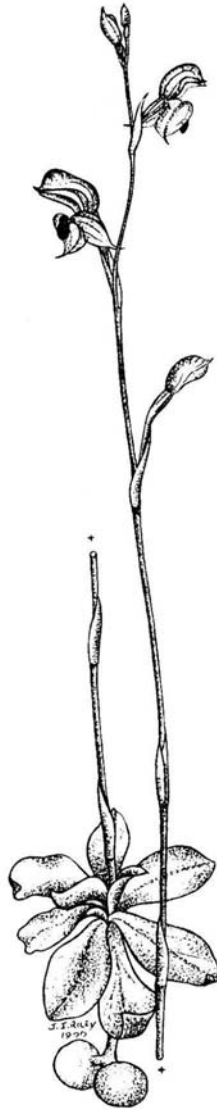


Pterostylis gibbosa (R.Br.) Illawarra Greenhood Orchid



September 2002



Natural Heritage Trust
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NSW National Parks and Wildlife Service Recovery Planning Program

Illawarra Greenhood Orchid
(*Pterostylis gibbosa*)
Recovery Plan

**Prepared in accordance with the New South Wales
Threatened Species Conservation Act 1995 and the Commonwealth *Environment
Protection and Biodiversity Conservation Act 1999***

September 2002

Acknowledgments

This Recovery Plan is a revision of the plan prepared for the Australian Nature Conservation Agency (ANCA) in 1994. The NSW National Parks and Wildlife Service (NPWS) acknowledges all those individuals who contributed to the preparation of that Plan.

This revised recovery plan is the combined effort of a large number of people who have contributed to the survey and research on the species. The NPWS thanks the following:

The *Pterostylis gibbosa* Recovery Team for advice on the preparation of the Recovery Plan, particularly Professor Rob Whelan and Inger Taylor, University of Wollongong and Graeme Bradburn, Illawarra Australasian Native Orchid Society (Illawarra ANOS).

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Robert Humphries (NPWS) for advice and comments on the recovery strategy.

Foreword

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

The preparation and implementation of recovery plans is identified by both the National Strategy for the Conservation of Australia's Biological Diversity and the NSW Biodiversity Strategy as a key strategy for the conservation of threatened flora, fauna and invertebrates. The object of a recovery plan is to document the 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 the Illawarra Greenhood Orchid (*Pterostylis gibbosa*), documents the research and management actions undertaken to date, and identifies the actions required and parties responsible to ensure the ongoing management of the taxon in nature.

The Illawarra Greenhood Orchid Recovery Plan was prepared with the assistance of a recovery team comprising relevant land management and research interests, and was placed on public exhibition during January and February 2001. I thank these people for their efforts to date and I look forward to their continued involvement in the implementation of recovery actions identified in this plan.



BOB DEBUS MP

Minister for the Environment

Executive Summary

Introduction

Pterostylis gibbosa, the Illawarra Greenhood orchid, is a deciduous terrestrial orchid belonging to the Rufa group of species within the genus *Pterostylis*. *P. gibbosa* is known from five locations in NSW with a total estimated population of approximately 4500 individuals.

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

Current conservation status

Pterostylis gibbosa is listed as nationally endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. It is also listed as endangered on Schedule 1 of the NSW *Threatened Species Conservation Act 1995* (TSC Act). *P. gibbosa* is restricted to three sites within isolated patches of woodland in the Illawarra (Shellharbour and Wollongong LGAs), one site in Worrigee Nature Reserve, near Nowra in the Shoalhaven (Shoalhaven LGA) and one site at Milbrodale in the Hunter Valley (Singleton LGA).

Legislative context

The TSC Act is the legislative framework to protect and encourage the recovery of threatened species, populations and communities in NSW. 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 the plan

This Recovery Plan has been prepared with the assistance of a recovery team, a non-statutory group of interested parties with relevant expertise, established to discuss 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 knowledge available to the NPWS on the date it was approved.

A draft of this Recovery Plan was placed on public exhibition for the period 13 January 2001 to 24 February 2001. Four written submissions were received including that of the NSW Scientific Committee. These submissions were considered during the finalisation of the plan.

The plan will be reviewed and updated five years from the date of publication.

Implementation of the plan

The TSC Act requires that Ministers and Public Authorities (including the Director-General of National Parks and Wildlife) are to take appropriate action available to them to implement those measures in a recovery plan for which they are identified as being responsible. In addition, a Minister or Public Authority must not undertake actions inconsistent with an approved recovery plan. Public Authorities relevant to this plan are the NPWS, Shellharbour, Wollongong, Singleton, and Shoalhaven Councils, and TransGrid. Consequently, these public authorities are required to manage *P. gibbosa* and its habitat in accordance with this recovery plan.

The plan will be reviewed and updated 5 years from the date of publication.

Overall objective of the Recovery Plan

The overall objective of the recovery plan is to protect known populations of *Pterostylis gibbosa* from decline and to develop a management regime, based on current knowledge, designed to promote the plant's conservation and evolutionary potential *in situ*.

Overall recovery performance criteria

The overall performance criteria are that:

- land tenure agreements are in place that protect known sites;
- management plans are prepared and implemented;
- populations are maintained or increased in current areas; and
- additional populations are located through further survey.

Species ability to recover

The likelihood of preventing the extinction of *P. gibbosa* is high. This plan provides for the increased legislative protection of known populations through the environmental planning and assessment process and other legal instruments, threat reduction and appropriate habitat management and increased community awareness and education regarding the significance of the species. Biological and ecological investigations will provide additional information, which will aid the management of the species.

Recovery objectives

The specific objectives of the recovery plan are:

- To ensure that all known *P. gibbosa* populations occurring on public and private lands are protected and managed for conservation (Reservation/Conservation status of populations);
- To minimise the risk of *P. gibbosa* populations from declining in the long term through the development and implementation of appropriate threat and habitat management practices at all known sites (Threat and Habitat Management);
- To establish the full extent of the distribution of *P. gibbosa* (Survey);
- To ensure the management of *P. gibbosa* habitat is adaptive to the outcomes of research and monitoring and is informed by essential aspects of the biology and ecology of the species; (Research/Monitoring); and
- To raise awareness among the broader community about the conservation status of *P. gibbosa* and involve the community in the recovery program (Education, Awareness and Involvement).

Summary of implementation costs

A summary of the funds required to implement this recovery plan over a 5 year period is shown in Table 1.

Table 1

Action	Description	NPWS	Shellharbour Council	Shoalhaven Council	TransGrid
10.3	Reservation/ Conservation	12500	1250	0	2500
11.3	Threat/Habitat Management	8750	25000	0	20000
12.3	Survey	13500	0	1000	0
13.3	Research/ Monitoring	16250	*	0	*
14.3	Community Education etc	3500	1500	0	0
TOTAL		54500	27750	1000	22500

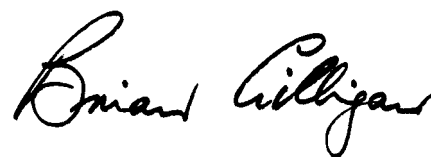
* included in implementation of PoM

Biodiversity benefits

This species is currently found in sclerophyll woodland that is poorly conserved in both the Hunter Valley and in the Illawarra. Much of the flat land in the Hunter Valley and the Illawarra coastal plain has been cleared for agriculture. Only isolated remnants remain. These remnants are important in their own right, in addition to the vital role they play in supporting populations of *P. gibbosa* and other threatened species. *P. gibbosa* has not been recorded outside these woodland communities.

The conservation and study of the Illawarra Greenhood Orchid will also benefit other species which share the same habitat. The recent listing by the NSW Scientific Committee of Illawarra Lowlands Grassy Woodland as an endangered ecological community will aid in the protection of potential *P. gibbosa* habitat in the Illawarra region.

Orchids are a high profile plant group and there is much public interest in them both horticulturally and ornamentally. Through awareness of the Illawarra Greenhood Orchid the profile of all orchids and 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.

A handwritten signature in black ink, reading "Brian Gilligan". The signature is fluid and cursive, with the first name "Brian" and the last name "Gilligan" clearly distinguishable.

**BRIAN GILLIGAN
DIRECTOR-GENERAL**

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1 **Introduction**

The Illawarra Greenhood Orchid (*Pterostylis gibbosa*) is a perennial terrestrial orchid. The tuberoid forms a flat rosette of leaves up to approximately 100 mm in diameter and the plant develops a flower spike that grows to 45 cm tall.

P. gibbosa is currently known from five locations: Milbrodale in the Hunter Valley, Yallah (2 sites) and Albion Park in the Illawarra and Nowra in the Shoalhaven. The species occurs among grasses in sclerophyll forest. The total known population size of *P. gibbosa* is approximately 4,500 plants although this is likely to be higher given the extent of the Milbrodale and Worrigee Nature Reserve populations which have not yet been fully assessed.

This Recovery Plan is a revision of the plan prepared for the Australian Nature Conservation Agency (ANCA (now Environment Australia)) in 1994. The majority of actions in the ANCA plan have been implemented including surveys on the Cumberland Plain and Illawarra regions, liaison with land managers, monitoring permanent quadrats for survivorship, flowering, capsule and seed production, and investigation of the response of *P. gibbosa* to fire.

This Plan describes our current understanding of *P. gibbosa*, reports on the implementation of the 1994 Plan and outlines the recovery program for this species for the next 5 years.

2 Legislative context

2.1 Legal status

P. gibbosa is listed as endangered in NSW on Part 1, Schedule 1 of the TSC Act.

P. gibbosa is also listed as a nationally endangered species on Schedule 1 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). As the species is listed nationally, it is eligible for funding under the Commonwealth Endangered Species Program and is protected under Commonwealth legislation.

2.2 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 Recovery Plan has been prepared in accordance with the provisions of the TSC Act and the requirements of the Commonwealth EPBC Act.

A draft of this Recovery Plan was placed on public exhibition for the period 13 January 2001 to 24 February 2001. Four written submissions were received including that of the NSW Scientific Committee. These submissions were considered during the finalisation of the plan.

2.3 Recovery Plan implementation

In NSW, the TSC Act requires that Ministers and public authorities (including the Director-General of the National Parks and Wildlife Service) take appropriate action available to them to implement those measures included in an approved recovery plan for which they are responsible. In addition, the TSC Act requires that a government agency must not undertake actions inconsistent with an approved recovery plan. The government agencies relevant to this plan are the NPWS, Shellharbour Council, Shoalhaven Council, Singleton Council, Wollongong Council, and TransGrid. Consequently, the actions outlined for each of these agencies (see sections 9 to 14 of the plan) must be implemented as described in the plan.

2.4 Relationship to other legislation

The lands on which *P. gibbosa* occurs include those that are owned and/or managed by the NPWS, TransGrid, Shellharbour Council and private landholders. Relevant legislation for *P. gibbosa* populations include:

- *National Parks and Wildlife Act 1975* (NP&W Act)
- *Threatened Species Conservation Act 1995*
- *Environmental Planning and Assessment Act 1979* (EP&A Act)
- *Local Government Act 1993*
- *Rural Fires Act 1997*

- *Native Vegetation Conservation Act 1997*
- *Forestry Act 1916*

2.5 Key Threatening Processes

High frequency fire resulting in the disruption of life cycle process in plants and animals and loss of vegetation structure and composition is listed as a key threatening process on Schedule 3 of the TSC Act. High frequency fire is defined as “two or more successive fires close enough together in time to interfere with or limit the ability of plants or animals to recruit new individuals into a population, or for plants to build-up a seedbank sufficient in size to maintain the population through the next fire” (NSW Scientific Committee Determination Advice - 99/23). The NSW Scientific Committee describes *P. gibbosa* as a species that is affected by this key threatening process in its Final Determination.

Other key threatening processes (as defined and described in their respective final determinations) that may affect *P. gibbosa* include:

- *Clearing of native vegetation*; and
- *Competition and grazing by the feral European Rabbit, Oryctolagus cuniculus (L.)*.

2.6 Critical Habitat

The TSC Act makes provision for the identification and declaration of critical habitat for species, populations and ecological communities listed as endangered. Critical Habitat, as defined in the TSC Act (s. 37), is considered to be “the whole or any part or parts of the area or areas of land comprising the habitat of an endangered species ... that is critical to the survival of the species”. Once declared, it becomes an offence to damage critical habitat (unless the action is specifically exempted by the TSC Act), a species impact statement is mandatory for all developments and activities proposed within critical habitat and the concurrence of the Director-General of National Parks and Wildlife is required before any approval is given.

To date there has been no critical habitat identified and declared for *P. gibbosa*. The feasibility of declaring critical habitat will be investigated by the recovery team following further survey (see section 10.2).

2.7 Environmental assessment

The TSC Act amendments to the environmental assessment provisions of the EP&A Act require that consent and determining authorities and the Director-General of National Parks and Wildlife, as a concurrence authority, consider relevant recovery plans when exercising a decision making function under Parts 4 & 5 of the EP&A Act.

The following public authorities are currently known to have a decision making function in relation to *P. gibbosa* and its habitat: the NPWS, Shellharbour Council, Shoalhaven Council, Singleton Council, Wollongong Council, and TransGrid.

When exercising a decision making function under the EP&A Act for any development or activity which may affect *P. gibbosa* or its habitat, these and other relevant public authorities (should additional populations be found) must consider the content and objectives of this recovery plan.

3 Conservation Status

The Illawarra Greenhood orchid is currently known from only five locations consisting of approximately 4,500 individuals. Population numbers have probably decreased since the arrival of Europeans due to clearing of habitat for grazing, urban development and other activities. Extensive surveys conducted as part of the implementation of the initial recovery plan have failed to locate any populations on the Cumberland Plain in western Sydney, where it was originally discovered in 1803. It is considered that the species is probably now extinct on the Cumberland Plain.

The species is listed as 2E (Endangered and inadequately conserved) on the Rare or Threatened Australian Plants (RoTAP) listing (Briggs and Leigh 1996).

The ROTAP ranking has not been amended to include reference to those populations in the Hunter Valley and Shoalhaven regions.

P. gibbosa is present in one conservation reserve, Worrigeen Nature Reserve.

4 Description

4.1 Description

Harden (1993) provides the following description of *Pterostylis gibbosa* in “*Flora of New South Wales*”:

“Terrestrial herb. Rosette leaves 4-7, elliptic to ovate, 1.5-3.5 cm long, 8-15 mm wide, margins entire. Scape to 45 cm high, with 3-6 closely sheathing stem leaves. Flowers 2-7, c.1.5 cm long, bright green with transparent patches in the petals and galea, tips of lateral sepals brownish, shiny, semi-erect. Dorsal sepal with an upcurved filiform point 2-3 mm long. Lateral sepals broad-ovate in outline when flattened; joined part flat, margins strongly reflexed, glabrous, free points filamentous, 3-4 mm wide, brownish black, deeply grooved; marginal trichomes 2-4 pairs, c. 2 mm long, white; basal lobe large, with numerous trichomes c. 0.3 mm long. Flowers Aug - Nov. Grows among grass in sclerophyll forest; rare, chiefly in the southern parts of the CC, with a disjunct population in the Hunter Valley. NC CC. [*P. ceriflora* Blackmore & Clemesha]" (see Figure 1).

4.2 Taxonomic Significance

Pterostylis is a genus of around 120 species confined to Australia, New Zealand, New Guinea and New Caledonia. The majority of the species are found in Australia, with the main centre of diversity being the south-east of the continent (Jones 1993). The group is easily recognisable, due to the structure of the flower, which gives rise to the common name “greenhoods”.

P. gibbosa is closely related to *Pterostylis saxicola*, being distinguished principally by features of the flower and by habitat.

The species taxonomy is as follows:

Division:	Magnoliophyta
Class:	Magnoliopsida
Subclass:	Liliidae
Order:	Orchidales
Family:	Orchidaeceae
Genus:	<i>Pterostylis</i>
Species:	<i>gibbosa</i>



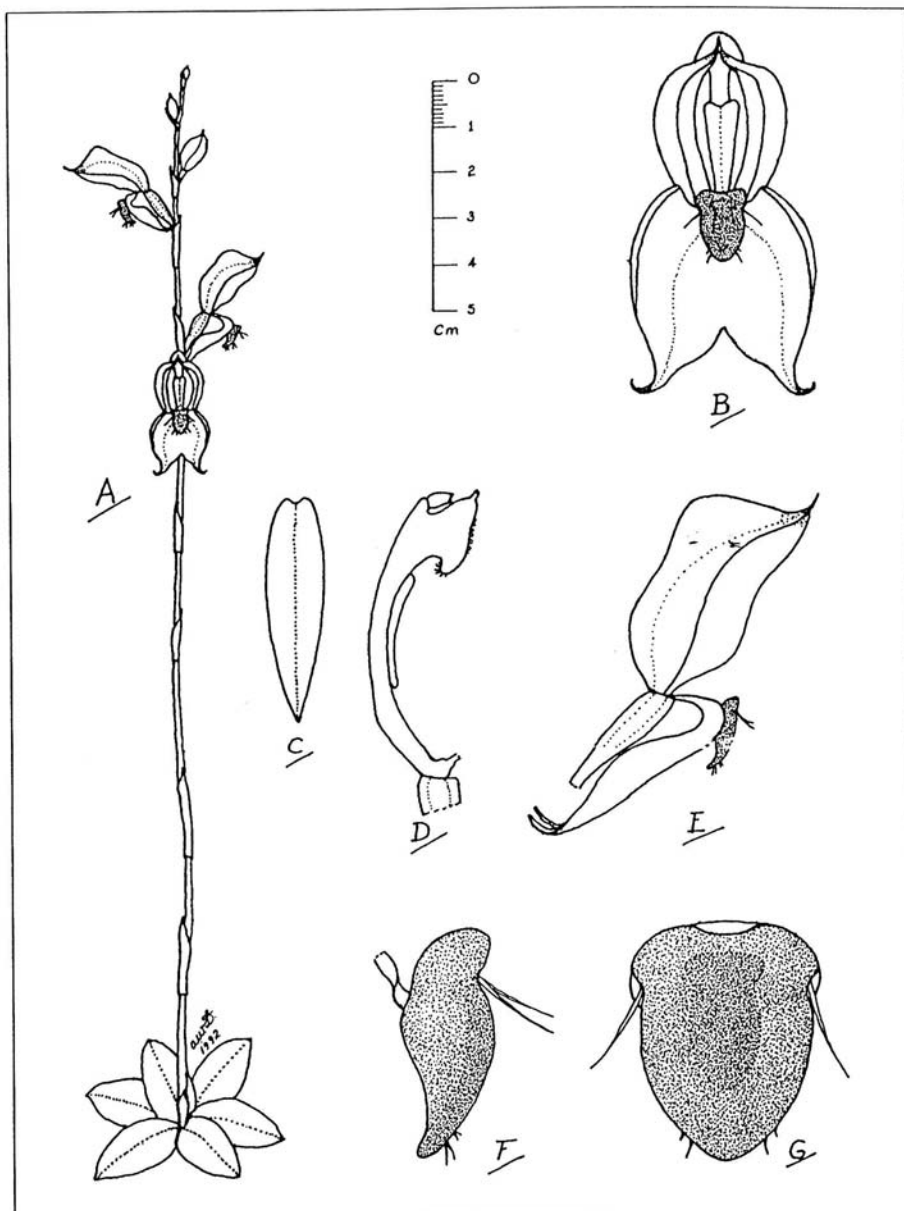
**Plate 1: Flowering *P. gibbosa* plants
(Photo R. Tunstall)**



**Plate 2: *P. gibbosa* flower
(Photo R. Tunstall)**



Plate 3: *P. gibbosa* leaf rosettes (Photo L. Johnston)



Pterostylis gibbosa R. Br., from near Lake Illawarra, N.S.W.;

a. plant,(to indicated scale); b. flower from the front,(x 3); c. stigma, (x 10); d. column from the side, (x 5); e. flower from the side (x 3); f. labellum from the side, (x 10); g. labellum from above, (x 10).

Drawing 1992 by A.W. Dockrill.©

Figure 1: *Pterostylis gibbosa* drawing by A. W. Dockrill (reproduced from *The Orchardian* Volume 12, Number 3, March 1997 with the permission of the Editor).

5 Distribution and habitat

5.1 Historical and current distribution

Pterostylis gibbosa was first collected by Robert Brown on a roadside “between Parramatta and Green Hills” in September 1803. George Caley, collector for Joseph Banks, also found specimens at “Cowpastures” between “Prospect and South Creek” in October 1803 (Jones 1997). Although Caley was the first to prepare a description of *P. gibbosa*, it was never published, and the species was formally described by Brown in 1810 in “*Prodramus Florae Novae Hollandiae et Insulae Van Diemen*”.

There is no published information on the numbers and distribution of *P. gibbosa* between its first discovery in 1803 and its re-discovery in 1967. This is probably because a large number of now separate species of *Pterostylis* (including *P. gibbosa*) were considered variations of *Pterostylis rufa* during this period (Quality Environmental Management 1994).

Currently, *P. gibbosa* is known from five locations: three sites in the Illawarra, one site in the Hunter Valley at Milbrodale, and one site near Nowra in the Shoalhaven (Figure 2).

Cumberland Plain

The above historic accounts are the last recordings of *P. gibbosa* on the Cumberland Plain. Searches by the NPWS and the Australasian Native Orchid Society (ANOS) between 1996 and 1998 have failed to find *P. gibbosa* individuals on the Cumberland Plain (see 7.2.2).

Yallah-Albion Park

In 1967, the species was collected by Brian Whitehead (McAlpine 1982) on privately owned, timbered grazing land south of Dapto at a site generally referred to as 'Yallah Bush'. In 1981 the Yallah Bush site was sold and foreshadowed for future urban development. To prevent destruction of the orchids the Heritage Council of NSW placed an Interim Conservation Order on the property. An inspection by the then Wollongong and District Native Orchid Society (now called the Illawarra ANOS) in 1987 recorded at least 100 plants at the Yallah Bush site (G Bradburn, ANOS pers. comm.). The Interim Conservation Order lapsed in 1988. It is not known if *P. gibbosa* still occurs at this site as parts of the area have been destroyed. No searches have been made of this site since 1991.

In 1983, *P. gibbosa* was found in bushland at Shellharbour Council's Croom Road Sports Complex at Albion Park. The 1993 census indicated that this site contained 575 individuals with the bulk of the population occurring in one clump of about 460 individuals (Quality Environmental Management 1994). In December 1999, the population was estimated to contain over 1000 individuals with the bulk still occurring in one clump (I. Taylor pers. comm.).

In 1984, botanical surveys for a proposed coal transport corridor indicated that additional suitable habitat for *P. gibbosa* occurred in open woodland in the Yallah area (Muston & Robinson 1984).

This was confirmed in 1987 when Graeme Bradburn of the Illawarra ANOS found two groupings of *P. gibbosa* on private property at Yallah (Bradburn 1988).

In 1988, two groups of *P. gibbosa* with an estimated total of approximately 740 individuals (including 312 in Area 1 and 428 in Area 2) were found in woodland patches to the north of the Yallah substation on property owned by TransGrid (formerly Pacific Power) (Muston & Bradburn 1988).

An annual census of *P. gibbosa* abundance at the Transgrid site has been undertaken since 1991. The census follows the design set up by Whelan and Kohler (1991) where randomly placed and selected one metre quadrats were positioned within the two fenced areas of the site. It should be noted that the census is not a population count but provides an estimate of fluctuation in the number of individuals present at the site over time.

The 1993 census for the ANCA plan counted 413 plants in quadrats (180 in Area 1 and 228 in Area 2) (Bradburn & Tunstall 1993). In 1997, there were 169 *P. gibbosa* plants in the quadrats (Areas 1 and 2) only at Yallah (Bradburn and Tunstall 1997). In 1999, the number of orchids in each of the quadrats (Areas 1 and 2) was 405 providing a total of 810 plants in those two areas (G Bradburn, ANOS pers. comm.).

Nowra

In 1969 Brian Whitehead found a flowering specimen of *P. gibbosa* among plants of *Pterostylis mutica* in the Browns Creek catchment near Nowra (Whitehead 1970). This part of the catchment has now been partially urbanised. Some areas of native vegetation remain in the catchment but these have been altered by grazing, clearing and burning.

In June 1997 between 300-600 *P. gibbosa* individuals were found in the former Currambene State Forest (now Worrigee Nature Reserve), about 1.5km south-east of Browns Creek. A survey was carried out in September 1998 to establish the distribution of *P. gibbosa* in the State Forest. To date, no attempts have been made to determine the exact size of this population.

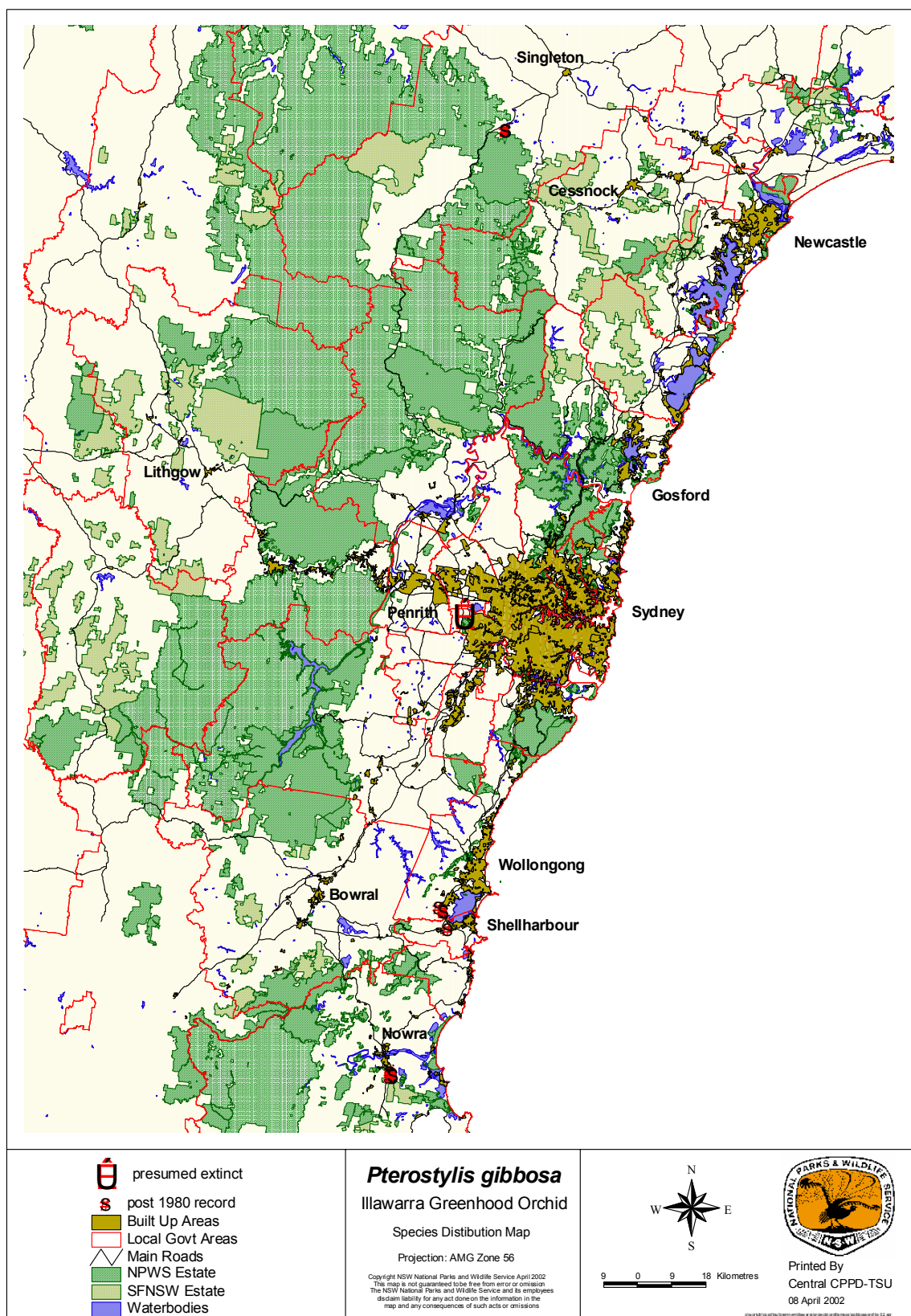


Figure 2: Distribution of *P. gibbosa* sites

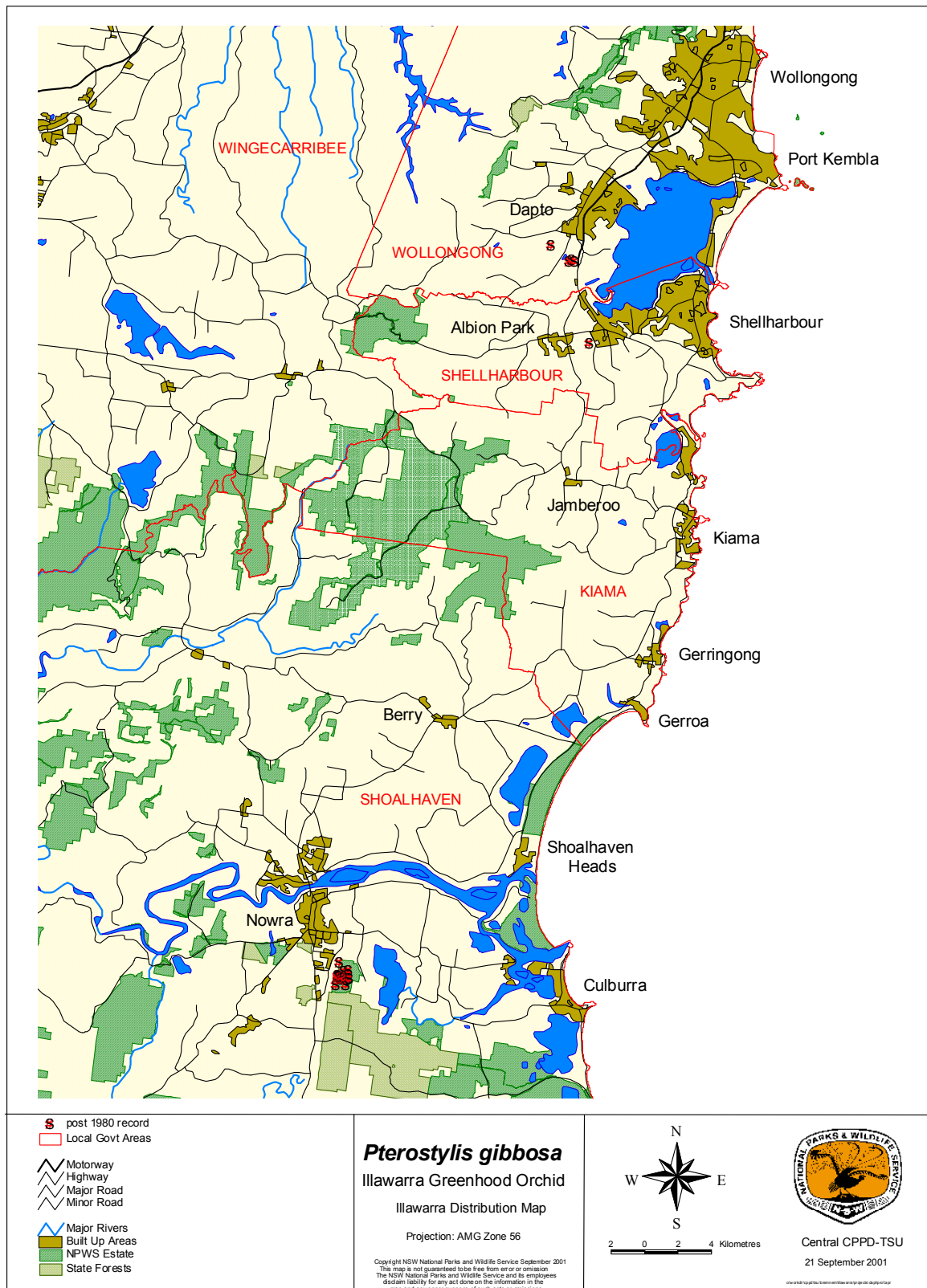


Figure 3: Southern distribution of *P. gibbosa* sites

Hunter

In 1989, orchids thought to be *P. gibbosa* were discovered on private property in the Milbrodale area of the Hunter Valley (Quality Environmental Management 1994). In 1996, these were confirmed as being *P. gibbosa* by David Jones of the Australian National Herbarium. In 1999, the Milbrodale population was estimated as comprising at least 1000 plants but it may contain up to 2000 or more (I. Taylor pers. comm.).

A count of the population has not been undertaken although monitoring of tagged plants has been carried out in 1997, 1998 and 1999. Surveys in the vicinity of the Milbrodale population did not reveal any other populations. Further surveys in the Hunter region are recommended by this Plan.

5.2 Tenure

Pterostylis gibbosa occurs on private property and land owned by Shellharbour Council, TransGrid and the NPWS. A list of tenure, zoning and management responsibility for each location is detailed in Appendix 1.

5.3 Habitat

The habitat preferences of *Pterostylis gibbosa* are difficult to identify due to variation in the species composition and vegetation types between the sites where *P. gibbosa* is known to occur.

Cumberland Plain

Nothing is known of the habitat of the original specimens of *P. gibbosa* collected on the Cumberland Plain west of Sydney, apart from the comment in George Caley's diary that the orchid was "an inhabitant of barren land" and was "much concealed by the grass". However the soil types and rainfall of the Illawarra is similar to the pattern on the Cumberland Plain (Quality Environmental Management 1994).

Yallah - Albion Park

Pterostylis gibbosa at Yallah and Albion Park occurs in woodlands with a native grass understorey. The isolated patches of woodland in which *P. gibbosa* is found in the Illawarra have, until the last few decades, been grazed by domestic stock. The woodland patches presently at these sites are not considered to be representative of the original vegetation. The remnants represent species which are tolerant to disturbance and include *Eucalyptus teriticornis* (Forest Red Gum), *Melaleuca decora* (White Feather



Plate 4: Woodland habitat of *P. gibbosa* at Albion Park (Photo NPWS)

Honeymyrtle), *Acacia falcata*, *Leucopogon juniperinus* (Bearded Heath) and *Themeda australis* (Kangaroo Grass).

Nowra

At Nowra, the plant community is an open forest. The presence of *Eucalyptus maculata* (Spotted Gum) is a distinguishing feature of the forest in the area. Structurally and floristically this area is distinct from other *P. gibbosa* sites in the Illawarra and the Hunter with species such as *Eucalyptus paniculata* (Grey Ironbark) and *Exocarpus cupressiformis* (Cherry Ballart). The leaf litter at this site is quite abundant and in some years it is very deep.

Milbrodale

In the Hunter Valley *P. gibbosa* occurs in open woodland dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark), *Eucalyptus moluccana* (Grey Box) with a sub-dominant of *Callitris endlicheri* (Black Cypress Pine). The understorey is thick with *Dodonaea cuneata* with varying amounts of leaf litter. Some of the *P. gibbosa* plants were found on bare soil underneath stands of *Callitris endlicheri*.

A list of major species associated with *P. gibbosa* at the various sites is provided in Appendix 2.

5.4 Geology and Soils

The populations at Albion Park, Yallah and Nowra all occur on soils derived from the Berry formation, a Permian sediment composed of undifferentiated siltstone, shale and sandstone. Yallah and Albion Park are between 10-20 metres above sea level while the Nowra populations are between 20-30 metres.

The soils have a seasonally hardsetting, acid (pH 5 - 5.5) surface horizon, 10 - 20 cm thick with a loam to clay loam texture. This overlies a mottled, acid (pH 5 - 5.5) subsoil with a heavy clay texture. These soils are poorly drained, although in the areas where *P. gibbosa* occurs they are only likely to be waterlogged for short periods following heavy rain

The population at Milbrodale in the Hunter Valley is found at an altitude of 150-160 metres on soils derived from the Narrabeen Group, a Triassic sediment composed of sandstone, conglomerate, red and green claystone and shale. The topsoil is a sandy loam with an orangey-yellow clay subsoil. Ironstone gravel is common in the profile.

The soils are all leached, acidic and have a clay subsoil that impedes drainage.

5.5 Aspect and slope

All sites are flat or only gently sloping. In the Illawarra and at Nowra, the populations occur on the coastal plain to the east of the escarpment. In the Hunter Valley, the population occurs on a north-west facing terrace about 50 metres above the valley floor. The terrace at this point is between 100 - 500 metres wide before the land rises another 270 metres to the ridgetop.

5.6 Climate

The mean total annual rainfall using available data between 1970 and 1999 for Wollongong University, which is the closest site to the Yallah populations, is 1401.1 mm. January receives an average of 143.3 mm, June receives 120.2 mm and September receives a mean of 73.6 mm.

The mean total annual rainfall using available data between 1892 and 1999 for Albion Park is 1102.1 mm. January receives an average of 107.9 mm, June receives 59.1 mm and September receives a mean of 62.0 mm.

The mean total annual rainfall using available data between 1969 and 1999 for Milbrodale is 772.6 mm. January receives an average of 102.5 mm, June receives 41.1 mm and September receives a mean of 46.6 mm.

The mean total annual rainfall using available data between 1942 and 1999 for Nowra which is the closest measuring site for the Worrigee Nature Reserve population is 1090.7 mm. January receives an average of 91.4 mm, June receives 107.8 mm and September receives a mean of 65.7 mm.

The seasonal pattern of rainfall is broadly similar at all sites. Rainfall is highest in summer and autumn falling to a low in late winter and increasing throughout the spring.

6 Biology and ecology

6.1 Life Cycle and Habit

Pterostylis gibbosa is a deciduous, perennial plant that dies back to an underground tuberoid during the summer season. During late summer or autumn the tuberoid produces a flat rosette of leaves up to 100 mm in diameter. In winter the flower spike develops and grows up to 45 cm tall. After flowering in September - October, the rosette withers as the fruits develop. The basal rosette of leaves often withers as the flower stalk emerges but may persist if there are cool, moist conditions in spring. The original tuberoid dies each year with a replacement tuberoid being formed on a small stolon or 'dropper'. Each year the plant will emerge in a slightly different location (but within a centimetre or so), depending on the length of the stolon to the new tuberoid. Time of emergence and time of desiccation are very dependent on the prevailing climatic conditions. In wet seasons, the plant emerges earlier and survives longer above ground (Recovery Team pers. comm.).

6.2 Phenology

Flowering occurs from late August and can last until early December in favourable seasons. Usually up to nine or ten (although up to 12 have been observed by Taylor (1999)) apple-green, hooded, waxy flowers are formed per spike. The lowest flowers open first, with opening occurring progressively up the spike as the lower flowers close and wither.

6.3 Reproductive Biology

6.3.1 Vegetative reproduction

Pterostylis gibbosa does not spread vegetatively to any great extent. Under exceptionally favourable conditions, a single plant can produce more than one new tuberoid in the same winter season. Additionally, an extra tuberoid could be produced in response to damage to the new tuberoid as a replacement to the damaged one (G. Bradburn, ANOS pers. comm.). In cultivation more than one tuber can be formed by removing new tubers prematurely. The plant responds by developing a new tuber from the rosette and by producing a new rosette from the tuber. This procedure can be successful more than once in the one season with optimised growing conditions in cultivation or occasionally in the field if climatic conditions allow.

6.3.2 Breeding System

Pterostylis species are generally pollinated by male gnats of the genus *Mycomya*. These insects are called fungus gnats, as one species has larvae that live in silken tubes on the underside of bracket fungi. Only two or three other genera are implicated in the pollination of *Pterostylis*, but these are regarded as being of minor significance (D. Colless, CSIRO pers. comm.). The male *Mycomya* are deceived into attempting to copulate with the labellum. The labellum is located on the end of a sensitive elastic strap that flips upwards in response to disturbance to partially block the opening of the hood.

In order for pollination to occur, the pollinator lands on the labellum with its dorsal side towards the flower. This triggers the labellum to spring back and trap the insect with its front end towards the top of the hood and against the column, where the stigma and anthers with the pollinia are positioned. If the right pollinator is trapped it will be able to crawl out through the opening at the

top of the hood passing the stigma, where any pollen from previously visited flowers will rub off and then past the anthers where the pollinia will adhere to its head or back. If insects smaller than the pollinator become trapped they may crawl out without pollination occurring or, if larger than the pollinator, they may stay trapped until the labellum opens again.

Nothing is known of the habitat requirements of *Mycomya*. They are probably very common, but are not often seen due to their small size (D. Colless, CSIRO pers. comm.). Abundance is believed to peak in September, which is the main month of flowering of *P. gibbosa*.

Movement of the labellum has also been observed without any apparent triggering by an insect (Whelan & Kohler 1991). During one observation period, the labellum of selected flowers in one grouping covering several hectares were all closed prior to sunrise but began to open after sunrise. The labella of most of the observed orchids did not close again until well after dusk.

During a study by Zedler (1994), one insect was found with orchid pollinium attached and is thought to be a potential pollinator of *P. gibbosa*. It was sent to the CSIRO Division of Entomology for identification. This insect has not previously been described but is a Mycerophilid (fungus gnat) of the genus *Heteropterna* in the family Keroplatidae.

A study conducted by Whelan & Kohler (1991) at Yallah showed that, in 1990, only 8% of the flowers had pollinia removed. Darwin (1886) reported that in a New Zealand *Pterostylis* species the flower-to-capsule ratio was “much less than a quarter”, which may indicate that the pollination rate should perhaps not be expected to be very high if this is true for other *Pterostylis* species. Only 11% of the flowers set fruit. Artificially self and cross-pollinated flowers both set seed, however it is not known if the seed produced by artificial self-pollination was viable (Whelan and Kohler, 1991). Genetic investigations in the same study confirmed that the orchid reproduces by outcrossing (R. Peakall, Australian National University pers. comm.), as genetic variability within the Transgrid populations was consistent with random mating, not selfing or clonal spread.

In an Honours project by Taylor (1999) on herbivory and pollination of *Pterostylis gibbosa* in four populations the flower-to-capsule ratio (pollination rate) was found to be 19% at Nowra, 14% at Milbrodale and 5% for both Yallah and Albion Park. The density of plants at Nowra was lower than at other sites yet it has the highest pollination rate. This may indicate that there may be factors other than density such as pollinator availability that are important for pollination success. The Nowra and Milbrodale sites adjoin surrounding forests, which is potential pollinator habitat. In contrast, the Yallah and Albion Park sites are surrounded by agricultural and urban land use. The limited potential pollinator habitat and use of pesticides and other chemicals may have an impact in reducing the number of available pollinators for these two sites and thereby lowering the pollination rate.

6.3.3 Fruiting

The fruit of *P. gibbosa* is a dry, dehiscent, obovoid capsule. When the fruit is mature, six longitudinal slits form through which the seed is shed. The seed is minute and each capsule contains thousands of seeds. The testa of the seed is elongate, giving the seed a high surface to volume ratio. This shape is found in other plant families and is characteristic of wind dispersal (Rasmussen 1995).

6.3.4 Seed biology and ecology

Orchid seeds do not have specialised storage tissue, but contain tiny lipid bodies within the embryo that serve as a food source. Nearly all species are reliant on a mycorrhizal fungus to support the first stages of growth after germination.

Pterostylis gibbosa sheds seed in spring and is dormant until the following autumn. The presence of fungi in the leaf litter, as for all terrestrial orchids, is needed for successful germination. *P. gibbosa*, like other orchids in the Rufa group, require the presence of a specific strain of *Ceratobasidium cornigerum* for successful germination (Mark Clements, Centre for Plant Biodiversity and Research pers. comm.). This fungus is widespread and associated with leaf litter.

In autumn, when cooler temperatures and moist conditions stimulate the growth of the fungus, seeds of *P. gibbosa* imbibe. If infected by a specific fungus, the seed germinates and forms a tiny corm-like structure known as a protocorm. This develops into a tuberoid that stays dormant until the next growing season. In some cases, the protocorm formed between the fungus and the seed can remain dormant for up to two seasons. Seeds have the ability to exclude other fungi for about a month. However if they have not come in contact with *C. cornigerum* within this time they will be invaded and killed by other fungi (Quality Environmental Management 1994).

Sharma *et al.* (2000) found a high mean seed viability of 76% in a selection of seeds collected from 23 *P. gibbosa* plants (15 from Milbrodale, three from Yallah, three from Albion Park and two from Nowra).

6.3.5 Seedling growth

Seedlings appear to take several seasons before reaching sexual maturity. Depending on the growing season, the seedlings may form one or two leaves one season and then re-emerge and form three or more leaves the next season.

Seedlings first appear as a plant of one or two very small leaves. As the growing season continues these leaves will increase in size. New seedlings will continue to appear throughout the growing season. Therefore, in any one year some seedlings will be significantly larger than the newly appearing seedlings.

A seedling in its second year will appear as a relatively large and vigorous two leaf seedling. (A mature plant that has been severely affected by adverse conditions will have the same appearance as a second year seedling that has developed rapidly under ideal conditions.)

In the third year seedlings will vary greatly depending on attributes and environment. Some will remain as two leaf plants while others will have three or more leaves and will be counted as a non flowering mature plant. Some of these may flower.

6.4 Population Structure

Pterostylis gibbosa tends to occur in clumps with individuals scattered in clusters. Outside these clumps, only scattered individuals or small groups are found. The smaller clusters within the

patches usually consist of one or several mature flowering plants with a scatter of more numerous small rosettes that do not flower (Whelan & Kohler 1991).

6.5 Response to Disturbance

6.5.1 Response to fire

P. gibbosa is capable of surviving fire, due to the regenerative capacity of its tuberoid. Occasional fire may be necessary to provide suitable conditions for the establishment of seeds and seedlings and to maintain habitat suitable for the survival of the species (Recovery Team pers. comm.).

If a fire occurs after the orchid has emerged (winter or spring), the above ground parts of the plant are destroyed and the orchid will generally remain dormant until the following season. Fires at this time clearly preclude seed set in that season.

In the long term, frequent fire at this time of year will probably eliminate the population since the plant does not propagate itself vegetatively to any great extent (see sections 2.5 and 6.3.1). Even though the tuber replaces itself each year, it is not known how long it can keep doing this.

Summer fires are assumed to have the least impact on *P. gibbosa*, as the species remains dormant underground over summer, provided such fires are not of a sufficient intensity to destroy the underground tuber. Observations following bushfires in East Gippsland's Croajingalong National Park, Victoria in March 1983 and the effects of Ash Wednesday, February 1983, in the Adelaide Hills on orchids (*The Orchadian*, 1984) indicate that high intensity fires can destroy some orchid tubers completely.

The Croom Road site at Albion Park experiences frequent fires that are the result of arson. Despite this, the *P. gibbosa* population appears to have increased in numbers (G. Bradburn, ANOS pers. comm.). This appears to argue against the supposition that high frequency fire is a key threatening process for *P. gibbosa*.

It must be noted that the fires at Croom Road are generally localised and it is unknown how frequently and at what time of year areas of the site that contain *P. gibbosa* are being burnt. It does appear however, that burning areas adjacent to *P. gibbosa* populations provides ideal conditions for recruitment (G. Bradburn, ANOS pers. comm.).

Monitoring in 1999 where plants were tagged in four areas, two burnt in December and two that remained unburnt, indicated that there was no difference in the number of leaves and rosette diameter between burnt and unburnt areas. Due to a fire in the unburnt areas in August/September, it was not possible to compare flowering or pollination data between the burnt and unburnt areas.

Any prescribed fires in areas containing *P. gibbosa* should be undertaken after flowering and prior to emergence of the rosette. This period will vary with climatic conditions but generally occurs between December and February. Monitoring should be undertaken to ensure that rosettes emerge after any prescribed fires, and that they set seed and recruit.

6.5.2 Response to drought

In seasons that become dry after the rosette has appeared, individuals may not flower or may even die back to the tuberoid. If conditions later improve, the plant may re-emerge but in these circumstances flowering is rare (G. Bradburn and J. Riley, ANOS pers. comm.). In exceptionally severe seasons the plant may not emerge at all.

Generally, the species is quite flexible in its response to climatic conditions with plants dying back in poor conditions and growing quickly in good times. Additionally, the plant may die back and reappear within a season.

6.5.3 Response to grazing

Grazing can have a beneficial or unfavourable effect on *Pterostylis gibbosa*, depending on its timing and intensity. The removal of adjacent vegetation cover may benefit the orchid by increasing light levels and allowing the growth of *P. gibbosa* where vegetation cover is dense. The extensive removal of adjacent vegetation cover may be unfavourable as it will reduce moisture levels and increase exposure of the orchid to heat and wind.

Grazing causing the removal of *P. gibbosa* plant parts is likely to have a direct effect on the growth potential and reproductive success since each plant produces only one flowering stem in a season. When damage is inflicted it completely denies the plant the chance to reproduce until the following season. If herbivory levels remain high in subsequent seasons this may be detrimental to the long term reproductive success and survival of the species (I. Taylor pers. comm.).

7 Previous management actions

7.1 Preparation of a Conservation and Research Statement and Species Recovery Plan (ANCA Plan)

In 1994, a Conservation Research Statement and Species Recovery Plan was prepared for ANCA (now Environment Australia) (Quality Environmental Management 1994). The objectives of the plan were:

- to achieve more secure protection and management of the known occurrences of *Pterostylis gibbosa*;
- to further research the population dynamics of *Pterostylis gibbosa* in particular factors influencing variations in distribution, abundance and fecundity;
- to establish *ex-situ* cultivation of the Illawarra populations of *Pterostylis gibbosa*, if required;
- to further research the taxonomy of *Pterostylis gibbosa*, including confirmation of the possible Hunter Valley population, and the genetic variation between and within known populations of the orchid;
- to determine the full extent of the current distribution of *Pterostylis gibbosa*; and
- to protect and manage new sites if they are found.

7.2 Implementation of ANCA Plan

Between 1994 and 1999, the following actions in the 1994 ANCA plan were funded by the NPWS and the Endangered Species Program (Environment Australia):

- 1) to secure protection and management of known populations by liaison with relevant land owners;
- 2) to survey areas likely to support *P. gibbosa* on the Cumberland Plain and the Illawarra and Shoalhaven Coastal Plain;
- 3) to undertake research into population dynamics of *P. gibbosa* including:
 - set up permanent quadrats to monitor survivorship, flowering, capsule and seed production;
 - conduct seed viability and germination trials; and
 - investigate the response of *P. gibbosa* to fire.
- 4) to undertake taxonomy and genetic variability of *P. gibbosa*, particularly the Hunter population; and
- 5) to review the existing draft recovery plan.

7.2.1 Liaison

To guide the implementation of the ANCA plan, a Recovery Team consisting of representatives from Transgrid, Shellharbour Council, Wollongong University, Illawarra ANOS, NPWS and a private landholder from Yallah was established by the NPWS in 1996.

The Recovery Team continues to play an important role during the preparation of this plan, and to supervise and monitor recovery actions. The Recovery Team provides a forum to liaise with land owners and managers to secure protection and management of known populations. Other landholders not able to attend Team meetings are contacted regularly.

7.2.2 Targeted Surveys

Cumberland Plain

Between 1996 and 1998, surveys in western Sydney were conducted by the NPWS and ANOS in Prospect Reservoir, defence land at Orchard Hills, Holsworthy and St Marys, Shanes Park, Kemps Creek, St Andrew's, Longneck Lagoon, and Nurranginy Reserve. No *P. gibbosa* was found despite the presence of ideal habitat in areas such as Shane's Park and Longneck Lagoon.

Yallah-Albion Park

Further surveys in the Yallah area were carried out by Graeme Bradburn, Gary Leonard, Dr. Roslyn Muston and Axel von Krusenstierna in 1994.

Nowra

In 1996, the area around Brown's Creek near Nowra was searched in an attempt to locate the site where the 1969 collection was made. The general area around Brown's Creek had been subdivided. Many properties were being used to graze cattle or horses. No *P. gibbosa* was found. Areas to the east of Brown's Creek containing suitable habitat was also searched but no *P. gibbosa* was found.

Further searches by NPWS and ANOS were undertaken during the 1997 flowering season in potential habitat in forest about 1.5km south-east of the area in Browns Creek where the 1969 record is believed to have been come from. The surveys in 1997 resulted in the discovery of between 300-600 *P. gibbosa* individuals in Currumbene State Forest (now Worrigee Nature Reserve).

A survey in the Currumbene State Forest was undertaken in September 1998 to establish the extent over which *P. gibbosa* occurs in the area.

Hunter

Searches were also undertaken in the Hunter Valley in the vicinity of the Milbrodale population. In 1996, the Milbrodale population was confirmed as *Pterostylis gibbosa* and a survey was conducted to determine the extent of the population.

7.2.3 Monitoring

Since 1990, Graeme Bradburn and Rob Tunstall (Illawarra ANOS) have undertaken an annual census of the Yallah population using the quadrats selected by Whelan and Kohler (1991). Surveys were also carried out in surrounding areas (Area 3, 4, and 5). Data annually collected includes plant numbers and types, seedling numbers, flowering data and capsule count.

A census was carried out by Graham Kohler and Graeme Bradburn at Yallah and Albion Park to determine the size of the populations and distinguish between seedlings, mature plants and mature plants with flowering stems.

In 1997, 1998 and 1999 the NPWS and the University of Wollongong tagged and monitored individual plants at Currumbene State Forest (now Worrigee Nature Reserve) and Milbrodale. The orchid parameters measured were:

- number of leaves;
- rosette diameter;
- height of scape;
- number of flowers;
- number of capsule;
- number of buds and forming leaves;
- number of withered flowers;
- mature plants without scapes;
- damage to scapes; and
- plants missing.

Comments on damage to any parts of the plants, the state of plants and location of individuals in relation to other tagged plants were also noted.

Not all these parameters were included in every year.

In 1999, plants were tagged and monitoring work was undertaken at Albion Park.

7.2.4 Research

The NPWS, in conjunction with the University of Wollongong, TransGrid and Illawarra ANOS, has undertaken research into the population dynamics of *P. gibbosa* including the monitoring of seed production, survivorship, and flowering capsule, seed viability and germination to enable informed management of the site.

In summary, the studies undertaken on *Pterostylis gibbosa* during the implementation of the ANCA plan are:

1996: Zoran Dokonal, as part of his Honours Environmental Science project at Wollongong University, undertook a study which aimed to survey orchid density in relation to site conditions at Yallah and Albion Park and to investigate the effects of grass removal through clipping at Yallah.

The study found that the environmental factors controlling the abundance and distribution of *P. gibbosa* at Yallah and Albion Park were light, moisture and space availability. No significant difference was found in rosette size, number of leaves, stem height or number of flowers per stem between the clipped and unclipped areas after one growing season.

1997: Elisa Heylin as part of her Honours study at the University of Wollongong investigated the effects of grass removal at Yallah (which followed on from Dokonal's study) and the effects of fire through post-fire observations at Albion Park. The study found a significantly lower average rosette size in clipped areas compared to unclipped areas. This was possibly due to a reduction in soil moisture levels in the areas where grass was removed. Grass clipping was found to have no impact on recruitment levels in the second growth season.

In comparing the effects of an accidental spring burn, an autumn burn and an unburnt area, Heylin (1997) found that the spring burn resulted in a lower average rosette size when compared to an unburnt area but had no impact on flowering or recruitment rates. The autumn burn was found to have no effect on orchid size, flowering or recruitment rates. It should be noted that this fire experiment was unreplicated and involved one spring burn and one summer burn at one location. The period of the study covered one post fire growth season.

1997: Some seed capsules were collected by NPWS for viability and germination trials. At Nowra, Milbrodale, Yallah and Albion Park, material was collected for genetic variability analyses at the Centre for Plant Biodiversity Research, Canberra.

1998: Inger Taylor undertook a research study on *P. gibbosa* as part of her Honours Environmental Science project at Wollongong University. The study aimed to quantify the level of herbivory on flowering stems and quantify the pollination rate of each of the four populations at Yallah, Albion Park, Nowra and Milbrodale.

The largest proportion of flowering stem damage was recorded at Nowra (41%) followed by Milbrodale (35%), Albion Park (27%) and Yallah (20%). The pollination rate of flowers (i.e. the proportion of flowers that form capsules) was found to be highest at Milbrodale (42%), followed by Nowra (39%), Yallah (9%) and Albion Park (7%).

Research is also being undertaken by the NPWS and Wollongong University to investigate the response of *P. gibbosa* to fire. An experimental burn was originally planned at the Yallah population for the 1997/98 season and then the 1998/99 season to test the responses of *P. gibbosa* to fire. Burns were postponed on both occasions due to unfavourable conditions. An ecological burn was undertaken at Yallah in December 1999 during the species' dormant season.

7.3 Southern Regional Forest Agreement

The final determination of the Southern Regional Forest Agreement (SRFA) on 1 January 2001 resulted in the gazettal of Worrigee Nature Reserve to protect the *P. gibbosa* population in the northern section of Currambene State Forest.

A Threatened Species Licence (TSL) was issued to State Forests of NSW (SFNSW) through the Integrated Forestry Operations Approvals process established by the Southern RFA. Under the TSL, SFNSW must meet the following conditions that relate to *P. gibbosa* before harvesting can occur in potential *P. gibbosa* habitat:

Condition 6.16.2

Where there is a record of the species within a compartment or within 20 metres outside the boundary of the compartment, the following must apply:

- (a) A 10 metre radius exclusion zone must be implemented around all individuals; and
- (b) An additional 10 metre width buffer zone must be implemented around all exclusion zones established under Condition 6.16.2a above. Limited operations (snigging and selective tree removal) may be conducted within the buffer. Hazard reduction burning must be excluded from the buffer zone to the greatest extent practicable.

Condition 6.16.3

- (a) Where SFNSW can demonstrate to the satisfaction of the NPWS that the application of Conditions 6.16.1 or 6.16.2 for a particular species will significantly reduce the net harvest area then SFNSW may develop a Species Specific Management Plan as an alternative management approach.
- (b) A Species Specific Management Plan must be developed in consultation with the NPWS and relevant independent experts and must consider:
 - The species distribution and range;
 - The conservation status of the species and extent of formal reservation;
 - Any relevant Recovery Plan or Threat Abatement Plan;
 - Alternative measures for amelioration of impact.
- (c) Species Specific Management Plans must be approved in writing by the NPWS.

Condition 6.16.4

- (a) Where SFNSW can demonstrate to the satisfaction of the NPWS that due to exceptional circumstances impacts on a flora species listed below or their exclusion /buffer zones (as required by Conditions 6.16.1 and 6.16.2) within a compartment are unavoidable, SFNSW may develop a Site Specific Management Plan as an alternative management approach.
- (b) A Site Specific Management Plan must be developed in consultation with the NPWS and relevant independent experts and must consider:
 - The population size both at the site and across the species range;
 - The conservation status of the species and extent of formal reservation;
 - Any relevant Recovery Plans or Threat Abatement Plans;
 - The distributional significance of the site;
 - The viability of the population at the site;
 - The extent of proposed impact;
 - Alternative measures for amelioration of impact.
- (c) Site Specific Management Plans must be approved in writing by the NPWS.

Condition 8.7.1

- (a) A Compartment Traverse must be conducted to search for threatened and protected flora species and certain threatened and protected fauna features;
- (b) Samples of flora species that are unfamiliar to the surveyor must be collected and identified or verified by a relevant herbarium;
- (c) The threatened and protected flora component and threatened and protected fauna features component can both be conducted at the same time, the minimum survey effort required is ten hours per 200 hectares of net survey area.

Condition 8.7.3

- (a) For the threatened and protected flora component of the Compartment Traverse, the surveyor(s) must search in a random meander along the traverse identified in part 8.7.1 above, searching for and recording those threatened and protected flora species that require species specific or site specific conditions. The search should be conducted within the net survey area and in areas 50 metres outside the net survey area.
- (b) A minimum of six person hours per 200 hectares of net survey area must be conducted along the traverse. Threatened and protected flora species requiring species-specific conditions must be searched for continuously along the traverse.
- (c) If habitats not previously identified in the desktop component are encountered while sampling along the traverse, a proportion of the sampling time should be used to survey these habitats.
- (d) The timing of the threatened and protected flora component of the compartment traverse should take into account flowering periods of the threatened flora species being surveyed (this is particularly relevant to orchids and annual species). Data on the known flowering periods of cryptic species is included in Schedule 2 of this licence where this information is available.
- (e) Where individuals or groups of threatened or protected plants requiring these conditions are found, the individual or the extent of the group of individuals must be flagged (e.g. with flagging tape) by the person conducting the flora survey. The location of the individual or group of individuals must also be marked on the Harvesting Plan map to assist the Supervising Forest Officer in finding the flagged plant(s) during the compartment mark up.

7.4 Recent Research

Studies undertaken on *P. gibbosa* since the completion of the ANCA plan are summarised below:

Sharma *et al* (2000) investigated the levels of genetic variability and seed viability in all known populations of *P. gibbosa*. The study found a high degree of genetic variability and low population divergence between the populations. This was thought to have resulted either from recent population fragmentation or from extensive gene flow through seed and pollen movement. The study also found a high mean rate of seed viability (76%) existed for *P. gibbosa* populations.

Visman (2000) used a replicated fire experiment to determine the response of *P. gibbosa* to a summer fire in two areas of the TransGrid site. The study concluded that while there was an overall decline in population numbers at the site that year, the decline was less pronounced in the burnt quadrats than in the unburnt quadrats. This study also found that the effect of the summer fire on *P. gibbosa* flowering rates varied between two study areas, causing a decrease in flowering rates in one of the areas but not the other.

8 Management issues

The management of the conservation of threatened species requires the development of a “recovery program” which considers (i) the biological and ecological aspects of the species; (ii) the social, political and organisational parameters that may affect the success or otherwise of the program; and (iii) the economic factors which may influence the operation of the program’s implementation.

As such, this section identifies the management issues affecting *Pterostylis gibbosa* including:

- limits of our current understanding of the biology of the species and its’ ecology in the three principal areas of occurrence;
- threats and reasons for decline; and
- social and economic factors which may influence the success or otherwise of the recovery plan.

8.1 Level of current understanding

There are significant gaps in our understanding of the biology of *P. gibbosa*. The most significant are a lack of knowledge of recruitment processes, the role of fire, what is the pollinator species, and the ecology of pollination. Active site management (particularly of isolated remnants) would be greatly assisted with improved understanding of the conditions required for recruitment. G. Bradburn (Illawarra ANOS) has collected some information in regards to seedlings at Yallah and Albion Park. This is very localised and show rapid increases in numbers of plants in some quadrats monitored over time.

The monitoring of known sites and the targeted surveys undertaken has significantly increased our understanding of the distribution and abundance of *P. gibbosa*. The limited number of known populations before the surveys provided only a narrow view of the preferred habitat of *P. gibbosa*. Additional surveys, particularly in the Hunter and Nowra areas, will help to further define the ecological requirements of *P. gibbosa* which will assist in managing known populations and their habitats, and further refine the prediction of potential habitat to target for future surveys.

8.2 Threatening processes

The main potential threats to *P. gibbosa* plants, both for the plant and its pollinator(s), are habitat loss and degradation from development, land use incompatible with the requirements of the species, inappropriate fire regimes, and weed encroachment.

8.2.1 Habitat Loss

Habitat loss from urban development and agriculture has reduced the area of available habitat on the Cumberland Plain and Illawarra to isolated remnants. The capacity of the species to extend beyond its known range in the Illawarra, Hunter and Shoalhaven regions is limited by the availability of suitable habitat. In areas, such as the Hunter Valley and Nowra, there may be suitable habitat and these areas may be subject to future development pressures.

Any reduction of available habitat near existing populations will threaten *P. gibbosa* in the long term by rendering the populations more vulnerable to stochastic events. Small remnants are inherently more vulnerable since there is a greater likelihood that the entire habitat will be affected by chance events, such as repeated fires.

8.2.2 Habitat Degradation

Grazing

At least two populations of *P. gibbosa* occur on private land where the primary land use is grazing of domestic stock.

In the Hunter, the southern part of the low plateau on which *P. gibbosa* is found is already completely cleared and grazed. The orchid population is found adjacent to the fenceline, but not beyond it.

Routine agricultural activities are excluded from the provisions of the TSC Act, so there is no legal obligation to conserve populations if an agricultural activity is in conflict with the species' requirements. However, current landowners are sympathetic to the management of *P. gibbosa*.

Inappropriate fire regimes

Fire, by occurring at an inappropriate time of year or at inappropriate frequencies, is potentially a significant threat to *P. gibbosa* (see section 2.5 and 6.5.1). Fire between March and November will destroy the above ground parts of the plant. A single fire at this time of year is unlikely to kill individuals but repeated fires are likely to eliminate plants as there is no opportunity for plants to replenish food reserves stored in the underground tuberoids or to flower and set seed.

Too frequent fires may also encourage fire tolerant species which could outcompete *P. gibbosa*. Blady Grass *Imperata cylindrica*, a native grass already present at Yallah and Albion Park is favoured by frequent disturbance. Species such as Lantana *Lantana camara*, also at Yallah and Albion Park is a prolific invader of open spaces.

The prevention of fire, or having infrequent fires may also be a threat. Other understorey plants that are not deciduous have a competitive advantage in these circumstances. The level of leaf litter will build up and increase the risk of high intensity fires, which are likely to have a greater impact on *P. gibbosa* due to higher temperatures above and below the ground. *P. gibbosa* rosettes lie flat on the ground, so dense groundcover is likely to be detrimental by limiting light levels and space. In the absence of fire, some pioneer rainforest species such as *Pittosporum undulatum* have the opportunity to grow. At Yallah, young plants of *P. undulatum* are common. In the long term, the light levels under a dense canopy of such plants may be too low for *P. gibbosa*.

The environment that the plants were adapted to, prior to European arrival, is difficult to determine. The loss of native herbivores, introduction of exotic animals and plants, and changes to the fire regime have altered the habitat significantly in the past 200 years. Developing appropriate fire regimes in the absence of the native animals that helped crop the native groundcovers is difficult. It is believed that a combination of summer fires and light grazing by native animals create the open areas that *P. gibbosa* appears to favour.

Further research is needed to determine the appropriate intervals for ecological burns which also must consider the requirements of the mycorrhizal partner, *Ceratobasidium cornigerum*, and pollinators. Only by managing the community as a whole will the orchid persist in the long term.

Weed invasion

Weeds, particularly *Lantana camara*, pose a potential threat to *P. gibbosa*. In the woodlands where *P. gibbosa* grows, *L. camara* is highly invasive. Large sections of the habitat at Yallah were infested before it was weeded by members of the Wollongong Australian Native Orchid Society (now Illawarra ANOS). *L. camara*, Blackberry *Rubus fruticosus*, Privet *Ligustrum* spp., *Senna* spp., Prickly Pear *Opuntia* spp. are some of the weed species found at Albion Park. Monitoring of weeds and ongoing control is essential at all populations in the Illawarra. In the Hunter Valley and the Shoalhaven sites, exotic species do not appear to be as abundant. No significant weeds were found in the understorey at either site.

Collecting from the wild

Pterostylis gibbosa is of value to orchid enthusiasts interested in terrestrial species. The species, however, is unlikely to ever become highly attractive to the general public since the flowers are small, cultivation is not simple and the species is deciduous. Nevertheless, collecting from the wild still occurs (Recovery Team pers. comm.).

8.3 Social and economic issues

8.3.1 Social considerations

The NPWS recognises that actions within this plan may have impacts on the public authorities and private individuals who own or manage land on which the species occurs. Personal and regular contact with landholders is a key strategy in encouraging awareness and involvement in the recovery effort.

Orchids appeal to many people particularly orchid enthusiasts. The ANOS has been actively involved in the recovery and management of this species.

It is considered that the plan will result in some positive impacts on sections of the community. For example, implementation of the plan will result in increased protection of natural woodland habitats, which have largely been lost in areas where *P. gibbosa* occurs.

However, preservation of habitats may also require that public access is restricted such as areas of the Croom Rd site. As this would not occur without public consultation such as through the exhibition of the PoM for the VCA being prepared. Any negative social consequences of restricted access should, therefore, be minimised.

It may also require restrictions on certain activities such as grazing. This is not considered to be a significant cost to the landholder as it would only apply to those sections of the land where *P. gibbosa* occurs. It is envisaged that any such restrictions will only occur following negotiations with the relevant land manager.

8.3.2 Economic considerations

The NPWS recognises that the implementation of the actions for this Recovery Plan will result in some degree of economic impact. The proposed recovery strategy seeks to minimise these impacts through the prioritisation and targeting of recovery efforts.

Two of the five populations occur on private property. The cost to the landowners of maintaining populations of *P. gibbosa* is low, provided the land is not required for any other purpose.

8.4 Translocation/Ex-situ Conservation

Translocation is defined as the “deliberate transfer of plants or regenerate plant material from one place to another, including existing or new sites or those where the taxon is now extinct” (Australian Network for Plant Conservation 1997). Translocation may also involve the removal of plant material to undertake an *ex-situ* conservation program.

At this stage, translocation is not considered necessary for the survival of the species or appropriate given the current lack of knowledge of the species.

The conservation of threatened species is most successful when species are managed and protected in their natural habitat (*in-situ*). In relation to *P. gibbosa*, given the amount of commitment required and the probability of failure with any trial, the use of translocation is not encouraged.

8.5 Species Ability to recover

Pterostylis gibbosa can persist in the long term at all known sites provided management is appropriate and threatening processes are managed and monitored. Appropriate management regimes are attainable through negotiations, liaison, assistance and community support at all sites.

The area of suitable habitat at Albion Park and Yallah is limited. Any reductions in the current habitat is likely to result in further declines in the populations. Management of potential habitat adjacent to where the orchids currently exist is important to provide opportunity for natural expansion of the populations under appropriate conditions.

If current sympathetic management continues by private landholders, the security of the long-term viability of these sites is more certain.

The areas where *P. gibbosa* is known to occur in the Shoalhaven area are now protected in Worrigee Nature Reserve. Development pressures in the Shoalhaven area are high however, and it is important that suitable habitat is identified so that targeted surveys can be undertaken and significant areas considered in strategic planning programs for the expansion of Nowra.

9 Recovery objectives and performance criteria

9.1 Overall objective

The overall objective of the recovery plan is to protect known populations of *Pterostylis gibbosa* from decline and to develop a management regime, based on current knowledge, designed to promote the plant's conservation and evolutionary potential *in situ*.

9.2 Overall recovery performance criteria

The overall performance criteria are that:

- land tenure agreements are in place that protect known sites;
- management plans are prepared and implemented;
- populations are maintained or increased in current areas; and
- additional populations are located through further survey.

10 Reservation/conservation of known populations

10.1 Objective

- To ensure that all known *P. gibbosa* populations occurring on public and private lands are protected and managed for conservation.

In order to give effect to this objective, the NPWS recognises that there are several legislative mechanisms including joint management agreements, property management plans, critical habitat declaration and NPWS acquisition among others that can be used. In relation to private land, the NPWS recognises that there are a variety of measures which may be implemented (e.g. property management plans, VCAs), and that the precise nature of management arrangements will depend largely on the circumstances and co-operation of private land holders.

10.2 Performance criteria

The criterion for the successful implementation of this conservation status objective is that:

- public and freehold lands which support *P. gibbosa* populations are afforded an increased level of legislative protection.

10.3 Recovery Actions

1. The NPWS will continue to liaise with Shellharbour Council to complete a VCA under the NPW Act at Croom Road, Albion Park.
2. The NPWS will continue to liaise with TransGrid over management of *P. gibbosa* populations at Yallah and discuss options for increasing the level of protection of the site. Options may include a joint management agreement, a property management plan, or voluntary conservation agreement.
3. The NPWS will seek to secure sympathetic management of *P. gibbosa* habitat on private land at Yallah and Milbrodale and will provide assistance and information on how best to manage the populations.
4. Following the completion of additional survey and research actions identified in this recovery plan, the NPWS will consult with the *P. gibbosa* Recovery Team to discuss the need for, and feasibility of, declaring critical habitat for the species.

11 Threat and habitat management

11.1 Objective

- To minimise the risk of *P. gibbosa* populations declining in the long term through the development and implementation of appropriate threat and habitat management practices.

Threatened species are best managed in perpetuity when conserved in their natural habitat, that is, *in-situ*. This involves the combination of both long-term strategic planning initiatives and short-term direct on-ground activities to mitigate or ameliorate actual and potential threatening processes. (The habitat management issues affecting *P. gibbosa* are discussed in section 8.)

11.2 Performance criteria

The criteria for the successful implementation of the threat and habitat management objective are that:

- management plans for each site are prepared and implemented;
- threats are managed and monitored in co-operation with the NPWS, public authorities and private landholders; and
- activities and decisions are undertaken based on an understanding of the ecology of the species.

11.3 Recovery Actions

1. TransGrid will revise and implement the PoM for the site at Yallah on TransGrid property by June 2001 in accordance with any joint management plan, property management plan or VCA entered into in accordance with section 10.3.
2. NPWS will prepare and implement a management plan for the protection of *P. gibbosa* within Worrigee Nature Reserve.
3. The NPWS will provide advice to private land owners in regards to appropriate management for the protection of populations of *P. gibbosa* on their properties.
4. Shellharbour Council will implement the PoM for the Croom Road site.
5. The NPWS will prepare Environmental Impact Assessment Guidelines for *P. gibbosa* in order to assist consent and determining authorities in their statutory assessment of development applications.
6. Consent and determining authorities will ensure that developments and activities are assessed with reference to this recovery plan, Environmental Impact Assessment Guidelines for *P. gibbosa* (see point 5 above) and any future advice from the NPWS regarding the distribution, threats, biology and ecology of *P. gibbosa*.
7. Consent and determining authorities will ensure that any relevant environmental policies, management plans and Environmental Planning Instruments are prepared or reviewed with

reference to the recovery plan and any future advice from the NPWS regarding the distribution, threats, biology and ecology of *P. gibbosa*.

12 Survey

12.1 Objective

- To establish the full extent of the distribution of *P. gibbosa*.

The current distribution of *P. gibbosa* is detailed in section 5.1 of this recovery plan. Whilst it is unlikely that additional populations exist on the Cumberland Plain or in the Illawarra, it is likely that new populations of this species will be discovered with further survey, particularly in the Hunter and Shoalhaven areas.

12.2 Performance criteria

The criterion for the successful implementation of the survey objective is that:

- potential habitat is identified and surveyed.

12.3 Recovery Actions

1. The NPWS will investigate the possibility of using predictive modelling techniques to identify suitable potential habitat for future surveys.
2. The NPWS will liaise with the ANOS, State Forests of NSW, and Shoalhaven City Council to undertake a survey of populations in Currumbene State Forest, Nowra and surrounding environs.
3. The NPWS will liaise with the ANOS and Singleton Council to undertake further surveys in suitable habitat in the Hunter Valley area.
4. All relevant stakeholders (public authorities and private landholders) will be informed of survey results, particularly Shoalhaven and Singleton Councils.
5. Atlas of NSW Wildlife cards are submitted to the NPWS and specimens lodged with the Australian National Herbarium, Canberra and the NSW Herbarium, Sydney upon the discovery of any new populations.

13 Research and Monitoring

13.1 Objective

- To ensure the management of *P. gibbosa* habitat is adaptive to the outcomes of research and monitoring and is informed by essential aspects of the biology and ecology of the species.

Key attributes of *P. gibbosa* are currently unknown (see section 8.1), particularly the responses of *P. gibbosa* to fire and knowledge of its recruitment processes. Research into these areas combined with low-impact *in-situ* monitoring is required to systematically collect and analyse biological information concerning *P. gibbosa* and its habitat. This information will be used by land managers to make confident and informed decisions regarding the management of *P. gibbosa*.

13.2 Performance criteria

The criterion for the successful implementation of the research and monitoring objective is that:

- a greater understanding of *P. gibbosa* is achieved and applied to the management of the species.

13.3 Recovery Actions

1. The NPWS in conjunction with the ANOS will develop pro-formas for monitoring populations at all known sites.
2. The NPWS will liaise with landholders to continue to undertake annual monitoring of known populations as part of the agreed management plans (TransGrid, Shellharbour Council).
3. The NPWS will continue research into population dynamics of *P. gibbosa* including monitoring permanent quadrats for survivorship, flowering, capsule and seed production, in addition to conducting seed viability and germination trials.
4. The University of Wollongong, with the permission of TransGrid and in co-operation with the NPWS will monitor the results of the ecological burn at the TransGrid site to investigate the response of *P. gibbosa* rosettes to fire and observe their response. The species' response to unplanned fires at Croom Rd, Albion Park will also be monitored by NPWS with permission from Shellharbour Council.

14 Community education, awareness and involvement

14.1 Objective

- To raise awareness among the broader community about the conservation status of *P. gibbosa* and involve the community in the recovery program.

14.2 Performance criteria

The criteria for the successful implementation of the education objective are that:

- information is disseminated to the community regarding the conservation status and management issues affecting *P. gibbosa* and its habitat, in particular those private landholders on whose properties *P. gibbosa* occurs; and
- the broader community (including ANOS) is actively involved in aspects of the recovery program.

14.3 Recovery Actions

1. The NPWS will produce a brochure providing information about the conservation status and management issues affecting *P. gibbosa*. The brochure will be distributed to private landholders with *P. gibbosa* on their properties and relevant Councils.
2. Shellharbour Council in conjunction with NPWS and ANOS will prepare an information brochure regarding the remnant bushland at Croom Rd to raise awareness of the importance of the site and of the VCA.
3. The NPWS will continue to liaise with private land holders in the Illawarra and Hunter regions to emphasise the conservation significance of populations of *P. gibbosa* occurring on or adjacent to their properties with a view to secure sympathetic management (refer to section 10.3.4).
4. In undertaking surveys for new *P. gibbosa* populations and site management, the NPWS will seek to involve NPWS volunteers and community groups in the survey effort (12.3.2 and 12.3.3).
5. The NPWS will seek media coverage to raise awareness of the co-operative work between industry and conservation groups to protect *P. gibbosa* including TransGrid at the Yallah substation site.

15 Implementation

15.1 Implementation Schedule

The following table allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies for the first 5 years of the recovery plan's implementation.

Table 2: Implementation schedule

Action	Description	Responsibility	Year 1	Year 2	Year 3	Year 4	Year 5
10.3	Reservation and Conservation	NPWS Shellharbour Council TransGrid	• • •	•	•	•	•
11.3	Threat/Habitat Management	NPWS Shellharbour Council TransGrid	• • •	• • •	• • •	• • •	• • •
12.3	Survey	NPWS Shoalhaven Council	• •	• •			
13.3	Research and Monitoring	NPWS Shellharbour Council TransGrid	• • •	• • •	• • •	• • •	• • •
14.3	Community Education etc	NPWS Shellharbour Council	• •	• •	•	•	•

15.2 Implementation Costs

The recovery actions and recommendations identified in this plan state what must be done to ensure the recovery of the endangered species *Pterostylis gibbosa*. Appendix 3 identifies the costs needed to implement those actions which require funding for implementation.

16 Preparation details

This revised recovery plan was prepared by Tania Duratovic and Martin Bremner, Threatened Species Unit, Central Directorate in consultation with the *Pterostylis gibbosa* Recovery Team.

16.1 Date of last amendment

This document is the first recovery plan for *Pterostylis gibbosa* prepared in accordance with the TSC Act. No amendments to the plan have been made.

16.2 Review date

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

17 **Contacts**

The coordinator of the *Pterostylis gibbosa* Recovery Team can be contacted at the following address:

Coordinator – *Pterostylis gibbosa* Recovery Team

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Threatened Species Unit, Central Directorate
PO Box 1967
HURSTVILLE 2220

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fax 02 9585 6442

Other useful contacts:

Organisation	Postal address	Contact numbers
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TransGrid Environmental Officer	PO Box 456 DAPTO, NSW 2530	Ph. (02) 4261 0616 Fax (02) 4261 0605
Graeme Bradburn Illawarra Australasian Native Orchid Society	10 Jaylang Place FIGTREE NSW 2525	Ph. (02) 4227 1301 Email: anos@leearth.net
Dr Rob Whelan Dept. of Biological Sciences University of Wollongong	Northfields Avenue WOLLONGONG NSW 2522	Ph. (02) 4221 3013 Fax (02) 4221 4135
National Herbarium of NSW, Royal Botanic Garden Sydney	Mrs Macquaries Road SYDNEY, NSW 2000	Ph. (02) 92318111 Fax (02) 92517231
David Jones Taxonomist Centre for Plant Biodiversity	Australian National Herbarium GPO Box 1600, CANBERRA, ACT 2601	Ph. (02) 6246 5502

Organisation	Postal address	Contact numbers	
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		Fax	(02) 4221 6016
Shoalhaven City Council	PO Box 42 NOWRA 2541	Ph.	(02) 4429 3111
		Fax	(02) 4422 1816
Singleton Council	PO Box 314 SINGLETON NSW 2330	Ph.	(02) 6578 7290
		Fax	(02) 6572 4197
Wollongong City Council	PO Box 314 South Coast Mail Centre NSW 2330	Ph.	(02) 4227 7111
		Fax	(02) 4227 7277
State Forests of NSW South Coast Region	PO Box 42 BATEMANS BAY NSW 2536	Ph.	(02) 4472 6211
		Fax	(02) 4472 6557

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Appendix 1

***Pterostylis gibbosa* Species Profile**

Pterostylis gibbosa

R.Br.

Illawarra Greenhood Orchid

Conservation Status

Pterostylis gibbosa is listed as an **endangered species** on Schedule 1 of the NSW *Threatened Species Conservation Act* 1995 and as an **endangered species** under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

Description

P. gibbosa (Orchidaceae) is a perennial terrestrial orchid. It belongs to the “greenhood” group of orchids that are characterised by green, hood-shaped flowers (Dressler 1981).

Leaves are elliptic to ovate in shape, 1.5 to 3.5 cm long, entire and arranged in a small basal rosette (Jones 1993).



Photo: R. Tunstall

The inflorescence consists of two to seven flowers held on a single scape (stalk) to 45 cm high with three to six closely sheathing stem leaves (Harden 1990).

Flowers are bright green with transparent areas in the galea (hood) and petals although light reddish-brown flowers have been observed (Jones & Clements 1997). The labelum (lip) is strongly exerted, brownish-black to black, with a deep central groove and thick basal lobe (Jones & Clements 1997).



Photo: L. Johnston

Distribution

P. gibbosa is presently known from five locations: three sites in the Illawarra (two sites at Yallah and one at Albion Park); one site near Nowra in the Shoalhaven; and one site at Milbrodale in the Hunter Valley.

The original or “type” specimen of *P. gibbosa* was collected in 1803 in western Sydney (NPWS 2000). Extensive surveys in recent years have failed to relocate the species in western Sydney and it is now considered likely to be extinct in that area (NPWS 2000).

Recorded occurrences in conservation reserves

P. gibbosa has been recorded from one conservation reserve, Worrigee Nature Reserve (previously part of Currambene State Forest), near Nowra.

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Habitat

All known sub-populations of *P. gibbosa* occur in open forest or woodland on flat or gently sloping land with poorly drained soils.

In the Illawarra, *P. gibbosa* occurs on soils derived from Permian sedimentary rocks of the Berry formation at an altitude of 10 to 20 metres. Associated vegetation is woodland dominated by *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca decora* (White Feather Honey-myrtle) with an open grassy understorey.

Near Nowra, *P. gibbosa* also occurs on soils derived from rocks of the Berry formation although at a slightly higher altitude of 20 to 30 metres. Associated vegetation is open forest dominated by *Eucalyptus maculata* (Spotted Gum) and *Eucalyptus paniculata* (Grey Ironbark) with an open grassy understorey.

The Milbrodale sub-population of *P. gibbosa* occurs at an elevation of 150 to 160 metres on soils derived from Triassic sedimentary rocks of the Narrabeen group. Associated vegetation is open woodland dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark) and *Eucalyptus molucanna* (Grey Box), with *Callitris endlicherii* (Black Cypress Pine) present as a sub-dominant. The understorey at this location contains dense stands of the native shrub, *Dodonaea cuneata*.

Ecology

P. gibbosa is a deciduous orchid that is only visible above the ground between late summer and spring. Its rosette of leaves emerges from an underground tuberoid during late summer and autumn. A flower scape develops on mature plants over winter. Flowering occurs between September and October, after which the leaf rosette withers and seed capsules develop.

P. gibbosa flowers are thought to be pollinated by male fungus gnats (Genera *Mycomya* and *Heteropterna*) (NPWS 2000). The fruit is a dry, dehiscent, obovoid capsule containing thousands of minute, wind dispersed seeds (NPWS 2000).

P. gibbosa does not spread vegetatively to any great extent (NPWS 2000).

A study by Sharma *et al* (2000) found a high mean viability rate (76%) for seeds collected from each known sub-population of the species.

P. gibbosa is capable of surviving occasional fire due to the regenerative capacity of the tuberoid (NPWS 2000).

Threats

Habitat loss from urban development and agriculture has greatly reduced the area of available habitat for the species. Further habitat loss will threaten the long-term viability of the species by further reducing population sizes and rendering extant sub-populations more vulnerable to stochastic events (NPWS 2000).

Frequent fires, particularly between March and November, are a potential threat to the species. Such fires will destroy above ground parts of the plant and may prevent flowering, seed set and the establishment of seedlings. Over time this may lead to the elimination of sub-populations. Frequent fire may also change the composition of surrounding vegetation by encouraging more fire tolerant species that may disadvantage *P. gibbosa* (NPWS 2000).

Fire exclusion may also threaten *P. gibbosa* as occasional fire may be necessary to provide conditions suitable for recruitment and growth of the species. The build up of leaf litter in the absence of fire will also increase the risk of high intensity fires that are more likely to kill tuberoids than low intensity fires (NPWS 2000).

Other potential threats to the species include: degradation of habitat through weed invasion, particularly by *Lantana camara* and *Pittosporum undulatum*; uncontrolled vehicular and pedestrian access to sites; and the collection of *P. gibbosa* by orchid enthusiasts (NPWS 2000).

Management

Future management must aim to increase the level of legislative protection afforded land upon which the species occurs. This can be facilitated on public and private land through a range of mechanisms including Voluntary Conservation Agreements, Joint Management Agreements, Property Management Plans etc.

Appropriate threat and habitat management practices include: weed removal to maintain suitable habitat; fencing to exclude vehicles and prevent rubbish dumping; and the establishment of appropriate grazing and fire regimes where necessary.

Further research and monitoring is required to gain a better understanding of the species and in particular, its response to different fire regimes.

For Further Information contact

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Targeted survey is required to locate other extant populations of the species and so determine the full extent of the species distribution.

Recovery Plans

A recovery plan for *P. gibbosa* was approved in September 2002.

Appendix 2

Known distribution of *P. gibbosa*, tenure, zoning and threats at each site

Population	Site Name	LGA	Tenure	Status at each site	Zoning	Threats
CUMBERLAND PLAIN YALLAH	Cumberland Plain (western Sydney)	Various	Various	Presumed Extinct	various	habitat loss/degradation
	Yallah, Pacific Power Substation – fenced areas	Wollongong City Council	TransGrid	Extant	5(a) Special Use	no immediate threat
	Yallah, Pacific Power Substation – area outside fenced area ex-Norken	Wollongong City Council	TransGrid	Extant	5(a) Special Use	grazing, trampling
	Yallah Bush	Wollongong City Council	Private	Unknown	1 Non Urban	grazing, trampling
ALBION PARK	Albion Park Croom Road Sporting Complex	Shellharbour Council	Crown	Extant	7(a) Environment Protection (Special) 6(a) Open Space (Recreation)	trampling, fire management
NOWRA	Nowra Browns Creek	Shoalhaven City Council	Private	Presumed Extinct	2(c) Residential	rubbish dumping, access, Inappropriate fire regimes and weeds
	Nowra Currambene State Forest	Shoalhaven City Council	State Forest	Extant		rural activities, residential development
MILBRODALE	Milbrodale	Singleton Council	Private	Extant	Rural	timber harvesting, inappropriate fire regimes motorbikes, fire management

APPENDIX 3

Vegetation structure associated with *Pterostylis gibbosa* populations at Milbrodale, Yallah, Albion Park and Nowra (compiled by Inger Taylor, University of Wollongong).

Species common to all sites are highlighted. Information from (*) NPWS 1998 (unpublished data); (**) Heylin 1997; (***) personal observations; (****) Quality Environmental Management 1994

SITE	CANOPY	UNDERSTOREY	ORCHID SPP.
YALLAH * except where marked otherwise	<i>Acacia falcata</i> <i>Angophora floribunda</i> <i>Eucalyptus amplifolia</i> <i>Eucalyptus longifolia</i> <i>Eucalyptus tereticornis</i> <i>Melaleuca decora</i>	<i>Boronia polygalifolia</i> <i>Brachyloma daphnoides</i> <i>Danthonia pilosa</i> <i>Daviesia genistifolia</i> <i>Leucopogon juniperinus</i> <i>Lomandra longifolia</i> <i>Stipa</i> spp. <i>Themeda australis</i>	<i>Diuris sulphurea</i> **** <i>Pterostylis bicolor</i>**** <i>Pterostylis rufa</i> ****
ALBION PARK * except where marked otherwise	<i>Acacia falcata</i> <i>Acacia binervata</i> <i>Allocasuarina littoralis</i> <i>Eucalyptus amplifolia</i> <i>Eucalyptus eugenioides</i> <i>Eucalyptus globoidea</i> <i>Eucalyptus longifolia</i> <i>Eucalyptus tereticornis</i> <i>Melaleuca decora</i>	<i>Acacia brownii</i> <i>Boronia polygalifolia</i> <i>Daviesia genistifolia</i> <i>Goodenia hederacea</i> <i>Hardenbergia violacea</i> <i>Leucopogon juniperinus</i> <i>Pultenea retusa</i> <i>Stypandra caespitosa</i> <i>Themeda australis</i>	<i>Caledonia alba</i> **** <i>Caledonia catenata</i> **** <i>Diuris sulphurea</i> **** <i>Pterostylis bicolor</i>****
NOWRA ** except where marked otherwise	<i>Eucalyptus maculata</i> <i>Eucalyptus paniculata</i> <i>Eucalyptus longifolia</i> <i>Eucalyptus eugenoides</i> <i>Eucalyptus tereticornis</i> <i>Melaleuca decora</i> ****	<i>Acacia binervata</i> <i>Acacia falcata</i> <i>Acacia filicifolia</i> <i>Acacia longifolia</i> <i>Bossinia prostrata</i> <i>Cymbopogon refractus</i> <i>Daviesia ulicifolia</i> <i>Echinopogon ovatus</i> <i>Exocarpus cupressiformis</i> <i>Glycine clandestina</i> <i>Hardenbergia violacea</i> <i>Leucopogon juniperinus</i> <i>Lomandra longifolia</i> <i>Melaleuca ericifolia</i> <i>Mirbelia platyloboides</i> <i>Poa annua</i>	<i>Acianthus fornicatus</i> <i>Caledonia alba</i> **** <i>Caledonia catenata</i> **** <i>Calochilus</i> spp.*** <i>Diuris sulphurea</i> **** <i>Lyperanthus suaveolens</i> **** <i>Pterostylis baptistii</i> **** <i>Pterostylis bicolor</i>****

SITE	CANOPY	UNDERSTOREY	ORCHID SPP.
MILBRODALE ** except where marked otherwise	<i>Callitris endlicheri</i> <i>Eucalyptus albens</i> <i>Eucalyptus crebra</i> <i>Eucalyptus moluccana</i> <i>Eucalyptus teriticornis</i>	<i>Pratia purpurescens</i> <i>Pultenea linophylla</i> <i>Pultenea villosa</i> <i>Senecio lautus</i> <i>Stypandra caespitosa</i> <i>Themeda australis</i> <i>Acacia binervia</i> <i>Acacia buxifolia</i> <i>Aristida vagans</i> <i>Breynia oblongifolia</i> <i>Bursaria spinosa</i> <i>Cassinia quinquefaria</i> <i>Cheilanthes sieberi</i> <i>Choretrum</i> spp. <i>Cymbopogon refractus</i> <i>Danthonia longifolia</i> <i>Daviesia ulicifolia</i> <i>Dodonea cuneata</i> <i>Grevillea montana</i> <i>Hardenbergia violacea</i> <i>Jacksonia scoparia</i> <i>Lasiopetalum ferruginium</i> <i>Lomandra multiflora</i> <i>Melichrus urceolatus</i> <i>Myoporum montanum</i> <i>Panicum effusum</i> <i>Sporobolus creber</i> <i>Themeda australis</i> <i>Vittadinia</i> spp. <i>Wahlenbergia littoricola</i>	<i>Caledenia carnea</i> <i>Caledenia catenata</i> <i>Caledenia fuscata</i> <i>Microtis</i> spp. <i>Pterostylis bicolor</i> <i>Pterostylis concinna</i> *** <i>Pterostylis hamata</i> <i>Pterostylis mutica</i> <i>Pterostylis ophioglossa</i> <i>Thelymitra pauciflora</i>

APPENDIX 4

Implementation costs

Action	Description	Year of implementation						Source of funding				
		1	2	3	4	5	Total	NP Central recurrent funds	WS Thr. spp. program funds	Shellharbour Council	Shoalhaven Council	TransGrid
10.3	Reservation/conservation											
	liaison to complete VCA	2500					2500	1250		1250		
	liaison with TransGrid	2500	2500				5000	2500				2500
	liaison with private landholders	1250	1250	1250	1250	1250	6250	6250				
	critical habitat				2500		2500	2500				
11.3	Threat/Habitat Management											
	revision of TransGrid PoM	5250	4000	4000	4000	4000	21250	1250				20000
	PoM for Worrigee Nature Reserve	2250	1000	1000	1000	1000	6250	6250				
	advice to private landholders	¹ √	√	√	√	√						
	finalise/implement POM	5000	5000	5000	5000	5000	25000			25000		
	EIA Guidelines	1250					1250	1250				
	assessed w/ref to <i>P.gibbosa</i>	² ×	×	×	×	×						
	EPIs	×	×	×	×	×						
12.3	Survey											
	predictive modelling	2500					2500		2500			
	survey in Shoalhaven region	3500	3500				7000	3500	2500		1000	
	survey in Hunter Valley	2500	2500				5000		5000			
	inform re: survey results	√	√	√	√	√						
	specimens lodged at Herbarium	√	√	√	√	√						
13.3	Research/Monitoring											
	develop pro-formas	500					500	500				
	annual monitoring sites/research	2150	2150	2150	2150	2150	10750	10750		*		*

Action	Description	Year of implementation						Source of funding				
		1	2	3	4	5	Total	NP Central recurrent funds	WS Thr. spp. program funds	Shellharbour Council	Shoalhaven Council	TransGrid
	monitor burn results	1000	1000	1000	1000	1000	5000		5000			
14.3	Community education etc											
	brochure production	2500					2500	1250	1250			
	brochure for Croom Rd	2500					2500	1000		1500		
	liaison with private landholders	√	√	√	√	√						
	involve volunteers in surveys	√	√	√	√	√						
	media coverage	√	√	√	√	√						
	Total	37150	22900	14400	16900	14400	105750	38250	16250	27750	1000	22500

¹√ - no additional cost (included in other actions at some location)
implementation of PoM

* included in

² × - no direct cost (part of consent/determining authority's statutory planning responsibility)



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