Approved **Recovery Plan**

Hakea pulvinifera
Recovery Plan

April 2000

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

NSW National Parks and Wildlife Service
43 Bridge Street
(PO Box 1967)
Hurstville NSW 2220
Tel: 02 95856444
www.npws.nsw.gov.au/news/recovery_plans/index.html

For further information contact
Threatened Species Unit, Western Directorate.
NSW National Parks and Wildlife Service
P.O. Box 2111
Dubbo NSW 2830
Tel 02 6883 5330

Email <robyn.molsher@npws.nsw.gov.au

Cover illustration: Flowers of *Hakea pulvinifera*

Photo P. Christie NPWS

ISBN: 0 7313 6165 2

NSW National Parks and Wildlife Service Recovery Planning Program

Hakea pulvinifera
Recovery Plan

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

April 2000

Acknowledgments

This plan was prepared by Matt White of NSW National Parks and Wildlife Service, Western Directorate. Amendments were made to the draft and approved plans by Carolyn Raine and Robyn Molsher, respectively, from the NSW National Parks and Wildlife Service, Western Directorate.

Invaluable assistance towards the development of this plan was provided by Bill Barker of the State Herbarium of South Australia, Adelaide, Caroline Gross of the University of New England, Armidale, John Benson of the National Herbarium of New South Wales, Sydney, Ken McKenzie former General Manager, Lake Keepit State Park, Ian Thompson General Manager, Lake Keepit State Park, Joe McAuliffe of the Australian National Botanic Gardens, Canberra, Ish Sharma, Centre for Plant Diversity Research, Canberra, Ben Wallace of the Australian National Botanic Gardens, Canberra, Bob Leggat NPWS Armidale District, David Albrecht of the Parks and Wildlife Commission of the Northern Territory.

Foreword

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

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

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

NSW National Parks and Wildlife Service has prepared the *Hakea pulvinifera* Recovery Plan with the assistance of a number of people. I thank these people for their efforts to date and look forward to their continued contribution to the recovery of the species.

BOB DEBUS MP
Minister for the Environment

Executive Summary

Introduction

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 Service 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 approved Recovery Plan has been prepared with the assistance of interested parties with relevant expertise. Components within the plan do not necessarily represent the views nor the official positions of all the individuals or agencies consulted. The information in this Recovery Plan was accurate to the best of the NPWS' knowledge on the date that it was approved.

Current species status

Hakea pulvinifera is known from a single population on a hillslope above the Namoi River, near Gunnedah on the western slopes of the Great Dividing Range.

The species is listed as 'endangered' in part 1 Schedule 1 of the Commonwealth *Endangered Species Protection Act* 1992 and is listed as 'endangered' in Schedule 1 of the NSW *Threatened Species Conservation Act* 1995.

Recovery objectives

The overall objectives of this recovery plan are to:

1. ensure that human impacts on the wild population of *H. pulvinifera* are minimised such that the species continues to pursue its own evolutionary destiny; and
2. establish *ex-situ* populations of *H. pulvinifera* to be maintained in perpetuity.

Specific objectives are:

1. to survey potential habitat for further populations;
2. establish a monitoring program for *H. pulvinifera* at Lake Keepit State Park;
3. undertake further analysis of the genetic variation within the *H. pulvinifera* population;
4. establish secure *ex-situ* populations of *H. pulvinifera*;
5. minimise the risks to the population posed by soil borne pathogens and disease; and
6. monitor, and where necessary control, the invasion of *Callitris glaucophylla* at the Lake Keepit site.

Recovery performance criteria

Recovery criteria are that:

- survey of all potential habitat is completed;
- monitoring program is designed and base line data collected;
- secure and self-sustaining *ex-situ* population of *H. pulvinifera* is established which is representative of the genetic diversity in the wild population;
- site hygiene and access protocol is implemented; and
- mortality resulting from invasion by *C. glaucophylla* is ameliorated.

Recovery actions

Recovery actions for *H. pulvinifera* will be directed towards:

1. survey for further populations;
2. annual monitoring of the wild population;
3. establishing a secure and genetically representative *ex-situ* population;
4. site hygiene and access; and
5. the control of White Cypress Pines.

BRIAN GILLIGAN
Director-General

Table of Contents

List of figures

List of tables

1 Current Conservation Status

Hakea pulvinifera is known from a single population on a hillslope above the Namoi River, near Gunnedah on the western slopes of the Great Dividing Range. The species is very rare in terms of abundance and distribution and is prone to future threats that are likely to result in extinction.

The species is listed as 'endangered' in part 1 Schedule 1 of the Commonwealth *Endangered Species Protection Act* 1992 and is listed as 'endangered' in Schedule 1 of the NSW *Threatened Species Conservation Act* 1995. *H. pulvinifera* is not listed in the IUCN Red List of Threatened Species.

H. pulvinifera has been assigned a risk code of 2ECi on the 'Rare or Threatened Australian Plants' (ROTAP) listing, which indicates that it may become extinct in the wild within 10-20 years and is considered to be inadequately reserved (Briggs and Leigh 1996).

2 Description

2.1 Taxonomic description

Hakea pulvinifera L. Johnson (Proteaceae) is a root suckering shrub that grows to about 4m in height and has thick tessellated, 'cork-like' bark (Harden 1991, Barker 1999). The arrangement of branches is variable, being either sprawling or upright. Leaves are 4-12 cm in length, terete (rounded in cross section), and divided into 2-9 pointed segments, each 0.3-7 cm long. Young leaves are sparsely hairy, soon becoming glabrous. Flowers are creamy white and arranged in pairs on raceme-like conflorescences (typical of the Proteaceae) which arise from the leaf axils (Figure 1). Individual flowers are borne on spreading hairy pedicels (or flower stalks) and are 8-10 mm long. The rachis or axis of the conflorescence is 5-8 cm long. Each flower has a perianth 9-12 mm long and a style about 1.8 cm long. Flowering is in spring. Fruit has not been observed.

The species takes its name from the prominent 'cushion-like' swellings or pulvini at the base of each flower pair along the rachis (Johnson 1962).

Photo: P. Christie

Figure 1. *Hakea pulvinifera* inflorescence.

2.2 Taxonomic significance

H. pulvinifera and its closest relatives lie within the 'corkwood' clade or 'Lorea group' (Barker 1999), which is a subgroup of Section *Grevilleoides* within the genus *Hakea* (Table 1). Members of this group share many features with respect to leaves, buds, inflorescence and flowers (Barker 1999). However, the observed absence of fruits and the paucity of suitable morphological characters, renders the establishment of relations between *H. pulvinifera* and other related *Hakea* taxa particularly difficult. Based solely on the highly divided nature of the leaves, *H. pulvinifera*'s closest relatives include *H. divaricata*, *H. eyreana*, *H. ednieana*, (all arid zone taxa), *H. fraseri* (a rare endemic of the New England Tablelands) and *H. ivoryi* (confined to semi-arid north central New South Wales and south central Queensland) (Barker pers. comm.). Establishing the phylogenetic relationships of these and related *Hakea* taxa is worthy of further study and may reveal insights into

the events and processes which have been critical to the evolution and present distribution of the flora.

Table 1. Taxonomic hierarchy

Division:	Magnoliophyta	Flowering Plants
Class:	Magnoliopsida	Dicotyledons
Order:	Proteales	
Family:	Proteaceae	
subfamily	Grevilloeideae	
tribe:	Grevileeae	
Genus:	*Hakea*	
section:	*Grevilleoides*	
sub-section:	*Lorea*	Corkwood Hakeas
Species:	*pulvinifera*	

3 Distribution

3.1 Current and historical distribution

H. pulvinifera is known only from the type population which is a single location approximately 0.32 hectares in size. This site is at Lake Keepit on the western slopes of the Great Dividing Range near Gunnedah. This population lies within the boundaries of Manilla Shire and NPWS Northern Directorate.

3.2 Tenure

Lake Keepit State Park is Crown land reserved and managed under the provisions of the *Crown Lands Act 1989*. The management and control of the State Park has been vested in the Lake Keepit Trust which comprises members that have been appointed by the Minister for Land and Water Conservation. Revenue raised through entrance and camping fees fund day to day management of the park. Additional assistance to the Trust is provided by the Department of Land and Water Conservation. In general, State Parks are primarily managed to provide outdoor recreation. Their secondary role is the conservation of natural environments, scenery and significant cultural resources. The conservation of *Hakea pulvinifera* is a specific management objective for Lake Keepit State Park (Lake Keepit State Park Trust 1997).

4 Ecology

4.1 Life history

Little is known of the life history of *H. pulvinifera*. It is a slow growing and probably long-lived species. Benson (1988) speculates that the large individuals at the type locality may be hundreds of years old.

The species appears to be sterile and cannot reproduce from seed (Barker and Morrison 1989). Flowering within the population is short, lasting around two to three weeks, and is synchronous (P. Christie pers. obs.) with the whole population flowering at the same time. Flowering has been recorded from mid September to mid November. No fruiting has ever been recorded since the species' discovery in 1949. The woody remnants of the rachis, the short stalk which attaches the fruit to the stem, have not been observed. This provides strong circumstantial evidence of the inability of *H. pulvinifera* to produce fruit or seed, as the woody fruits or valves (open fruits minus the seed) of *Hakea* species are typically retained on plants for extended periods (Barker & Morrison 1989, Barker *et al.* 1996).

Investigations of fresh, fixed and dried flowers have shown them to be sterile, with no evidence of fertile pollen. Pollen grains, when present, are devoid of content and significantly smaller than related *Hakea* taxa (Barker & Morrison 1989, W. Barker pers. comm.).

A number of hypotheses have been put forward to explain the lack of sexual reproductive success within the population and the apparent pollen inviability in this species. Potential causes of sterility include:

- inbreeding depression (Benson 1988);
- hybridisation (of extinct or regionally extinct progenitors);
- climate change and subsequent absence or corruption of environmental cues to development (W. Barker pers. comm.);
- the persistence of vegetatively reproducing 'recombinants' which have survived the original outcrossing population; or
- the emergence of polyploidy or some other major genomic structural change within a single plant progenitor (W. Barker pers. comm.).

The species is able to reproduce vegetatively via root-suckers (J. Benson pers. comm.). As such, it is feasible, that the entire population of *Hakea pulvinifera* is clonal and all putative individuals are actually ramets of a single or limited number of genets. Vegetative recruitment is rarely observed. Several recent recruits appear to be root suckers (M. White pers. obs. 1998, see also Figure 2).

Figure 2. Vegetative reproduction - a recently emerged root sucker.

4.2 Disturbance regimes

The site has not been burnt in recent years (Benson 1988, I. Thompson pers. comm.). Although there is some evidence of past fires in the form of burnt *Callitris glaucophylla* (White Cypress-pine) stumps. The response of *Hakea pulvinifera* to fire is unknown. *Hakea divaricata* another 'corkwood' *Hakea* resprouts from rootstock following fire (Griffin 1985, D. Albrecht pers. comm.). The persistence of *Hakea pulvinifera* at the Lake Keepit site suggests a tolerance to fire and extended drought.

The age structure of the *C. glaucophylla* population at the site and in the surrounding landscape would suggest that it is currently becoming more abundant and dominant as there is a high percentage of young and\or recently germinated pines. At least two adult *Hakea pulvinifera* individuals appear to have succumbed to invasion as they were dead beside young *C. glaucophylla* trees. However, this evidence is speculative.

4.3 Population structure

There are less than 150 individual plants comprising the only known population. In general, individuals are well spaced. Benson (1988) recorded at least two size classes within the population, suggesting that reproduction may accompany environmental 'episodes' (environmental events that trigger recruitment). Until recently there has been limited documentation of recruitment (from either seed or root suckers). Three recruits, which were less than 15cm in height, were observed in Autumn 1998. Each were within 2.5 m of larger 'adult' plants and were probably root suckers, although this was not confirmed.

Most of the oldest age class of individuals is considered senescent and the population as a whole appears to be moribund and in a protracted decline. There appears to be a high degree of recent mortality. Of the 18 individuals tagged for monitoring purposes in 1988, one was confirmed dead and three could not be relocated.

5 Habitat

H. pulvinifera occurs on a steep west facing slope that ranges from 30-50 degrees. The altitude is around 320 m above sea level. Throughout much of the year, the site is hot and dry, being exposed to direct sunlight through the hottest parts of the day. The *H. pulvinifera* population is relatively well protected from wildfire by the proximity of the river to the immediate west of the site, the sweeping meander bends in the river to the north, by the local topographic relief (ie steep slopes) and general lack of fine fuels (Figure 3).

The lithology of the site is coarse polymitic conglomerate in a matrix of greywacke composition. This formation is the 'Keepit Conglomerate' the 'type section' of which occurs just above the *H. pulvinifera* site (Voisey and Packam 1969). The area is well-drained and the soils are derived from Keepit Conglomerate which appears to have a high feldspar content (Benson 1988).

The climate of the area is 'dry-sub-tropical'. Winters are typically mild to cool with moderate rainfall, while summers are hot, and punctuated by heavy rainfall events. The average annual rainfall of nearby Gunnedah is 614 mm (Figure 4).

The vegetation of the site is sparse low-open woodland dominated by *Callitris glaucophylla* in the highest stratum. *H. pulvinifera* is prevalent in an open middle stratum with *Alstonia constricta* and *Acacia decora* also present as shrubs. A sparse cover of grasses and forbs forms a ground layer but at least 50% of the site is bare earth or rock (Benson 1988). Common ground cover species include the introduced annuals *Verbascum virgatum* and *Petrorhagia nantueilli* (Proliferous

photo P. Christie

Figure 3. Habitat of *Hakea pulvinifera*. Note the gnarled shrubs in the immediate foreground growing on the slopes above the river. This photograph was taken in spring 1998 following exceptional cool seasonal rainfall.

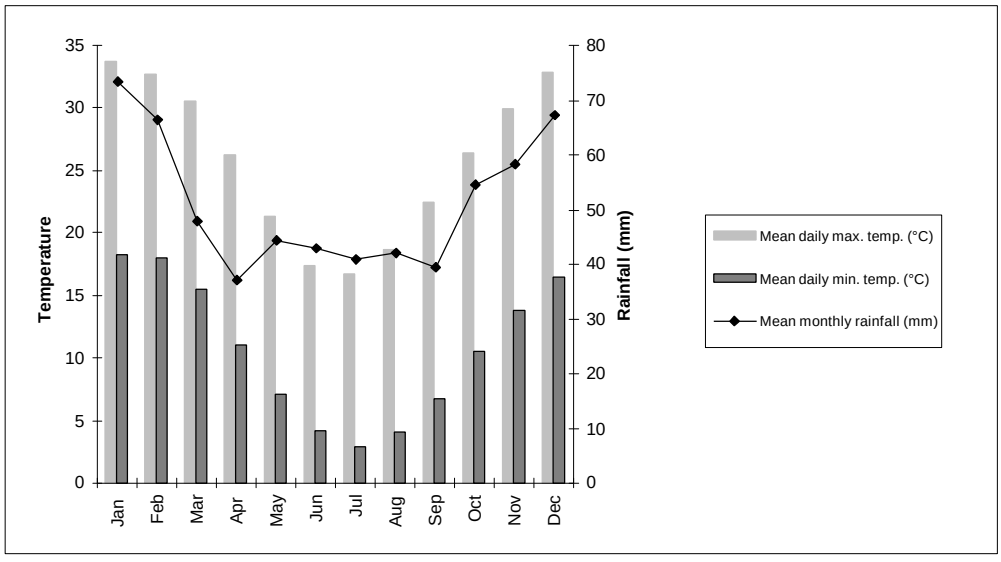

Figure 4. Mean monthly rainfall and temperature for Gunnedah (source Bureau of Meteorology)

pink), and the native grasses *Themeda australis*, *Cymbopogon obtectus* and *Heteropogon contorta*.

The site was part of a pastoral property prior to Government acquisition. It may have been partially cleared and has been subject to grazing by both cattle and sheep. However, much of the site is extremely steep and probably has been subject to only low grazing pressure.

6 Relevant Legislation

Lake Keepit State Park is reserved under the *Crown Lands Act* 1989. The management of Lake Keepit State Park is the responsibility of the Board of Trustees and the Department of Land and Water Conservation.

As a species of native flora, *H. pulvinifera* is protected on lands in the ownership of the Crown under the provisions of the *National Parks and Wildlife Act* 1974.

H. pulvinifera is listed in Schedule 1 of the *Threatened Species Conservation Act* 1995 (TSC Act) as an endangered species. It is a serious offence to harm, pick or damage the habitat of a threatened species unless the damage is the result of activities which have been licensed under section 91 of the TSC Act, or have otherwise gained approval under the *Environmental Planning and Assessment Act* 1979.

H. pulvinifera is also listed in Schedule 1 Part 1 of the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act) as an 'endangered' species. The ESP Act protects threatened species in Commonwealth areas and regulates the activities of Commonwealth agencies.

6.2 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. At present, no critical habitat has been declared for this species under the TSC Act.

6.3 Environmental assessment

The TSC Act amendments to the environmental assessment provisions of the *Environmental Planning and Assessment Act* 1979 (EP&A Act) requires that consent and determining authorities consider relevant recovery plans when exercising a decision making function under Parts 4 & 5 of the EP&A Act. When considering activities which may affect the remaining population of *Hakea*

pulvinifera, the Department of Land & Water Conservation or Manilla Shire, must consider the conservation strategy for this species outlined in this plan.

7 Management Issues

7.1 Threats and reasons for decline

There is no evidence for either the decline or expansion of the single population of *Hakea pulvinifera*. It is likely that it was never widespread or abundant prior to European settlement. The species may be in the final throes of a largely 'natural' extinction event - a process which has been operating over extended periods of time or it may be in an early expansion phase. The inability of the species to reproduce and disperse via seed is implicated in its narrowly circumscribed geographic range. It is a matter of conjecture as to why the species has lost this ability or whether it ever exhibited this trait.

Its extreme geographic rarity and small population size renders *H. pulvinifera* susceptible to stochastic threats such as disease.

7.1.2 Browsing

Some browsing damage to young or small individuals has been noted. This is likely to be the result of rabbit or macropod herbivory. Repeated browsing of the palatable growing tips of susceptible young plants may impair their development and ultimate recruitment.

7.1.3 Trampling

The subject site is very steep and as a consequence surface soils and deeply weathered substrates are loose and prone to displacement by stock and foot-traffic.

7.1.4 Invasion

The possible 'invasion' of the *H. pulvinifera* site by *Callitris glaucophylla* needs to be monitored carefully. There is some circumstantial evidence that these native Pines may be encroaching on and occupying the niche currently utilized by *Hakea pulvinifera* as three *H. pulvinifera* individuals were found dead beside young pines.

7.1.5 Disease

There is potential for the introduction of diseases, especially soil borne pathogens, to the site. The impact of disease may be catastrophic to the wild population as it has, based on existing knowledge, a limited degree of genotypic diversity and may be intimately connected via root systems. In addition, the site is adjacent to a road and a popular walking track which are potential sources of pathogen material.

7.1.6 Fire

It is unclear as to whether fire poses a direct threat to the extant population of *Hakea pulvinifera*. Many species of *Hakea* are adapted to wildfire. Typically seed is protected from fire and its dissemination is cued by fire. Also, the passage of fire often promotes new and vigorous growth from lignotubers, root suckers or epicormic shoots. It is plausible, therefore, given the extended survival of the *H. pulvinifera* population and its sole method of reproduction by suckering that most, if not all, the individuals would survive a wildfire.

The known population of *H. pulvinifera* occurs on a site that is a natural refuge from frequent and intense fire and it is feasible that the fire regime, which prevailed in the past, has influenced the current distribution of the species. As such, while a precautionary approach should be adopted with respect to fire, investigations into the fire response of related corkwood species and *H. pulvinifera* itself, is highly desirable. It is not inconceivable, given the sole method of reproduction of the species, that the absence of fire may hasten the demise of the species (B. Barker pers. comm.).

7.2 Social and economic consequences

Any adverse social and economic consequences of conserving this species are either unknown or insignificant. The land which supports the only known population is publicly owned and managed for conservation. There are currently no competing commercial or recreational uses of the site apart from grazing. Stock rarely enter the site as the slopes are prohibitively steep. The direct costs of achieving the objectives of the Recovery Plan are minimal and will be borne by Government. The cost of implementing proposed actions will be less than $37,000 net present value.

7.2.1 Scientific and taxonomic value

The events and processes that have led to the current distribution and impaired breeding system of *Hakea pulvinifera* remain unknown. Investigations into the genetic diversity inherent within the population, the age of remaining ‘individuals’ and the impediments to sexual reproduction may contribute to a better understanding of critical thresholds in the decline or even extinction of plant taxa (see also section 2.2). In addition, research into the fire response of the species and related taxa, would provide useful information on the significance of fire in the viability of plants which have similar means of vegetative propagation.

8 Previous Actions Undertaken

8.1 General history

The type collection of *H. pulvinifera* was made in October 1950 and the species was formally described in 1962 (Johnson 1962). During the late 1970's and early 1980's, the only known population was thought to have been destroyed by earthworks (Briggs *et al.* 1984). However, the population was relocated undisturbed in 1988 (Barker and Morrison 1989).

8.2 Survey of potential habitat for further populations

A survey of all potential habitat of *H. pulvinifera* within 30 km of the type location was conducted in 1998 and was funded by the NSW National Parks and Wildlife Service, Western Directorate (Hunter *et al.* 1999). Potential habitat was determined using edaphic, physiographic and geologic variables. All exposed steep rocky slopes, especially those exposed to the west, were particularly targeted. No additional populations of *H. pulvinifera* were found (Hunter *et al.* 1999). In addition, this survey did not locate any potential habitat that exactly matched the aspect, elevation, rockiness and steepness or the type and sparseness of vegetation of the type location (Hunter *et al.* 1999).

8.3 *In-situ* monitoring and management

Following the 'rediscovery' of *Hakea pulvinifera*, a preliminary survey of the population was carried out by the National Parks and Wildlife Service in 1988 (Benson 1988). Eighteen individual plants were tagged and measured for long-term monitoring purposes (Benson 1988). Subsequent to this, a small triangular area of approximately 130 m^2 was fenced to exclude rabbits and stock. The fenced exclosure contained nine individuals (five shrubs and four sub-shrubs), which comprised less than 10% of the entire population.

The 18 tagged plants were relocated ten years later and observations made of growth and condition. One plant was confirmed dead and three could not be relocated (M. White pers. obs. May 1998). Height growth was negligible. There appeared to be no difference in growth or survival between plants inside and outside the exclosure.

8.4 *Ex-situ* propagation and conservation

Over the last 10 years the Australian National Botanic Gardens (ANBG) has been trialing techniques for the propagation of *Hakea pulvinifera* (McAuliffe 1996). The difficulties in striking cuttings, the limited quantities of suitable cutting material available and slow growth rates have acted against the development of a successful

propagation technique (J. McAuliffe pers. comm.). However, after extensive trials the ANBG have more than 10 actively growing individuals in cultivation and have developed a successful propagation technique. Cutting material is slow growing and cuttings are now being grafted onto the rootstock of *Hakea salicifolia* to improve growth rates and increase the quantity of further propagative material (J. McAuliffe pers. comm.).

In addition, Jones (1997) has investigated the efficacy of various vegetative propagation techniques including *in-vitro* tissue culture, air layering, and cuttings. A consistently successful technique for the production of complete plants was not found. However, the results indicate that the use of *in-vitro* propagation techniques may be successful where propagative material is acquired from explants grown in optimal conditions, as opposed to material collected from the wild population. To this end, a living individual was removed from the wild population (Jones 1997) and is still in cultivation at the University of New England.

8.5 Population genetics

Preliminary work has been carried out by the Centre for Plant Biodiversity Research in Canberra to examine the degree of heterogeneity within the *H. pulvinifera* population. Electrophoretic assays, across 11 enzyme systems, were compared for 17 individuals collected randomly within the population. No variation was detected between individuals sampled (I. Sharma pers. comm.). This work supports the hypothesis that the population comprises a single clone.

9 Species Ability to Recover

It is most likely that *Hakea pulvinifera* is 'endangered' and highly restricted as a result of 'natural' ecological and evolutionary processes. As such, the objective of any recovery effort is to manage the known population such that it is protected from factors that may precipitate an accelerated or 'unnatural' decline.

The prognosis for the remaining wild population in the short to medium term (the next 50 years) would appear to be reasonable. However, given the restricted area in which the population occurs and the limited genetic resources of the population, the eventual demise of the species in the wild may be inevitable.

10 Recovery Objectives and Performance Criteria

10.1 Objectives of the Recovery Plan

The overall objectives of this recovery plan are to:

1. ensure that human impacts on the wild population of *H. pulvinifera* are minimised such that the species continues to pursue its own evolutionary destiny; and
2. establish *ex-situ* populations of *H. pulvinifera* to be maintained in perpetuity.

Specific objectives are:

1. to survey potential habitat for further populations;
2. establish a monitoring program for *H. pulvinifera* at Lake Keepit State Park;
3. undertake further analysis of the genetic variation within the *H. pulvinifera* population;
4. establish secure *ex-situ* populations of *H. pulvinifera*;
5. minimise the risks to the population posed by soil borne pathogens and disease; and
6. monitor, and where necessary control, the invasion of *Callitris glaucophylla* at the Lake Keepit site.

10.2 Recovery performance criteria

Recovery criteria are that:

- survey of all potential habitat is completed;
- monitoring program is designed and base line data collected;
- secure and self-sustaining *ex-situ* population of *H. pulvinifera* is established which is representative of the genetic diversity in the wild population;
- site hygiene and access protocol is implemented; and
- mortality resulting from invasion by *C. glaucophylla* is ameliorated.

11 Recovery Actions

11.1 Action 1 – Survey

Undertake a survey of potential habitat for *H. pulvinifera.* Although the type location of *H. pulvinifera* appears to be unique in its exposed, precipitous and west-facing physiography (Hunter 1999), one further search is warranted. This final survey would be best conducted outside the 30km radius of Lake Keepit that was previously surveyed and be targeted toward areas to the north and west of Lake Keepit (Hunter 1999). This survey will be conducted in October during flowering.

Outcome:
Increased certainty of the total population size and distribution of *H. pulvinifera* in New South Wales. The discovery of further populations of *H. pulvinifera* would have ramifications for the recovery of the species, particularly if found to have a different genetic makeup.

Action 1	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005
Survey	5000				
Total					**$ 5000**

Agency responsible for implementation

New South Wales National Parks and Wildlife Service. Survey work will be carried out by contractors.

Funding source

New South Wales National Parks and Wildlife Service.

11.2 Action 2 - Monitoring

Undertake annual monitoring in October of the wild population of *Hakea pulvinifera* at Lake Keepit to examine changes in population structure and to monitor the overall health of the population. The monitoring program will involve:

- All individuals being tagged and measured and health, mortality and recruitment recorded. Photopoints will also be established and herbivore scat abundance estimated;
- The population being mapped in detail and floristic data collected; and
- Active and potential threats being assessed.

Outcome:
Population and threatening processes are monitored.

Action 2	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005
Initial set up and measurements	1250				
Annual monitoring		1000	1000	1000	1000
Total					**$ 5250**

Agency responsible for implementation

New South Wales National Parks and Wildlife Service.

Funding source

New South Wales National Parks and Wildlife Service.

11.3 Action 3 - *Ex-situ* conservation and genetic diversity research

Continue to develop a secure and genetically representative *ex-situ* population of *H. pulvinifera* at the Australian National Botanic Gardens. In order to achieve this, it will be necessary to establish the extent and pattern of genetic diversity within the wild population. While there is some evidence to suggest that the wild population is clonal, the number of genets has not been established with any certainty. Some electrophoretic studies examining differences in enzyme systems have indicated strongly that there is only a single individual genet. Further genetic work is warranted to confirm or deny this hypothesis. Although enzyme polymorphism is common below the species level, more sensitive assays should be carried out on the population. DNA fingerprinting techniques should be employed to resolve these questions. If additional genetic variation within the population is identified, further collection of cuttings from the appropriate individuals will be undertaken.

Action 3	**2000/2001**	**2001/2002**	**2002/2003**	**2003/2004**	**2004/2005**
DNA "fingerprinting"		15000			
Ex-situ conservation	2000	2080	2160	2250	2340
Total					**$25830**

Outcome:
A secure and self-sustaining *ex-situ* population of *H. pulvinifera* is established which reflects the full genetic diversity of the wild population.

Agency responsible for implementation

Genetic variability research - New South Wales National Parks and Wildlife Service. Genetic assays will be carried out on a fee for service basis.

Ex-situ conservation - Australian National Botanic Gardens.

Funding source

Genetic variability research - New South Wales National Parks and Wildlife Service.

Ex-situ conservation - Australian National Botanic Gardens.

11.4 Action 4 - Site hygiene and site access

Implement the following site hygiene and access policy.

1. Inform all relevant land managers workers/contractors of the location of the *H. pulvinifera* population to prevent any unintentional damage or pathogen introduction.
2. Information regarding the exact location of the wild population will not be advertised.
3. Visitation to the site will be regulated. Access will be restricted to approved scientific and management purposes consistent with the policies and actions contained in this plan. Prior to permitting access to the site, researchers and management staff must agree to comply with the following site hygiene guidelines:

    - clean, soil free shoes or boots must be carried for use on the site.
    - all equipment such as secateurs, shovels etc. must be sterilised prior to use on the site.

Outcome:
Disease threats will be mitigated.

Agency responsible for implementation

Lake Keepit State Park Trust and New South Wales National Parks and Wildlife Service- Western Directorate.

11.5 Action 5 - Pine control

Juvenile White Cypress Pines (*Callitris glaucophylla*) will be controlled using mechanical methods if their encroachment is considered to be threatening the survival of any *H. pulvinifera* individuals.

Outcome:
Extant population protected from invasion by *C. glaucophylla*.

Action 5	**2000/2001**	**2001/2002**	**2002/2003**	**2003/2004**	**2004/2005**
Mechanical removal		$100	$108		$117
Total					**$325**

Agency responsible for implementation

Lake Keepit State Park Trust with advice from New South Wales National Parks and Wildlife Service.

Funding source

Lake Keepit State Park Trust and New South Wales National Parks and Wildlife Service.

12 Alternative Management Strategies

This section considers a series of options for the recovery of *H. pulvinifera*.

12.1 Option 1. No management action taken

As the species is known from just one locality in New South Wales and appears to be sterile and unable to reproduce, an alternative strategy is not to undertake any management for the species.

This approach is not considered appropriate, as a stated objective of the TSC Act is the conservation of biodiversity and the recovery of threatened species within NSW. In addition, *H. pulvinifera* is listed nationally as endangered and Lake Keepit is the only known location for this species in the world.

12.2 Option 2. Fencing to reduce grazing impacts

A fence around the *H. pulvinifera* population that is rabbit, stock and macropod proof will eliminate browsing and trampling damage.

This alternative action is not considered appropriate at present as grazing does not appear to be having a marked effect on the *H. pulvinifera* population. There is no obvious difference in recruitment or growth between individuals in the small exclosure erected in 1988 and those outside (M. White personal observation). In addition, it is not known whether fencing per se will result in harmful effects. For example, *H. pulvinifera* may require disturbance, such as trampling, for regeneration.

If fencing is deemed necessary in the future then only the southern half of the population should be fenced off from herbivores (rabbits, cattle and macropods) in the first instance (Benson 1988). This will entail an enclosure of 30*50m and will allow at least a gross comparison between the fenced and unfenced population over time.

13 Implementation

The following table allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies for the period 2000 to 2005.

Table 2: Implementation schedule

Section	Description	Responsibility for implementation	Timeframe	Priority	Cost
11.1	Survey	NPWS	2000/01	High	$5000
11.2	Monitoring	NPWS	Ongoing	High	$5250
11.3	*Ex-situ* conservation	ANBG	Ongoing	High	$10830
11.3	Genetic variability analysis	NPWS, ANBG	2001/02	Low	$15000
11.4	Site hygiene	NPWS	Ongoing	High	
11.5	Pine control	LKSPT	Ongoing	Medium	$325
				Total	**$36405**

ANBG= Australian National Botanic Gardens
LKSPT= Lake Keepit State Park Trust

13.1 Review date

This plan will be reviewed 5 years from the date of publication.

References

Barker, R.M., Barker, W.R. & Haegi, L. (1996). *Hakea.* In *Flora of Victoria Volume 3* (eds) N.G. Walsh & T. Entwisle. Royal Botanic Gardens Melbourne, National Herbarium of Victoria. Inkata Press.

Barker, W.R. (1999). *Hakea* "Lorea group". *In* Barker, R.M., Barker, W.R. & Haegi, L. *Flora of Australia* volume **18**.

Barker, W.R. and Morrison, S.P. (1989). *Hakea pulvinifera* L. Johnson (Proteaceae): A rediscovered species under threat. *Journal of the Adelaide Botanic Gardens* **11**, 175-178.

Benson, J. (1988). Survey report on *Hakea pulvinifera* (Proteaceae) L. Johnson, Lake Keepit State Recreation Area. New South Wales National Parks and Wildlife Service internal report.

Briggs, J.D. Boden,.R. & Leigh, J.H. (1984). *Extinct and Endangered Plants of Australia*. Macmillan Australia.

Briggs, J.D. & Leigh, J.H. (1996). *Rare or Threatened Australian Plants*. Centre for Plant Biodiversity Research, CSIRO Australia.

Griffin, G.F. (1985). *Manual for collection and analysis of data for fire behaviour predictions: applications of a fire management strategy at Uluru National Park.* Technical Memorandum No. 22, CSIRO.

Harden, G.J. (1991). *Hakea*. *In Flora of New South Wales Volume 2* (ed) G.J. Harden. Royal Botanic Gardens Sydney, New South Wales University Press.

Hunter, J. T., Bell, D. M. and Earl, J. (1999). Survey for *Hakea pulvinifera* in the Lake Keepit area. New South Wales National Parks and Wildlife Service internal report.

Jones, E. (1997). Conservation of Rare *Hakea pulvinifera*. Unpublished Honours Thesis. Faculty of Sciences, University of New England, Armidale, NSW.

Johnson, L.A.S. (1962). Taxonomic notes on Australian plants. *Contr. NSW Nat. Herb.* **3**:93-102.

Lake Keepit State Park Trust (1997). Draft Lake Keepit State Park Management Plan 1997. Unpublished.

McAuliffe, J (1996). Propagation success with Endangered Species: *Hakea pulvinifera. Danthonia* **4**:11.

Voisey, A.H. & Packham, G.H. (1969). "Upper Devonian Series" in *The Geology of NSW* ed G.H. Packham. Mercury Press.

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

43 Bridge Street
Hurstville 2220
(02) 9585 6444