be used in emergency situations on wild populations of Wollemi Pine if recommended by the emergency incident management team to contain active fungal pathogen outbreaks.

- The RBG in consultation with the Recovery Team will keep under review approved procedures for minimising the risk of introducing fungal pathogens to the Wollemi Pine site and to *ex situ* populations where appropriate.

- NPWS District Officers will be trained in recognising and reporting fungal pathogen outbreaks.

- The RBG, in consultation with the Recovery Team, will develop an emergency management plan for dealing with fungal pathogen outbreaks and will list appropriate contacts within State Forests, RBG and Department of Agriculture who may be available to assist.

Outcome

The known sites of the Wollemi Pine will be protected from the introduction of pathogens.

12.2 Ecological research and monitoring

This action consists of three main tasks as discussed below. All research programs will be reviewed by the Wollemi Pine Recovery Team.

12.2.1 Ecological monitoring program

The ecology of the Wollemi Pine is not well understood. A number of years of low impact *in situ* monitoring of the known populations is required to gather ecological data. An ecological monitoring program will be developed and implemented by the RBG, in consultation with the Recovery Team, to study the following aspects of the ecology of the Wollemi Pine:

- Population dynamics
- Seedling recruitment
- Seedling survivorship
- Associated species
- Edaphic factors
- Biophysical factors
- Climatic factors.

Outcome

Aspects of the ecology of the Wollemi Pine will be better understood. Ecological data gained will be used to modify the management program outlined in Section 12.1 and will assist in the tasks outlined in Section 12.4.

12.2.2 Age structure and fire history

A study of the ring chronology and fire scarring of the Wollemi Pine will be designed and implemented by the RBG, in consultation with the Recovery Team, in order to:

1. relate the size of standing trunks to their age;

2. determine the fire history of the sites; and

3. determine how fire history has influenced the present population structure.

Dead fallen material and a method of incremental coring which does not endanger living trees, will be used.

Outcome

The age structure of the known populations of the Wollemi Pine and the fire history of the sites will be determined. This information will be used to modify existing management practices outlined under Section 12.1.

12.2.3 Mycological studies

A program of mycological studies on cultivated material is also to be undertaken to assess the susceptibility of the Wollemi Pine to plant pathogens.

Knowledge of the susceptibility of the Wollemi Pine to the main soil-borne diseases, particularly *Phytophthora cinnamomi*, is critical to the success of the *ex situ* program, the wider cultivation of the species and the protection of the wild sites from human visitation. Investigations into the effects of a range of pathogens on the species will be undertaken by inoculation of immature plant material (seedlings or struck cuttings) with soil-borne and foliar pathogens and observations of the effects of the fungi on the plant and of immunological reactions in vitro.

Outcomes

The following outcomes are anticipated.

1. Determination of any real or potential disease problems that may be associated with the species.

2. Identification of any mycorrhizal associations of the species.

3. Systematic survey of the fungi associated with this species.

12.3 Genetic studies

The coppicing habit of the Wollemi Pine suggests that the species may be clonal and preliminary genetic analysis indicates that the actual number of genetic individuals in the known populations may be far fewer than the census size of 40. Further detailed genetic study is required to determine how many individuals occur in each population and therefore how much genetic variation is present in the known populations of the Wollemi Pine.

The RBG and the ANU established a collaborative research program in March 1996. This program involves undertaking genetic variability analysis on the Wollemi Pine, and will continue.

Genetic variability analysis consists of two main tasks, as described below.

12.3.1 DNA extraction

DNA for the genetic variability analysis will be extracted by the RBG from material collected and maintained by the RBG. A full representation of all putative individuals of both populations is maintained by the RBG to provide material for genetic analyses when required.

Outcome

The DNA extracted by the RBG will be sent to ANU for analysis.

12.3.2 Genetic variability analysis

The project will be in two stages. Techniques will be evaluated and a preliminary study of the genetic variation will be conducted. Application of the selected techniques will address the following issues:

1. Genetic variation within Wollemi Pine populations
2. Gene flow between the two Wollemi Pine populations
3. Clonality of the larger stem groups
4. Extent of cross-pollination
5. Representative sample for *ex situ* collection.

Outcome

This knowledge will provide guidelines for propagation to ensure that the *ex situ* collection represents the full range of the species genetic diversity (R. Peakall pers. comm.). An effective *ex situ* collection can be established and maintained using a system which DNA "fingerprints" each individual. This ensures that there is no unnecessary and costly duplication of clones. It will also help to clarify the structure and the breeding behaviour of the known populations.

12.4 *Ex situ* collections

The production of an *ex situ* collection is considered necessary for the long-term survival of the Wollemi Pine, in case of severe decline of the wild population, to provide material for genetic study and for horticultural development. The *ex situ* population will be established first by successfully propagating the species, then by establishing its optimal growing conditions and, thirdly, by planting at a number of locations in order to reduce the risks of a catastrophic loss at one site (C. Offord pers. comm.).

All these phases will be assisted by knowledge of the genetic variation of the material available in the wild. The wild population is small enough to obtain, grow and analyse material from nearly every mature plant.

There are seven main tasks as discussed below.

12.4.1 Collection

The *in situ* monitoring of the population will produce counts of the cones on trees at both sites and will be able to predict the seed fall for the following season. Seeds will continue to be collected mainly from Site 1 (as Site 2 has very few cones).

Outcome

Seed will be available to allow:

1. commercial propagation;
2. dispersal to other conservation agencies, principally botanic gardens;
3. establishment of *ex situ* collection at RBG; and
4. research into seed biology.

12.4.2 Register

A register which will be kept by the RBG will specify the institution, type and amount of material and its genetic makeup as an ongoing requirement.

Outcome

Dispersal of seed, plants and tissue culture stock to take place in accordance with a Memorandum of Understanding between the NPWS and RBG.

12.4.3 Seed storage

The most efficient way of maintaining an *ex situ* collection is seed storage. There are perceived problems with seed storage of this species as the family in general is recalcitrant to long-term storage at low temperature and moisture content. Some work has been undertaken with low temperature storage of *Araucaria spp*. seed (Tompsett 1982, 1983, 1984a, 1984b). This study will be based on Tompsett's and others' work with other Araucariaceae and will examine the effect of storage at low temperature and reduced moisture content on the germination of the Wollemi Pine seed (C. Offord pers. comm.).

Outcome

These germination experiments will determine if the seed can be effectively stored and thus provide a means of low cost *ex situ* conservation.

12.4.4 Vegetative propagation

Vegetative propagation material already collected from the two known populations will be used in experiments to find ways of rapidly propagating the Wollemi Pine. A combination of conventional cutting propagation techniques and tissue culture variations will be used. The species is a slow-growing woody perennial whose closest relatives do not lend themselves easily to tissue culture (C. Offord pers. comm.).

Outcome

Vegetative propagation is vital to the success of the horticultural program. Techniques for rapid propagation are required for large-scale distribution of the species for genetic and ecological studies and horticultural demand (C. Offord pers. comm.).

12.4.5 Cultivation

This will be a series of studies designed to determine the optimum growing conditions for the Wollemi Pine. It will include studies of nutrition, potting mix, soil requirements, light intensity and photoperiod in combination with temperature on propagated stock held in pots. All propagated stocks currently held as pot plants and the growth of plants in pots is being monitored (C. Offord pers. comm.).

Outcome

The optimum conditions for the cultivation of the Wollemi Pine will be determined.

12.4.6 Commercialisation strategy

In order to discourage illegal trade in the Wollemi Pine and illegal collection of propagation material from the wild populations, the NPWS and the RBG will continue to:

- encourage and authorise the establishment of *ex situ* populations of the Wollemi Pine at botanic gardens in accordance with an *ex situ* transfer agreement;
- encourage the marketing of Wollemi Pine to the public from *ex situ* material;
- pursue CITES (Convention on International Trade on Endangered Species of Wild Fauna and Flora) listing for the Wollemi Pine;
- assist the Minister for the Environment to seek appropriate trademark registration of product names and labels associated with the Wollemi Pine; and
- seek tenders for the commercial marketing to the public of the Wollemi Pine and associated products.

Outcome

Risks to the wild populations will be minimised by the commercialisation of the Wollemi Pine.

12.4.7 Re-introduction

The NPWS in consultation with the Recovery Team will consider the reintroduction of the Wollemi Pine to the original sites under the following circumstances:

1. if the species has disappeared from the sites for more than 5 years; and
2. the decline was related to human-induced threats which have been effectively reduced.

The Wollemi Pine will be re-introduced with the aim of re-creating the original population size and genetic composition. Material for re-introduction will be sourced from a representative sample from the RBG. Any such translocation will be undertaken in accordance with the Australian Network for Plant Conservation Guidelines for the Translocation of Threatened Plants (ANPC in prep).

12.5 Systematic survey

Preliminary survey and aerial photo interpretation shows that there is suitable habitat for the Wollemi Pine in much of the 500 000 ha of Wollemi National Park. Areas

which have not been surveyed during 1995-1996 will be surveyed from the air by helicopter and ground sampling will then be carried out at the most likely locations. This program of survey will be implemented through the Wollemi National Park Plan of Management.

Outcome

An aerial and ground search for the Wollemi Pine will be conducted in all suitable sites in Wollemi National Park.

13 Implementation

The following table allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies for the period 1997 to 2002. A budget for plan implementation is included at Appendix 4.

Table 3: Implementation schedule

Section	Description	Responsibility for implementation	Timeframe	Priority
12.1	**Management**			
12.1.1	Wollemi Pine Access Strategy	NPWS	Ongoing	Essential
12.1.2	Wollemi Pine Community Relations Strategy	NPWS	Ongoing	Essential
12.1.3	Wollemi National Park Reserve Fire Plan	NPWS	Ongoing	Essential
12.1.4	Catchment management	NPWS	Ongoing	Essential
12.1.5	Site Hygiene Protocol	NPWS/RBG	As required	Essential
12.2	**Ecological research**			
12.2.1	Ecological monitoring	NPWS / RBG	Subject to funding	Highly desirable
12.2.2	Age structure studies	RBG	Subject to funding	Highly desirable
12.2.3	Mycological studies	RBG	Subject to funding	Highly desirable
12.3	**Genetic studies**			
12.3.1	DNA extraction	RBG	Subject to funding	Highly desirable
12.3.2	Genetic variability analysis	ANU/RBG	Subject to funding	Highly desirable
12.4	***Ex situ* collection**			
12.4.1	Collection of material for propagation	RBG	Subject to funding	Highly desirable
12.4.2	Create and maintain a register of propagules	RBG	Subject to funding	Highly desirable
12.4.3	Seed storage studies	RBG	Subject to funding	Highly desirable
12.4.4	Vegetative propagation research	RBG	Subject to funding	Highly desirable
12.4.5	Investigation of aspects of cultivation	RBG	Subject to funding	Highly desirable
12.4.6	Commercialisation strategy	NPWS/RBG	Subject to funding	Highly desirable
12.4.7	Reintroduction	NPWS/RBG	As required	Highly desirable
12. 5	**Survey of potential habitat**	NPWS	Subject to funding	Highly desirable

14 Preparation details

This Recovery Plan was prepared by Sharon Nash and Julie Ravallion in consultation with the Wollemi Pine Recovery Team.

14.1 Date of last amendment

No amendments have been made to date. Minor changes were made to the internet version of the recovery plan by Julie Ravallion on 8 June 2000. These changes updated the Site Access Policy to reflect the current organisational structure within NPWS. Minor amendments were also made to the text of the recovery plan.

14.2 Review date

This Recovery Plan will be reviewed within five years of the date of publication.

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Appendix 1: Site Hygiene Procedures

Procedures for hygiene and prevention of entry of disease-causing organisms at the Wollemi Pine site.

Aim: The aim of these procedures is to prevent disease-causing organisms from entering or being transported into the area in which the Wollemi Pines are located. At present there appear to be no pathogens present at the site at which the Wollemi Pine is found. Soil tests performed by the Plant Disease Diagnostic Unit, Royal Botanic Gardens, Sydney showed that Phytophthora and other root pathogens did not appear to be present. It is essential to ensure that these types of organisms are not transported into the site as the effects are likely to be severe. It is likely that the Wollemi Pine, like other members of Araucariaceae, will be susceptible to attack by organisms such as Phytophthora cinnamomi. Prevention of these diseases is the best method of control.

The following procedures outline steps that should be taken when it is necessary to enter the site. Such stringent measures are the only means by which it is possible to minimise the entry of these pathogens.

Procedures. The most important pathogens of trees are carried in the soil. All the following procedures aim to prevent entry of soil or to disinfect those soil particles that may adhere to personnel.

1 All material taken into the site should be free of soil. Preferably it should be cleaned before trips to the site and should be sterilised with an appropriate sterilant such as bleach (sodium hypochlorite) or a commercial disinfectant (eg. biogram). Clothes and backpacks should be washed with a detergent prior to trips to the site. secateurs, trowels, spades and other such equipment should be sterilised carefully to ensure no possible transportation of pathogens. Shoes and boots should be carefully cleaned prior to trips to the site.

2 A footbath should be used to clean footwear prior to entering the immediate area around and adjacent to the trees. Again a sterilant such as bleach or biogram is appropriate. A sterilant which requires a higher dilution rate is recommended as the amount that is needed to be carried is much less. Shoes should be soaked in the sterilant for one minute. It is advisable to remove shoes as the sterilant can be damaging to the skin of some people.

3 New sterilant should be prepared on each new entry to the site. The life of these sterilants when exposed to soil particles is very short. The old sterilant must be removed from the immediate vicinity of the site. It must never be emptied into watercourses.

Brett Summerell RBG, 1998.

Appendix 2: *Wollemia nobilis* plants in propagation as at 12 January 1998

Table 1. Cuttings - Site 1

Tree	**Orthotropic Total**		**Adult Plageotrophic**		**Juvenile**		**Total**	
	Mount Annan	Sydney	Mount Annan	Sydney	Mount Annan	Sydney	Mount Annan	Sydney
1	67		10	3	8	1	85	4
Seedlings (from Tree 1)	87				42		129	
2	43				10		53	
3	16				4	3	20	3
4	3				0		3	
5	22				0		22	
6	0				0		0	
7	57				23		80	
8	2				0		2	
9	16				3		19	
10	10				0		10	
11	14				0		14	
12	2				0		2	
13	8				6		14	
14	10				0		2	
15	0				0		0	
16	8				0		8	
17	4				1		5	
18	6				0		6	
19	29				27		56	
20	12				4		16	
Total	416		10	3	128	4	554	7

Table 2. Cuttings - Site 2

Tree	Orthotropic		Juvenile Plagiotrophic		Total	
	Mount Annan	Sydney	Mount Annan	Sydney	Mount Annan	Sydney
1	13		14	1	27	1
2	0		0		0	
3	6		28	2	34	2
4	10		7		17	
5	4		0		4	
6	11		26		37	
7	7		0		7	
8	8		4		12	
9	5		7		12	
10	1		1		2	
Total	65		87	3	152	3

Table 3. Seedlings - Sites 1 and 2

Site	Date	Tree	Trap	Number		
				Mt Annan	Sydney	Kew
1	1995	1	cone	39	6	
1	1996	1		178	2	1
1	1996	1	1-4,6-8,25,26	23	2	
1	1996	2	20,28-32	11		
1	1996	2-9	D-F	41		
1	1996	10	39	1		
1	1996	10-18	A-C	31		
1	1996	12-13	37	1		
1	1996	11,14	38	1		
1	1996	16-18	34-36, 40	11		
1	1996	17-18	near 17/18	4		
1	1996	18	near 18	13		
1	1996	mixed	ground	10		
1	1996	19	I,15-19	79	4	1
1	1996	20	H, 19,24	36		
1	1996	mixed		6		
2	1996	mixed	ground	0	1	
		Total		485	15	2

Appendix 3

WOLLEMI PINE SITE ACCESS POLICY

1 Introduction

The Wollemi Pine was discovered in Wollemi National Park in August 1994 by a group of bushwalkers. The Pine is known to occur only in two sites within a gorge surrounded by sandstone cliffs. Although information regarding the location of the Pine is known to a small number of people, this information has not been made public despite the interest shown in the species from both within Australia and from overseas.

The NSW National Parks and Wildlife Service and the Royal Botanic Gardens have formed a Wollemi Pine Conservation Team which has been responsible for overseeing the development and preliminary implementation of a recovery plan for the Pine in accordance with the *Threatened Species Conservation Act 1995*. Through the early adoption of a site access protocol and the co-operation of neighbours, staff members and the original bushwalking group, the Team has been able to maintain relatively tight security regarding the location of the sites.

The Team is primarily concerned with threats to the Pine arising from visits to the site rather than or arbitrarily restricting access. These threats include trampling of seedlings, the introduction of fungal pathogens, theft of plant material, site pollution and increased risk of wildfires. The Team has adopted a precautionary approach to the management of the Pine. This site access policy will be reviewed in future years if the implementation of the recovery plan actions are such that the risk of damage to the population can be managed within acceptable limits.

2 Definitions

Act means the *National Parks and Wildlife Act 1974*

Regional Manager means the Manager, Blue Mountains Region, NSW National Parks and Wildlife Service

Pine means the Wollemi Pine (*Wollemia nobilis*)

Wollemi Pine Conservation Team means the NPWS approved recovery team established to advise the Director-General of National Parks and Wildlife on the conservation of the Wollemi Pine.

3 Purpose of this Policy

3.1 To minimise the risk of damage to the wild population of the Pine arising from visitation to the Wollemi Pine Site.

3.2 To provide a consistent and transparent policy and procedure for managing requests for access.

4 Outcomes sought

4.1 Visitation to the site is regulated to ensure the risks associated with visits to the site are minimised.

4.2 The Pine populations within the Park do not decline as a result of threats arising from visitation to the Park; and

4.3 Visitation to the Wollemi Pine Site results in net benefits to threatened species conservation and Wollemi Pine conservation in particular.

5 Policies

5.1 Visits to the Wollemi Pine Site will be restricted to those activities necessary to achieve recovery plan outcomes.

5.2 The number of visits and the number of visitors will be restricted to the minimum number necessary to achieve recovery plan objectives.

5.3 All visits to the Wollemi Pine Site must be endorsed by the Wollemi Pine Conservation Team and be approved by the Regional Manager (see exception in 5.13).

5.4 Site visits will be restricted to research, threat management and public eduction purposes only (unless otherwise specified within the recovery plan), and will be permitted only where a net benefit to the conservation of threatened species and the Wollemi Pine in particular, has been demonstrated.

5.5 The Regional Manager will determine when visits to the site need to be curtailed. This will be when the Regional Manager determines that ‘acceptable risk’ has been exceeded. The decision of the Regional Manager will be final.

5.6 Non-NPWS/RBG applications to visit the Wollemi Pine site must be in writing to the Regional Manager and must clearly demonstrate that the purpose of the site visit is consistent with the Recovery Plan and that there is no practical alternative to the visit. The Regional Manager may refer the application to the Conservation Team if standing approvals do not cover the scope of the application.

5.7 All non-NPWS/RBG visits to the Wollemi Pine site will be in accordance with a consent issued by the Regional Manager (attached). The number of visits and extent of each visit will be clearly defined within that consent. Additional consents may also be issued for the purposes of other provisions of the Regulations (eg. filming). A confidentiality condition must be included on any consent issued.

5.8 The Regional Manager will nominate supervisors for any non-NPWS/RBG Wollemi Pine site visitors. Supervisors will be allocated at a ration of at least 1 supervisor to every 4 visitors.

5.9 The costs of this supervision and any other costs incurred by the NPWS in organising site access will be met by the Applicant unless otherwise determined by the Regional Manager.

5.10 Registers will be maintained of all persons approved to visit the Wollemi Pine site and of all Wollemi Pine site visits. The register will be presented to the Wollemi Pine Conservation Team at the end of June each year.

5.11 Approvals for NPWS/RBG staff to visit the site will be reviewed and renewed on an annual basis.

5.12 The continued co-operation of neighbours, local government, bushwalking clubs and previous site visitors will be sought in maintaining site confidentiality and in regulating and monitoring site visits.

5.13 Access for emergency purposes (*Rural Fires Act 1997* or the *State Emergency and Rescue Management Act 1989*), must be kept to the minimum number necessary for effective management of the incident and must be co-ordinated through the Regional Manager or the Manager's representative to minimise threats to the Wollemi Pine population.

5.14 No more that 5 persons will be permitted to visit the site on any one trip unless otherwise approved by the convenor of the Wollemi Pine Conservation Team or the Regional Manager.

5.15 All persons visiting the site will comply with the Wollemi Pine Site Hygiene Protocol.

6 Procedures

6.1 This policy will be made public as an appendix to the Wollemi Pine Recovery Plan and will also be available as a free publication.

6.2 This policy will be distributed to appropriate neighbours, local councils, bushwalking clubs, and all approved site visitors including staff members. A register will be maintained by the Blue Moutains Region of all persons receiving a copy of this policy. Updates will by provided as they occur.

6.3 This policy will be reviewed annually by the Wollemi Pine Conservation Team.

6.4 The Wollemi National Park Plan of Management and Reserve Fire Management Plan and relevant Section 51(1)(b) bush fire management plans will be amended if necessary to incorporate this policy.

7 Relevant legislation

7.1 *National Parks and Wildlife Act 1974*. Section 118D(1) states that a person must not, by an act or an omission, do anything to cause damage to any habitat of a threatened species, population or ecological community if the person knows that the land concerned is habitat of that kind. The habitat of the Pine is described in the Recovery Plan.

7.2 National Parks and Wildlife (Land Management) Regulation 1995. Clauses 4(1)(b), 19(1) and 20(1) of the Regulation enable a park authority to regulate certain activities within a national park.

8 Relevant policies and documents

8.1 Wollemi Pine Recovery Plan. Provides background information, species ecology and actions and responsibilities for recovery in accordance with the *Threatened Species Conservation Act 1995*.

8.2 Wollemi National Park Plan of Management. Lists the policies and actions to be undertaken to protect the Pine and its site from damage in the context of the planning framework for Wollemi National Park.

8.3 NPWS Threatened Species Information Circulars. Contain information relevant to threatened species management in NSW and the operation of the *Threatened Species Conservation Act 1995* in particular.

9. Contacts

9.1 National Parks and Wildlife Service, Central Directorate
Manager, Threatened Species Unit 02 9585 6623
Manager, Blue Mountains Region 02 4787 8877

9.2 Royal Botanic Gardens
Sydney Assistant Director, Collections 02 9231 8111

10 Policy information

10.1 Prepared by Bob Conroy, National Parks and Wildlife Service, October 1997 and incorporates comments received from NPWS - Sydney Zone, Legal Services Branch, Environmental Policy Division, Upper Hunter District; and the Royal Botanic Gardens, Sydney. Updated by Julie Ravallion, National Parks and Wildlife Service on 8 June 2000.

11 Policy Approval

11.1 This policy was approved for adoption by the Director-General on 11 May 1998

CONSENT

I,_____, Regional Manager of the Blue Mountains Region for the National Parks and Wildlife Service, do hereby consent, in accordance with the National Parks and Wildlife (Land Management) Regulation 1995 to_____
(the applicant/s) having access only to the location known to support populations of the Wollemi Pine (*Wollemia nobilis*) within Wollemi National Park on _____ occasion/s only during the period _____ subject to the conditions below. The applicant agrees to.

1. Always be accompanied on the site by a NPWS staff member appointed by the Regional Manager;

2. Maintain confidentiality over the location of the Wollemi Pine site and not to pass on or make available to any person or to cause any information to be disclosed to any person that may assist in the identification or location of the Wollemi Pine site/s within Wollemi National Park. The Applicant agrees to use the phrase "in a canyon in the northern section of Wollemi National Park" when referring to the location of the site;

3. Comply with any condition or instruction imposed on the Applicant by the Regional Manager or their representative;

4. Read and comply with the policies within the "Wollemi Pine Site Access Policy" and the "Wollemi Pine Site Hygiene Protocol";

5. Cause no avoidable damage to the site or any other lands within the Park;

6. Cause no annoyance, nuisance, injury or obstruction to the Director-General, his/her staff, servants, workmen, agents or contractors;

7. Observe and comply with the provision of the Act and all Regulation made thereunder, any Plan of Management for the Park, and all other applicable statutory and regulatory provisions and requirements;

8. Observe and comply with the provision of the Act and all Regulations made thereunder, any Plan of Management for the Park, and all other applicable statutory and regulatory provisions and requirements;

9. Indemnify, keep indemnified and release the Director-General and the Government of the State of New South Wales from and against all actions, suits, claims, demands, proceedings, losses, damages, compensation costs (including

Solicitor and Client costs) charges and expenses whatsoever to which the Director-General or the Government of the State of New South Wales shall or may become liable in respect of or arising from loss, damage or injury from any cause whatsoever to property or person caused or contributed to by the Applicant or by any omission, neglect, breach or default of the Applicant which may arise as a result of issuing this consent; and

10. Acknowledge that this consent may be cancelled at any time by the Regional Manager and in such an event, the Applicant will not be entitled to any compensation.

MANAGER, BLUE MOUNTAINS REGION
FOR DIRECTOR-GENERAL
DATE:

APPLICANT

Action	Description	1997/98				1998/99				1999/00				2000/01			
		External ESP	Other	NPWS	RBG	External ESP	Other[1]	NPWS	RBG	External ESP	Other	NPWS	RBG	External ESP	Other	NPWS	RBG
12.1	**Management program to ensure security of wild populations**																
12.1.1	Wollemi Pine access strategy	0	0	2,000	0	0	0	2,000	0	0	0	2,000	0	0	0	2,000	0
12.1.2	Wollemi Pine comm.relations strategy	0	5,000	1,000	0	0	0	1000	0	0	0	1000	0	0	0	1000	0
12.1.3	Wollemi NP fire management plan	0	0	2,000	0	0	0	2,000	0	0	0	2,000	0	0	0	2,000	0
12.1.4	Catchment Management Practices	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.1.5	Site Hygiene protocol	0	0	1,000	0	0	0	200	0	0	0	200	0	0	0	200	0
	SUBTOTAL	**0**	**5000**	**6,000**	**0**	**0**	**0**	**5,200**	**0**	**0**	**0**	**5,200**	**0**	**0**	**0**	**5,200**	**0**
12.2	**Ecological research and monitoring**																
12.2.1	Ecological monitoring program (biennial)	0	0	0	0	10000	0	0	0	0	0	0	0	0	0	10,000	0
12.2.2	Age structure & fire history	0	0	0	0	5,000	0	0	0	0	0	0	0	0	0	0	0
12.2.3	Myocological studies	0	0	0	0	10,000	0	0	0	0	0	0	0	0	0	0	0
	SUBTOTAL	**0**	**0**	**0**	**0**	**25,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**10,000**	**0**
12.3	**Genetic variability analysis**																
12.3.1	DNA extraction	0	0	0	10,500	0	0	0	5,000	0	0	0	5,000	0	0	0	5000
12.3.2	Genetic variability analysis	0	15,000	8000	0	10,000	7,500	0	0	8,000	0	0	0	8,000	0	0	0
	SUBTOTAL	**0**	**15,000**	**8000**	**10,500**	**10,000**	**7,500**	**0**	**5,000**	**8,000**	**0**	**0**	**5,000**	**8,000**	**0**	**0**	**5000**
12.4	**Establish *ex situ* populations**																
12.4.1	Collection and maintenence of *ex situ*	0	0	20,000	6,000	0	0	20,000	26,000	0	0	0	10,000	0	0	0	10,000
12.4.2	Register of propagules	0	0	0	1,500	0	0	0	1,500	0	0	0	1,500	0	0	0	1,500
12.4.3	Seed storage trials	0	0	0	20,000	10,000	10,000	0	0	10,000	10,000	0	0	0	0	0	0
12.4.4	Vegetative propagation research	0	0	0	3,000		17,500	0	0	0	17,500	0	0	0	0	0	0
12.4.5	Cultivation techniques	0	0	0	23,000		10,000	0	0	0	10,000	0	0	0	0	0	0
12.4.6	Commercialisation strategy	0	0	1,500	0	0	0	0	1,500	0	0	1,500	1,500	0	0	0	0
12.4.7	Reintroduction (if required)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SUBTOTAL	**0**	**0**	**21,500**	**53,500**	**10,000**	**37,500**	**20,000**	**29,000**	**10,000**	**37,500**	**1,500**	**13,000**	**0**	**0**	**0**	**11,500**
12.5	Systematic survey of likely habitat	0	0	0	0	0	0	10000	0	0	0	0	0	0	0	0	0
	SUBTOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**10000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	TOTAL BY AGENCY PER YEAR	**0**	**20,000**	**35,500**	**64,000**	**45,000**	**45,000**	**35,200**	**34,000**	**18,000**	**37,500**	**6,700**	**18,000**	**8,000**	**0**	**15,200**	**16,500**
	OVERALL TOTAL PER YEAR	**119,500**				**159,200**				**80,200**				**39,700**			
	1. Other - Expected external sources are commercialisation and donations																

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