

Persoonia mollis subspecies *maxima* Recovery Plan



April 2000



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Persoonia mollis subspecies *maxima* Recovery Plan

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

April 2000

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Foreword

The conservation of threatened species, populations and ecological communities is crucial for the maintenance of this State's unique biodiversity. In NSW, the *Threatened Species Conservation Act* 1995 (TSC Act) provides the framework 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 *Persoonia mollis* subspecies *maxima*, 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 *Persoonia mollis* subspecies *maxima* 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 October-November 1999. I thank these people for their efforts to date and I look forward to their continued involvement in the implementation of recovery actions identified in this plan.

BOB DEBUS MP

Minister for the Environment

Executive Summary

Introduction

Persoonia mollis subspecies *maxima* Krauss & L. Johnson is a tall, branching, spreading shrub which grows from 2-6 metres high. The current known distribution indicates that *P. mollis* ssp. *maxima* is highly restricted, known from three catchments over an approximate north-south range of 5.75km and east-west range of approximately 7.5km. All known locations occur within or adjacent to Berowra Valley Regional Park and Ku-ring-gai Chase National Park in the Hornsby Heights-Mt Colah-Mt Kuring-gai area in the Central Coast Botanical Division, south eastern Australia.

Current Species Status

P. mollis ssp. *maxima* is listed as nationally endangered on the Commonwealth *Endangered Species Protection Act* 1992 (ESP Act). It is also listed as endangered in NSW on Schedule 1 of the *Threatened Species Conservation Act* 1995 (TSC Act).

Legislative context

The TSC Act 1995 (NSW) is NSW's legislative framework to protect and encourage the recovery of threatened species, populations and communities. Under the TSC Act 1995 (NSW), the Director-General of National Parks and Wildlife (DG of NP&W) has certain responsibilities including the preparation of recovery plans for threatened species, populations and ecological communities. The TSC Act 1995 (NSW) 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 1995 (NSW) and ESP Act 1992 (Cth).

Preparation of Plan

This Recovery Plan has been prepared with the assistance of a recovery team, a nonstatutory 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 NPWS' knowledge on the date it was approved.

A draft of this Recovery Plan was placed on public exhibition for the period 15 October 1999 to 29 November 1999. Three written public 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 5 years from the date of publication.

Recovery plan implementation

The TSC Act 1995 (NSW) requires that Ministers and public authorities (including the DG of NP&W) are to take appropriate action available to them to implement those measures included 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 a recovery plan.

Public authorities that are affected by this recovery plan are the NPWS, Berowra Valley Regional Park Trust, Hornsby Shire Council, Royal Botanic Gardens Sydney (RBG), Department of Urban Affairs and Planning, NSW Rural Fire Service, Transgrid and Landcom. Consequently, these public authorities agree to manage *Persoonia mollis* subspecies *maxima* and its habitat, in accordance with this recovery plan.

Recovery objectives

The broad objective of this recovery plan is:

To protect the populations of *Persoonia mollis* subspecies *maxima* from decline, and to implement a management regime, based on current knowledge, designed to promote the plant's conservation and evolutionary potential in nature.

Specific objectives of this recovery plan are to:

- minimise the risk of *P. mollis* ssp. *maxima* from declining in the long term;
- establish the full extent of the taxon's distribution;
- improve management of *P. mollis* ssp. *maxima* and its habitat based on biological understanding of the taxon; and
- safeguard populations against extinction in nature as a result of catastrophic disturbance events.

Recovery Criteria

Recovery criteria are that:

- natural populations do not decline in the long term as a consequence of human induced threats;
- potential habitat is surveyed and a greater understanding of the plant's distribution is known;
- management strategies are informed by relevant biological information; and
- contingency arrangements are implemented in the event of catastrophic disturbance.

Recovery Actions

In order to achieve these objectives, a number of specific actions are identified by this recovery plan. Recovery actions will be broadly directed towards:

- habitat management to ameliorate threatening processes, and thorough assessment of activities which may impact on the taxon;
- targeted survey to determine the extent of known populations and whether new populations exist;
- undertaking a monitoring program and facilitating research which investigates key attributes of the taxon's biology; and
- ensuring that appropriate contingency arrangements are implemented to protect populations from imminent extinction.

Biodiversity Benefits

The preparation and long term implementation of recovery plans for threatened species, populations and ecological communities, contributes to, and highlights the importance of, conserving all biodiversity. The conservation of biodiversity has a number of wider community benefits. These include:

- provision and maintenance of a range of ecosystem services on which we and other species depend;
- contributing to increased biological and ecological knowledge of species, communities, habitats and ecosystems;
- potential medical, economic, agricultural and industrial products; and
- cultural, aesthetic and spiritual biodiversity values.

Furthermore, the conservation of *P. mollis* ssp. *maxima* will benefit other threatened species which share the same habitat. Through increased community awareness of *P. mollis* ssp. *maxima*, the profile of all threatened species will be raised in the general community. This in turn leads to greater opportunities for the conservation of threatened species and increased protection of biodiversity.

BRIAN GILLIGAN DIRECTOR GENERAL

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1. Introduction

Persoonia mollis subspecies *maxima* is a tall, branching, spreading shrub which grows from 2-6 metres high. It is one of nine subspecies in the *Persoonia mollis* complex, which has been the subject of considerable scientific investigation (see section 8.1), and which is distributed approximately from Lithgow to Braidwood in the Central and South Coast Botanical Divisions of NSW (Harden 1991, see Figure 2).

P. mollis ssp. *maxima* is the most morphologically distinct taxon of all the *P. mollis* subspecies. It is geographically disjunct and isolated from the other subspecies, occurring over a restricted north-south distribution of approximately 5.75km in the Hornsby Heights-Mt Colah area, north-metropolitan Sydney. The total number of individual plants is approximately 550 adult plants and 380 juveniles/seedlings, comprised of three populations delineated on a catchment basis (see section 6.2, Appendix 1 summarises the site details for each of the populations).

Prior to the preparation of this recovery plan, the NPWS and the *P. mollis* ssp. *maxima* Recovery Team undertook a detailed assessment of each populations' age structure and made some preliminary assessments of the plant's age to reproductive maturity. This information suggests that a large proportion of mature individuals is restricted to just one population, and that at least two subpopulations (defined at section 6.2) are vulnerable to extinction due to the fact that they consist almost entirely of immature plants.

P. mollis ssp. *maxima* is fire sensitive. Spatial densities of the plant are highest in sheltered gullies and moist drainage depressions, which suggests that such areas may be acting as refuges in response to frequent fire regimes. Wildfire and frequent planned burning regimes are therefore the principal threat to *P. mollis* ssp. *maxima*. Other threatening processes include habitat degradation through weed invasion, and rubbish dumping. The evolutionary potential of *P. mollis* ssp. *maxima* may be threatened as a consequence of reduced genetic variation because of small subpopulation sizes and increased mating among close relatives (inbreeding depression), however, further research is required to confirm this.

With appropriate management, as outlined in this recovery plan, the likelihood of recovery for *P. mollis* ssp. *maxima* is high. The success or otherwise of this recovery plan will be in part dependent upon the cooperation exercised between the various land managers and decision makers responsible for *P. mollis* ssp. *maxima* and its habitat.

2. Legislative context

2.1 State and Commonwealth listing

Persoonia mollis subspecies *maxima* is endangered in NSW and is listed on Schedule 1 of the TSC Act 1995 (NSW). The NSW Scientific Committee established under the TSC Act 1995 (NSW) is responsible for maintaining the schedules of the Act.

P. mollis ssp. *maxima* is listed as a nationally endangered species on Schedule 1 of the ESP Act 1992 (Cth). The schedules in the ESP Act 1992 (Cth) are based on the lists compiled by the Australian and New Zealand Environment Conservation Council (ANZECC). This species is eligible for funding under the Federal Endangered Species Program and is protected under Commonwealth legislation.

2.2 **Recovery plan preparation and implementation**

2.2.1 Recovery plan preparation

The TSC Act 1995 (NSW) requires the DG of NP&W to prepare recovery plans for all species, populations and ecological communities listed as endangered or vulnerable. The TSC Act 1995 (NSW) includes specific requirements for both the matters to be addressed by recovery plans and the process for preparing recovery plans. This plan satisfies these provisions.

2.2.2 Recovery plan implementation

The TSC Act 1995 (NSW) requires that Ministers and public authorities (including the DG of NP&W) are to take appropriate action available to them to implement those measures included 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 a recovery plan.

Public authorities that are affected by this recovery plan are the NPWS, Berowra Valley Regional Park Trust, Hornsby Shire Council, Royal Botanic Gardens Sydney (RBG), Department of Urban Affairs and Planning, NSW Rural Fire Service, Transgrid and Landcom. Consequently, these public authorities agree to manage *Persoonia mollis* subspecies *maxima* and its habitat, in accordance with this recovery plan.

2.3 Critical habitat

The TSC Act 1995 (NSW) makes provision for the identification and declaration of critical habitat for species, populations and ecological communities listed as endangered. Once declared, it becomes an offence to damage critical habitat (unless

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

To date, critical habitat has not been declared for *Persoonia mollis* subspecies *maxima* under the TSC Act 1995 (NSW). Whilst recognising the ecological importance of maintaining the existing habitat of *P. mollis* ssp. *maxima*, the DG of NP & W considers that the declaration of critical habitat for *P. mollis* ssp. *maxima* is unlikely to provide greater protection than that which currently exists. The reasons for this are:

- existing habitat in which the majority of the populations occur is secure;
- this recovery plan identifies to public authorities and other land managers the distribution, habitat and other biological requirements of *P. mollis* ssp. *maxima*;
- public authorities have endorsed the actions proposed by the recovery plan;
- environmental assessment guidelines specific to *P. mollis* ssp. *maxima* have been prepared;
- a recovery team has been established to implement recovery actions and facilitate cooperative management;
- the consideration of this recovery plan during the preparation of strategic Bush Fire Risk Management Plans and Reserve Plans of Management will place the management of *P. mollis* ssp. *maxima* in a coordinated framework; and
- there may be potential for further subpopulations to be discovered with additional survey, therefore an assessment of critical habitat on current understanding of the taxon's distribution is inappropriate.

The DG of NP&W will reassess critical habitat as a conservation option for *P*. *mollis* ssp. *maxima* if existing management arrangements as detailed above are inadequate to ensure the conservation of this taxon. The most appropriate time to review critical habitat for *P*. *mollis* ssp. *maxima* is following the implementation of monitoring and survey actions and when the recovery plan is reviewed.

2.4 Key Threatening Processes

"High fire frequency resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition" is listed as a key threatening processes in Schedule 3 of the TSC Act 1995 (NSW). 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 to the next fire" (Scientific Committee, Final Determination, March 2000). The literature on *P. mollis* ssp. maxima indicates that high fire frequencies are a potential threatening process, hence this determination is directly relevant to the future management of this taxon and should be considered during statutory environmental assessments.

2.5 Environmental assessment

The TSC Act 1995 (NSW) amendments to the environmental assessment provisions of the *Environmental Planning and Assessment Act* 1979 (EP&A Act) requires that consent and determining authorities consider relevant recovery plans when exercising a decision making function under Parts 4 and 5 of the EP&A Act 1979 (NSW).

The following public authorities are currently known to have a decision making function in relation to *Persoonia mollis* subspecies *maxima* habitat.

- Hornsby Shire Council in relation to lands within the Hornsby Local Government Area.
- The NSW NPWS in relation to lands reserved under the *National Parks and Wildlife Act* 1974 (NPW Act) and where a concurrence role under the EP&A Act 1979 (NSW) is required.
- The Berowra Valley Regional Park Trust for lands within Berowra Valley Regional Park.
- NSW Rural Fire Service in relation to the planning and implementation of fire mitigation works.
- Transgrid for lands over which a formal easement is currently vested.
- Department of Urban Affairs and Planning for lands managed by Landcom.

When exercising a decision making function under the EP&A Act 1979 (NSW) for any development or activity which may affect *P. mollis* ssp. *maxima*, or its habitat, these and other relevant public authorities (should additional populations be found) should consider the content and objectives of this recovery plan. Appendix 3 provides guidelines which public authorities should consider in relation to the exercise of decision making functions which affect *P. mollis* ssp. *maxima*.

3. Current Conservation Status

Persoonia mollis subspecies *maxima* is known from three populations, with a total number of individuals as at February 2000 of approximately 550 adult plants and 380 juveniles/seedlings. The populations occur over a restricted north-south distribution of approximately 5.75km, in sheltered gullies, in the Hornsby Heights-Mt Colah-Mt Kuring-gai area in the Central Coast Botanical Division, south eastern Australia.

The known *P. mollis* ssp. *maxima* populations occur predominantly on lands managed for nature conservation (Ku-ring-gai Chase National Park, Berowra Valley Regional Park) or lands which are considered to have landuse zonings which are consistent with nature conservation objectives. Land managers responsible for *P. mollis* ssp. *maxima* populations include the NSW National Parks and Wildlife Service, Berowra Valley Regional Park Trust, Hornsby Shire Council, Department of Urban Affairs and Planning, and several private landholders. The success or otherwise of this recovery plan will depend in part upon the cooperation of all of the relevant land managers.

4. Description

4.1 Taxonomic description

Persoonia mollis subspecies *maxima* Krauss & L. Johnson is a tall, branching, spreading shrub which grows from 2 - 6 metres high. The bark is smooth, compact, dull grey-brown in colour (sometimes mottled), becoming finely fissured when older. The buds, and to a lesser extent young branchlets and young leaves, are covered with soft, erect copper coloured hairs which are approximately 2-3 mm long. This colour persists in both fresh and dried specimens. Leaves are simple, entire, and soft, 6-12 cm long, 1-1.7 cm wide and sparsely-hairy to hairy on both surfaces and tips when young (Krauss & Johnson 1991).

Persoonia fruits resemble a small plum, with a hard woody endocarp surrounding a (usually) single seed (Johnson & Briggs 1975). The fruits of *P. mollis* ssp. *maxima* are stipitate, that is, having a stipe or stalk, obliquely ovoid-globular or subglobular to elliptical, and are approximately 8 mm long and 7 mm in diameter (Krauss & Johnson 1991). The fruits are coloured green, becoming purplish-brown and soft when mature.

Figures 1a and 1b show the typical appearance of *P. mollis* ssp. maxima.

Figure 1a Typical appearance of *Persoonia mollis* subspecies *maxima*



1a) Flowers, buds, young leaves showing hairs 2-3mm long (Photo: Pat Pike, Binya Close 1993)



1b) Adult plant habit (Photo: Chris Lacey, Mt Kuring-gai 2000)

4.2 Taxonomic significance

Persoonia mollis R. Br. is a complex species which exhibits morphological and genetic variation over its geographical range. Variation within the *P. mollis* complex appears to have a genetic basis, with morphological differences most pronounced in the size, shape and pubescence of leaves and flowers, and in the large differences in growth habit (Krauss 1994a; Krauss 1996).

This variation is represented formally by nine (9) subspecies, of which subspecies *maxima* is the most distinctive (Krauss & Johnson 1991). *P. mollis* ssp. *maxima* derives its name from the Latin *mollis*, referring to the soft leaves, and *maximus*, referring to the subspecies being generally larger in its parts (ie, habit, leaves, buds, flowers and hairs) than all of the other subspecies (Krauss & Johnson 1991).

P. mollis ssp. *maxima* is currently recognised as a subspecies, however, Krauss (1996) concluded that there is support for the morphological distinctiveness of this taxon which may warrant its formal recognition at the species rank. Genetic analysis (using allozyme variation) has confirmed the distinctiveness of *P. mollis* ssp. *maxima*, however, the decision to recognise this taxon at species rank is premature and requires further sampling of other wild populations (Krauss 1998).

It is important to note, however, that the taxonomic status of *P. mollis* ssp. *maxima* is unlikely to affect the conservation status of the taxon.

5. Distribution and habitat

5.1 Current and historical distribution

5.1.1 Distribution of *Persoonia mollis*

Persoonia mollis is endemic to NSW. The nine subspecies have a restricted but relatively continuous distribution extending approximately 250km south of the Blue Mountains and 100km west of the coast-line (Krauss 1996). *Persoonia mollis* subspecies *maxima* is geographically disjunct and isolated from all other known populations of *P. mollis* subspecies. Figure 2 shows the distribution of all the *P. mollis* subspecies.



Figure 2. Distribution of *Persoonia mollis* subspecies: 1, subsp. mollis. 2, subsp. maxima. 3, subsp. nectens. 4, subsp. ledifolia. 5, subsp. revoluta. 6, subsp. leptophylla. 7, subsp. livens. 8, subsp. caleyi. 9, subsp. budawangensis. (Source: Krauss & Johnson 1991)

5.1.2 Distribution of *Persoonia mollis* subspecies *maxima*

Persoonia mollis subspecies *maxima* was first collected in March 1915 by W.F Blakely, with subsequent collections in April 1915 and February 1918. Since 1918, this taxon remained uncollected until December 1984, and since then, a further nine specimens have been added to the collection of the National Herbarium of NSW.

The current known distribution indicates that *P. mollis* ssp. *maxima* is highly restricted, known from the Hornsby Heights-Mt Colah-Mt Kuring-gai area north of Sydney, in the Central Coast Botanical Division of NSW. It is currently known to occur in three populations located in separate catchments over an approximate north-south range of 5.75 km and approximate east-west range of 7.5km. Figure 3 shows the distribution of *P. mollis* ssp. *maxima*, and Appendix 1 summarises the site details for *P. mollis* ssp. *maxima*.

Recent genetic research among populations of *Persoonia mollis* speculates that subspecies *maxima* has diverged little from its ancestral state (Krauss 1998). The relatively small amount of change from that ancestor in such a small and isolated population, suggests that the current distribution of *P. mollis* ssp. *maxima* may be a relict of an historically larger distribution, with a relatively recent range contraction (Krauss 1998). This is a tentative conclusion, however, and further biogeographic research is required to understand the historical distribution of subspecies *maxima* (Dr S. Krauss, Kings Park Botanic Garden pers comm).



Figure 3 Distribution of Persoonia mollis ssp. maxima

5.2 Tenure and security of populations

5.2.1 Tenure

Persoonia mollis subspecies maxima occurs within the following land tenures:

- Berowra Valley Regional Park, which is managed by the Berowra Valley Regional Park Trust consisting of Hornsby Shire Council, NSW National Parks and Wildlife Service, and local community representatives;
- Ku-ring-gai Chase National Park, which is managed by the NSW National Parks and Wildlife Service;
- Vacant Crown Land, which is managed by Landcom;
- Freehold land, owned and managed by various private landholders; and
- Regional Open Space, owned by the Department of Urban Affairs and Planning (DUAP).

5.2.2 Zoning

Persoonia mollis ssp. *maxima* populations are subject to the following zonings under the Hornsby Shire Local Environmental Plan (1994):

- Berowra Valley Regional Park is currently zoned Open Space B (Public Recreation);
- Ku-ring-gai Chase National Park is currently zoned National Parks and Nature Reserves;
- Vacant Crown land (Binya Close) is currently zoned Residential A (Low Density);
- Freehold lands (Galston Creek) are zoned Environmental Protection B (River Catchment); and
- DUAP Regional Open Space (Matthew Close) is currently zoned Open Space B (Public Recreation).

This information indicates that only part of one *P. mollis* ssp. *maxima* population occurs on land which does not have a land use zoning that is considered to be secure or consistent with nature conservation objectives.

5.2.3 Existing management

P. mollis ssp. *maxima* occurs predominantly on land that is reserved under the *National Parks & Wildlife Act*, 1974 (NPW Act). The management of National Park and Regional Park tenures is governed by the provisions of the NPW Act 1974 (NSW) and the Hornsby Local Environmental Plan (1994), and any Plans of Management prepared for those areas:

- Berowra Valley Regional Park is currently managed in accordance with the Berowra Valley Bushland Park Plan of Management (1996). This plan will be adopted as the first plan of management for the newly declared Berowra Valley Regional Park until revised.
- A plan of management for Ku-ring-gai Chase National Park is, at the preparation of this recovery plan, in draft form.

The Landcom owned Vacant Crown Land on which one *P. mollis* ssp. *maxima* subpopulation occurs is currently not subject to any formal management arrangement. Landcom owned lands in the Hornsby Local Government Area (LGA) are currently subject to an Ecologically Sustainable Development study by the Total Environment Centre. A principal objective of the study is to resolve current landuse conflict by identifying areas of conservation value that are suitable for reservation, and develop recommendations for areas which are suitable for housing construction and subdivision. The importance of protecting the Binya Close site for *P. mollis* ssp. *maxima* is discussed at section 8.2.1 of this plan.

The various privately owned lands and DUAP lands on which *P. mollis* ssp. *maxima* occurs are similarly not subject to any formal management arrangements.

5.3 Habitat

5.3.1 Landform

Persoonia mollis subspecies *maxima* occurs predominantly in deep gullies or on the steep upper hillsides of narrow gullies incised from Triassic Hawkesbury sandstone. This habitat is characterised by steep sideslopes, rocky benches and broken scarps, with creeks fed by small streams and intermittent drainage depressions. *P. mollis* ssp. *maxima* shows a preference for sites with sheltered aspects which support relatively moist vegetation communities. While occurrences of this taxon have been recorded on the dry upper-hillsides of gullies and in more exposed aspects, population density in these areas is low.

5.3.2 Vegetation communities

Persoonia mollis subspecies *maxima* occurs in vegetation communities that are widespread but restricted to the steep dissected gullies on the Hornsby Plateau and Hawkesbury Sandstone. This vegetation has been described by Benson & Howell (1994) as the Sydney Sandstone Complex (Map Units 10ag & 10ar) on the Sydney 1:100,000 map sheet. These communities are generally associated with sheltered hillsides and moist gullies (10ag) and dry plateaux and ridges (10ar), and often intergrade with each other.

P. mollis ssp. *maxima* is usually observed in highest densities at the bottom of these gullies from the creek-line to the first escarpment bench, or adjacent to moist drainage depressions which feed the main creek. Vegetation structure is generally

tall forest communities with a diverse understorey, sometimes with mesic influences. The plant does occur, though less frequently, on the dry upper-slopes of the gullies but usually in lower population densities and on more sheltered aspects (C. Lacey, NSW NPWS pers. obs.). Table 1 summarises the most commonly observed species associated with the habitat of *P. mollis* ssp. *maxima*.

Smith & Smith (1990) mapped this vegetation community in the Berowra Valley Regional Park as *Eucalyptus piperita-Angophora costata* open forest. The most common canopy species in this community are *Angophora costata, Corymbia gummifera,* and *Eucalyptus piperita,* with *Syncarpia glomulifera, E. pilularis* and *Allocasuarina littoralis* occurring in more fertile sites, and *E. punctata* occurring on the upper slopes and drier aspects. Warm temperate rainforest stands dominated by *Ceratopetalum apelatum, Callicoma serratifolia* and *Syncarpia glomulifera* often occur adjacent to this community in the most sheltered aspects, and particularly along creek lines. There is considerable variation in understorey species diversity and composition, reflecting changes in local environmental conditions such as aspect, soil moisture, and possibly differences in the fire regime.

Canopy Species	Common name	Shrubs	Herbs, Vines, & Grasses
Angophora costata Corymbia gummifera Eucalyptus piperita E. punctata [†] Syncarpia glomulifera ^{††} Adjacent creek- side warm temperate rainforest: Callicoma serratifolia Ceratopetalum apetalum C. gummiferum Tristaniopsis laurina	Smooth-barked Apple Red Bloodwood Sydney Peppermint Grey Gum Blackbutt Turpentine Black Wattle Coachwood Christmas Bush Sydney Water Gum	Acacia elata A. linearifolia Allocasuarina littoralis Astrotricha floccosa Backhousia myrtifolia Banksia spinulosa B. serrata Dodonaea triquetra Grevillea linearifolia G. mucronulata Hakea dactyloides H. salicifolia Isopogon anemonifolius Leptospermum trinervium Lomatia myricoides Persoonia levis P. lanceolata P. pinifolia Petrophile pulchella Phebalium dentatum Platylobium formosum Pultenaea flexilis Rulingia dasvphylla	Bauera rubioides Dianella caerulea Eriostemon hispidulus Gleichenia dicarpa Lomandra longifolia Pteridium esculentum Smilax glyciphylla Sticherus flabellatus Xanthorrhoea media

Table 1:Species commonly associated with the habitat of
P. mollis ssp. maxima.

† On drier aspects, particularly upper-slopes of gullies

†† On moist, sheltered gullies.

5.3.3 Altitude, aspect and slope

Recorded altitudes for *Persoonia mollis* subspecies *maxima* sites range from 10m to 190m above sea level. However, highest population densities have been recorded from altitudes of 10-100m, that is, along the creek lines to the first escarpment bench. Individual *P. mollis* ssp. *maxima* plants which occur along creeklines are therefore subject to occasional severe flooding events (P. Kubiak pers comm).

P. mollis ssp. *maxima* has been recorded as occurring across a range of aspects, however, it appears as though the taxon occurs less frequently and in lower population densities on those aspects with an exposed north-facing component.

Recorded slopes are generally high, but vary from approximately 10-15° on the dry upper-hillsides (low population densities) to 30-60° in the steep gullies (higher population densities).

5.3.4 Geology and soil characteristics

Persoonia mollis subspecies *maxima* occurs in the steep dissected gullies of the Hornsby Plateau and Hawkesbury. Sandstone escarpments and outcropping are common. Soils are generally shallow and sandy, highly permeable and low in fertility. The typical habitat of *P. mollis* ssp. *maxima*, as described above, occurs on the *Hawkesbury* soil landscape, following Chapman & Murphy (1983). Soils in this landscape are generally strongly acidic to moderately acidic, and colour varies from brownish-black (when there is abundant organic matter) to dull yellowy-orange. Sub-soils may have a fine sandy-clay influence derived from a remnant shale lens.

5.3.5 Fire history

Estimates of age structure (see 6.2 below) suggest a strong correlation between the population dynamics of *P. mollis* ssp. *maxima* and the previous fire history. For example, highest population densities were recorded at sites that have been less frequently burnt because either:

- fire has been absent from the landscape long enough for individual plants to mature and reproduce; and/or
- sites were protected from fire, either close to creek lines, drainage depressions, in sheltered aspects and/or moist vegetation communities, acting as refuge areas for the taxon.

Details on the fire history of sites is provided in Appendix 1.

6. Biology and Ecology

6.1 Habit, growth rate and longevity

The typical form of *Persoonia mollis* subspecies *maxima* is a tall, branching, spreading shrub. Mature plants are single trunked, with diameter at base observed up to 150 mm. Individual plants may live up to 30 years and the height of reproductively mature plants varies from 2-6 metres.

An approximate age of *P. mollis* ssp. *maxima* individuals can be determined by the nature of the plant's branching (Dr P. Weston, Royal Botanic Garden pers comm). Each year following the flowering period, a "whorl" of flowering branches is produced from the shoot tip. Each of these new shoots subsequently becomes a new growth segment which represents a seasonal growth unit. By assuming that one seasonal growth unit is equal to one year, counting the number of growth units provides an estimate of a plant's approximate age.

Variation in the length of growth units and thus the height of plants was observed in each of the populations. For example in the Calna Creek population, plants with 14-16 whorls varied in size from 3.5 - 6.5 metres. This variation is probably reflective of subtle changes in environmental conditions, such as soil moisture and/or exposure to light. Whilst there is currently no empirical evidence, *P. mollis* ssp. *maxima* seedlings currently growing *ex situ* at Mt Annan Botanic Gardens show no apparent signs of an exceptionally rapid or slow growth rate (R. Johnston, Mt Annan Botanic Garden pers comm).

6.2 **Population structure and dynamics**

6.2.1 Known population size

As of February 2000, the total number of *Persoonia mollis* subspecies *maxima* was 930 individuals, consisting of 550 mature individuals and 380 juveniles/seedlings. Following the IUCN Red List criteria (1994), the total population of a taxon is considered to be the number of mature individuals, therefore, the current population size of *P. mollis* ssp. *maxima* is approximately 550 individuals.

In the absence of information which clearly demonstrates the genetic distinctiveness of *P. mollis* ssp. *maxima* occurrences across its range, this recovery plan describes three populations for the taxon. These populations have been delineated on a catchment basis, owing to the potential for genetic exchange between occurrences of *P. mollis* ssp. *maxima* as a result of seed dispersal throughout each catchment. The three populations of *P. mollis* ssp. *maxima* are therefore named as follows: Calna Creek population, Cockle Creek population, and Berowra Creek population.

Occurrences of *P. mollis* ssp. *maxima* within each of these catchments have been further described in this recovery plan as discrete entities to assist and inform management practices. These are termed subpopulations and are described below.

6.2.2 Spatial population dynamics and age structure

Persoonia mollis subspecies *maxima* is not distributed evenly throughout each population. Population sizes highlight the distinct concentration of *P. mollis* ssp. *maxima* in the Calna Creek catchment (73% of total individuals), followed by the Cockle Creek catchment (14.5% of total individuals) and the Berowra Creek catchment (12.5% of total individuals).

Approximately 60% of the total number of *P. mollis* ssp. *maxima* individuals are considered to be reproductively mature. Similarly, age structure varies within and among the *P. mollis* ssp. *maxima* populations.

Appendix 2 summarises the population dynamics of the taxon as recorded in 1998/99. A discussion of each population is presented below.

Calna Creek population

The Calna Creek catchment supports a population of approximately 406 flowering adults and 129 juveniles/seedlings. There are four (4) subpopulations described for management purposes, and several scattered individuals occurring on upper slopes and ridgelines.

The largest number of flowering individuals occurs in the *Calna Creek* subpopulation (376 or 93% of the population), and there are 68 juveniles/seedlings. The mean age of individuals for the mid-section of Calna Creek is approximately 10 years. Age range within the subpopulation is approximately 16 years. Approximately 50% of plants were 10-14 years and just 10% were greater than 15 years, indicating that just half of the plants are likely to be reproductively mature. The oldest individual plant in the population occurs along Calna Creek and was estimated to be approximately 18 years. Most plants are concentrated along the main creekline, however there are several scattered individuals on the mid-upper slopes of the catchment, in particular, along the fire trail below Flinders Place, Mt Colah (R. Doig, SGAP pers. comm).

The *Binya Close* subpopulation contains the second highest number of flowering adults in the population (20 or 5% of the population), and no juveniles/seedlings. The plants are concentrated in an upper-slope, sheltered location that is connected to the Calna Creek subpopulation. Binya Close has been assigned a separate subpopulation status due to the ownership of the site (Landcom) and the atypical ridgetop habitat present. A 50% decline in the number of individuals at this site has been observed since the location was first surveyed in 1993 (P. Pike, SGAP pers comm). The mean age of individuals at Binya Close is approximately 6 years,

which is below reproductive maturity estimates, and the age range is approximately 3 years. The oldest individual plant is approximately 9 years.

The *Mt Kuring-gai* subpopulation contains 10 flowering adults (2% of the population), and no juveniles/seedlings. The plants occur along a drainage depression which is isolated from the other subpopulations. The mean age of individuals is approximately 7.5, which is below reproductive maturity estimates, and the age range is 3 years. The oldest individual plant is approximately 9 years.

The *Lyrebird Gully* subpopulation is comprised entirely of seedlings estimated to be <2 years. This subpopulation is considered to be the most vulnerable to extinction, since there are no flowering adults and a seedbank is unlikely to exist. Twelve *P. mollis* ssp. *maxima* individuals were recorded by Dr S. Krauss (pers. comm) prior to 1995, however all plants were destroyed following a fire in 1996. Monitoring of the site during 1998 and 1999 has revealed that approximately 100 seedlings have subsequently germinated.

Cockle Creek population

The Cockle Creek catchment supports a population of approximately 81 flowering adults and 143 juveniles/seedlings. There are two (2) subpopulations described for management purposes.

The *Chase Trail* subpopulation contains 14 flowering adults (17% of the population) scattered in small clumps along an intermittent drainage depression and along the north bank of Cockle Creek. The largest number of reproductively immature plants of any subpopulation occurs here (114), with the mean age being approximately three (3) years and the range being 17 years. The oldest individual plant is approximately 18 years. Approximately 90% of the Chase Trail plants are aged four (4) years or younger, however, several older individuals survived the previous fire event (1990) in refuge areas. The seedbank in this subpopulation is likely to be extremely low.

The Unnamed Drainage subpopulation contains 67 flowering adults (83% of the population) and approximately 29 juveniles/seedlings. The plants occur in a relatively high but restricted density along a drainage depression and sheltered sections of the north bank of Cockle Creek. The mean age of individuals within this subpopulation is approximately seven (7) years which is below reproductive maturity estimates, and the age range is 11 years. The oldest individual plant is 12 years.

Berowra Creek population

The Berowra Creek catchment supports a population of approximately 69 flowering adults and 105 juveniles/seedlings. There are four (4) subpopulations described for management purposes.

The largest number of flowering adults occurs in the *Galston Creek* subpopulation (47 or 63% of the population). Empirical data were not collected for this subpopulation, however, field observations indicated that approximately one third of the total number of plants surveyed were flowering adults (R. Doig, pers comm). There are therefore approximately 94 juveniles/seedlings. This subpopulation requires further investigation of population dynamics and age structure to confirm field observations.

The *Waddells Gully* subpopulation contains approximately 17 flowering adults (23% of the population) and eight (8) juveniles/seedlings. The mean age of individuals is approximately seven (7) years, which is below reproductive maturity estimates, and age range is 10 years. The oldest individual plant was approximately 12 years. Plants within this subpopulation occur mostly as scattered individuals with groups of more than 2-3 plants uncommon.

The *Matthew Close* subpopulation contains approximately seven (7) flowering adults (10% of the population) and 10 juveniles/seedlings. The mean age of individuals is approximately seven (7) years, which is below reproductive maturity estimates, and the age range is approximately eight (8) years. The oldest individual plant was approximately 11 years. Plants within this subpopulation occur mostly as scattered individuals with groups of 2-3 plants uncommon.

The *Tunks Creek* subpopulation contains four (4) flowering adults (4% of the population) and 2 juveniles/seedlings. The mean age of individuals is approximately seven (7) years, which is below reproductive maturity estimates, and the age range is approximately eight (8) years. The oldest individual plant was approximately 12 years. Plants within this subpopulation occur as scattered individuals in low densities.

6.3 **Reproductive biology**

6.3.1 Vegetative reproduction

Persoonia mollis subspecies *maxima* does not reproduce vegetatively (Krauss 1994a). No vegetative reproduction was observed during field survey for the preparation of this recovery plan.

6.3.2 Phenology and breeding system

Persoonia species in eastern Australia are often sympatric, that is, they occupy similar habitats and show a broad overlap in floral phenology (Bernhardt & Weston 1996). *P. mollis* ssp. *maxima* is allopatric, that is, it occurs in separate habitats from, and does not occur with, the other *P. mollis* subspecies.

Several other *Persoonia* species occur with *P. mollis* ssp. *maxima* including *P. levis*, *P. pinifolia*, *P. linearis*.

Flowering

The flowering period for *P. mollis* ssp. *maxima* is usually late December - March. Flowers are approximately 10 mm long, hermaphroditic, with four stamens that are attached to yellow petals. Each individual flower remains receptive for approximately five (5) days after the bud opens (Krauss 1994).

Pollination

The Proteaceae are known to exhibit specialised pollination syndromes involving birds, mammals and insects (Weston 1995). There has been no investigation into the pollinators of *P. mollis* ssp. *maxima*. However, recent research into the pollination ecology of *Persoonia* by Bernhardt & Weston (1996) concluded that the *Persoonia* species of eastern Australia have a specialised system of pollination, recruiting relatively few of the many genera of native bees as true pollinators.

The most consistent pollinators of Persoonias are *Leioproctus* species (Colletidae, subgenus Cladocerapis) and *Exoneura* species (Anthrophoridae). The naturalised European Honey Bee (*Apis mellifera*) forages actively on *Persoonia* pollen and nectar, but is likely to be less effective as a pollinator than native species because, in the process of pollen collection, nectar moistens the pollen grains which may cause them to lose their viability in transfer (Bernhardt & Weston 1996). In contrast, native bees transfer *Persoonia* pollen to scopal hairs on the hind legs and/or ventral hairs at the base of the abdomen, avoiding contact with nectar and maintaining pollen viability (Bernhardt & Weston 1996).

Persoonia mollis is partially self-compatible, however, self-pollination rarely results in successful seed set (Krauss 1994b). Artificial pollinations by Krauss have shown the *P. mollis* complex to be dominated by outcrossing genotypes in terms of both the quantity and quality of fruit (and therefore seed) produced. This means that the breeding system in *P. mollis* promotes outbreeding, and the limited self pollination ability may be a "bet hedging" mechanism whereby, if cross-pollen is not available, plants can continue to produce offspring (Krauss 1994b).

Fruiting

P. mollis ssp. *maxima* fruits are fleshy and drupaceous (plum-like), with a succulent mesocarp surrounding a hard woody endocarp carrying a (usually) single seed. Fruits are retained on the plant until maturation (usually November), at which time they become soft and fall to the ground. Krauss (1994b) concludes that approximately 20% of flowers pollinated with out-cross pollen set fruit, compared with 1% of flowers through self pollination in the absence of out-cross pollen. However, fruit-set varies markedly across populations of *P. mollis* (Dr S. Krauss pers comm).

Age specific fecundity, including the age at which individual plants reach their peak fruiting is empirically unknown in *P. mollis* ssp. *maxima*. Monitoring of the populations is required to investigate age to first fruit production, age at peak fruiting, and variation in flower/fruit production with disturbance history.

Reproductive maturity

The age at which *P. mollis* ssp. *maxima* is reproductively mature, and the time it takes for the taxon to produce viable seed and sufficiently restock the seedbank, are important biological variables, particularly in relation to developing an appropriate fire regime. *P. mollis* ssp. *maxima* probably reaches peak reproductive maturity at around 10-15 years (Dr S. Krauss, pers comm).

Preliminary monitoring of the Cockle Creek population to investigate the time to reproductive maturity was conducted during the preparation of this plan. The results of this monitoring indicated that few *P. mollis* ssp. *maxima* individuals with approximately six (6) "whorls" or fewer were observed to flower. Furthermore, it was not until plants had attained approximately eight (8) "whorls" that 100% of individuals in that age class or older were observed to flower.

These results suggest that subpopulations of *P. mollis* ssp. *maxima* which are aged less than eight (8) years are unlikely to have developed a seedbank and therefore are extremely vulnerable to extinction following disturbance which kills those individuals. For example, a subsequent fire in the Lyrebird Gully or Chase Trail subpopulations before the existing plants reach reproductive maturity is likely to result in the extinction of those subpopulations due to the fact that there is an insufficient seedbank.

Further monitoring of *in situ* and *ex situ* individuals is required to refine the reproductive maturity estimates, in terms of seed production and seedbank replenishment.

6.3.3 Genetic research on the *Persoonia mollis* complex

Pollen dispersal within the *P. mollis* complex has been shown to be extremely restricted, with the estimates of paternity pool size being among the smallest recorded (Krauss 1994a). Inbreeding and reduced heterozygosity (different genes) are expected from such restricted pollen dispersal and paternal pool size, however, contrary to these expectations *P. mollis* exhibits complete outcrossing and excess heterozygosity (Krauss 1994a).

One possible explanation for this apparent paradox is that seed dispersal in *P. mollis* is a substantially greater component of gene flow than pollen (Krauss 1994a). Seed dispersal over larger distances than pollen is possible, since *Persoonia* seeds are known to be eaten and dispersed by large birds (eg Currawongs *Strepera* spp)

(Buchanan, 1989) and probably also dispersed by mammals such as wallabies and possums. It has been speculated that pollen and seed dispersal over extremely small distances (principally bees and gravity respectively) thus occurs most of the time, but is supplemented by occasional dispersal of seed over longer distances (by birds and wallabies), which occurs frequently enough to facilitate gene flow (Krauss 1994a).

There is some evidence of consanguineous mating (that is, mating among close relatives) in at least one of the subpopulations of subspecies *maxima* (Lyrebird Gully) (Krauss 1994a). Although the relative longevity of *P. mollis* ssp. *maxima* plants provides the opportunity for parents and their offspring to co-exist and therefore mate (Krauss 1994a),

- potentially high seed dispersal, through birds and animals; and
- low levels of seed germination (Dr S. Krauss, pers comm).

probably combine to result in a more or less randomly mating population to facilitate gene flow. The evidence of consanguineous mating in the Lyrebird Gully subpopulation suggests that more detailed studies of the mating system in *P. mollis* ssp. *maxima* are required before definitive management recommendations concerning this issue can be developed (Dr S. Krauss pers comm).

6.4 Seedbank dynamics

6.4.1 Seed production and dispersal

Since fruit with more than one seed are rare, seed production is presumed to be close to the same as fruit set (that is, approximately 20% of flowers in outcrossed pollinations). Once mature, *Persoonia mollis* subspecies *maxima* fruits are principally gravity dispersed and, secondarily, dispersed by large birds that have often large home ranges (eg. Currawongs, *Strepera* spp.) (Krauss 1994a). Mammals such as wallabies and possums, foxes, other birds such as silver-eyes (*Zosterops* spp) and bower-birds (*Ptilinorhynchus violaceus*) may also forage on *Persoonia* fruits and supplement seed dispersal (Dr S. Krauss, pers comm).

Those seeds which are gravity dispersed or which remain viable after being dispersed by animals are stored in the soil seedbank until germination. Recent work by Wasley (1997) on three obligate seeding *Persoonia* species (including *Persoonia mollis* subspecies *nectens*) found that the majority of *Persoonia* seeds were stored in the leaf litter layer of the soil profile.

6.4.2 Seed dormancy and germination

Most *Persoonia* species have been difficult to propagate *ex situ*, either by seeds or by cuttings, indicating that the germination requirements of this taxon are not well understood (Ketelhohn & Johnson, 1995). Langkamp (1987) notes that no

germination of *Persoonia* seeds occurred *ex situ* until the second and third autumn after sowing, indicating the presence of a dormancy mechanism. In a separate trial, propagation of *P. mollis* ssp. *maxima* seeds collected from the Cockle Creek catchment was attempted by Mt Annan Botanic Gardens in 1993, however, all seeds failed to germinate (R. Johnstone, pers comm).

In other *Persoonia* species the dormancy mechanism has been overcome using high concentrations of gibberellic acid (Dr P. Weston, National Herbarium of NSW pers comm), however, the precise nature of this dormancy mechanism is unknown (Wasley 1997). *Persoonia* embryos have been extracted from the endocarp *ex situ*, and germination was again unsuccessful. This indicates that there may be a biochemical inhibitor which regulates seed germination *in situ* (Dr P. Weston pers comm). Robertson *et al* (1996) suggest that seeds passing through the gut of small mammals may assist germination. However, the relationship between seed dormancy and the factors which promote and/or inhibit seed germination in *Persoonias* is unclear.

Extremely low seed germination rates in the *P. mollis* complex have been noted by Krauss (*pers obs* in Krauss, 1994a), and of subspecies *maxima* by R. Doig (pers comm). The observed presence of seedling plants in the wild after a fire event indicates that germination of *P. mollis* ssp. *maxima* seeds *in situ* may be influenced by fire. However, there are also juveniles in each of the populations which have germinated in the absence of fire. The role of fire-related variables (including exposure of dormant seed to cold smoke) in the germination of *P. mollis* ssp. *maxima* seeds is therefore unclear.

Further investigation is needed to understand the dormancy mechanisms, germination requirements and the mortality of *P. mollis* ssp. *maxima* seeds. The results of this information will be used to inform current fire management practices.

6.4.3 Seed viability and seedling growth

No experiments have been conducted to test for the potential viability of *Persoonia* mollis subspecies maxima seeds. However, Wasley (1997) studied the seed viability of three obligate seeding *Persoonia* species (including *Persoonia* mollis ssp. nectens) and concluded that seed viability was consistently low. Further investigation is required to test seed viability in *P. mollis* ssp. maxima.

Furthermore, artificial pollinations by Krauss have shown that in *P. mollis*, lower fruit weights result following self pollination compared to outcrossed fruits. Krauss (1994b) has suggested that selfed seeds, if viable, may be less vigorous than outcrossed seeds, and therefore at a competitive disadvantage at the seedling stage when outcrossed seeds are present. Further investigation into the pollination ecology of *P. mollis* ssp. *maxima* is required.

There is no empirical evidence on the growth rate of P. mollis ssp. maxima seedlings. Seedlings in the Lyrebird Gully subpopulation were estimated to be no more than two (2) years old and varied in size from 20-80cm. The seedlings in the Lyrebird Gully subpopulation have been tagged with fire-proof metal rings in order to conduct annual monitoring of survivorship and growth.

6.4.4 Seed and seedling predation

Larger parrots (eg, cockatoos, rosellas) feed on *Persoonia* fruits (Dr S. Krauss, Dr P. Weston pers comm). Cockatoos usually crack open the stones of immature fruits and eat the seeds, which are thus destroyed. The role that other small mammals (eg. possums, small native rats) and potentially some reptiles (eg. blue tongue lizard *Tiliqua scincoides*) play in seed predation is unknown and requires investigation.

One consequence of active seed predation is that the rate at which the seedbank is replenished will be delayed, and longer intervals between fires may be required than that which is inferred simply from the time to first flowering (or reproductive maturity) of individuals (Auld 1996).

Several *P. mollis* ssp. *maxima* seedlings observed *in situ* showed evidence of predation by herbivorous animals and insects. Individual plants were not completely destroyed, with just 3 or 4 leaves usually damaged. The extent to which this disturbance impacts on the recruitment and survival of seedlings is unclear. There was no evidence of grazing or predation on the leaves of adult plants.
6.5 Fire ecology

Persoonia mollis subspecies *maxima* is a fire-sensitive taxon which occurs in a fireprone habitat (Krauss 1997). Fire-sensitive species are obligate seed regenerators, which means that adult plants are killed outright by fire, and post-fire survival is totally reliant upon seed regeneration (Keith 1996). The long term persistence of fire-sensitive species in fire-prone habitats is dependent upon whether sufficient seed is stored dormant in the soil, held in woody fruits on the adult plants, or must immigrate from unburnt areas (Gill & Bradstock 1996).

Fire-related variables which have a direct influence on species survival are elements of the fire regime, and include the spatial extent, intensity, seasonality and frequency of the fire (Gill 1996). For fire-sensitive species, a fire-free interval is required which allows seedlings to establish, mature, and produce sufficient seed to restock the soil seedbank. Frequent fires which interrupt maturation of individuals before they can successfully replenish the seedbank may lead to fire-driven extinction of local populations (Bradstock & Auld 1987; Keith 1996).

Benson (1985) and Krauss (1997) suggest that repeated fires with an interval of less than 5-6 years would be unlikely to allow sufficient time for many fire-sensitive species to become reproductively mature and produce a new seedbank, thus eliminating species locally. Monitoring of the Cockle Creek population indicates that this may be an under-estimate of an appropriate fire-free interval for *P. mollis* ssp. *maxima*, and that a minimum of at least eight (8) years is required to prevent extinction.

Recent work by Wasley (1997) found that due to high temperatures at the soil surface (where the majority of seeds are stored), most *Persoonia* seeds are likely to be killed by fire. For example, experimental burning indicated that most seeds were killed by exposure to temperatures of 150° for a duration of two (2) minutes (Wasley 1997). While some viable seeds were found in the litter layer following fire (due to spatial variation in fire exhibited at a micro-scale), Wasley (1997) predicts that the persistence of *Persoonia* species post fire may largely be reliant upon those few viable seeds stored deeper than the litter layer of the soil profile.

Wasley (1997) therefore notes the importance of:

- ensuring an appropriate fire-free interval which allows the development of a soil seedbank (for some sites, a seed bank may not start to develop for at least 10 years); and
- maintaining for long periods of time unburnt "refuge" areas, which could act as *Persoonia* seed sources and facilitate re-invasion of seed.

The empirical data used by Wasley (1997) is not available for *P. mollis* ssp. *maxima*. A conservative or precautionary estimate of an appropriate fire-free interval for *P. mollis* ssp. *maxima* of 12-15 years should be implemented until further data are

collected through the long-term monitoring of existing subpopulations which have been recently burnt. Future fire-related investigations identified in this plan will be directed towards informing current management practices.

6.6 Drought response and climate change

The effects of prolonged periods of drought are unknown for this taxon. *Persoonia mollis* subspecies *maxima* displays a distinct preference for sites which have sheltered aspects and therefore support relatively moist vegetation communities. While occurrences of this taxon have been recorded on the dry upper-hillsides of gullies and in more exposed aspects, population densities in these areas are generally low. This observation may indicate that drought conditions could play an important role in regulating the yearly growth rate, seedling recruitment and survival, and reproductive capacity of the taxon.

The impact of natural or anthropogenic climate change on this taxon has not been empirically investigated. However, Krauss' speculation that the present-day distribution of *P. mollis* ssp. *maxima* may be a relict of an historically larger distribution may be explained by natural climatic changes over the Australian continent. Anthropogenic climate change potentially enhances this impact and may accentuate any natural population declines that have been or are presently operating.

Further monitoring of various populations may help to understand the disturbance impact of persistent drought and natural or human induced climate change on the survival of this taxon.

7. **Previous management actions**

Several actions targeted at the management of this taxon were undertaken prior to the establishment of the recovery team and the preparation of this plan. These activities, which have contributed much to the current knowledge of *Persoonia mollis* subspecies *maxima*, are summarised below.

7.1 Survey

Cooperative surveys involving Hornsby Shire Council, NSW NPWS, Royal Botanic Gardens and the local community were conducted during 1995 to collect information on the distribution and abundance of *Persoonia mollis* subspecies *maxima*. The NSW NPWS has conducted targeted field survey for *P. mollis* ssp. *maxima* since December 1997 and further surveys involving community volunteers were held in January 1999. During these surveys, populations were censused, and habitat and threatening processes details were recorded.

7.2 Research

The *Persoonia mollis* complex has been the subject of considerable scientific investigation (Krauss & Johnson 1991; Krauss 1994a, 1994b, 1996, 1997, 1998, 1999; Krauss & Peakall 1998; Wasley 1997). In particular, Dr S.L. Krauss has used new genetic markers which allows the unique genetic fingerprinting of individuals within a natural population and the characterisation of mating patterns in *P. mollis*.

7.3 Age structure, population dynamics and reproductive maturity estimates

Age structure and population dynamics information for *Persoonia mollis* subspecies *maxima* was collected during field survey for the preparation of this plan. Plant height and approximate age were recorded (for method see section 6.1; for results see 6.2 and Appendices 1 & 2) for each subpopulation except the Galston Creek subpopulation. Seedling plants in the Lyrebird Gully subpopulation were tagged with numbered metal fire-proof tags, and seedling height and spatial dimensions were measured for future monitoring. Monitoring of the Chase Trail subpopulation provided preliminary estimates on the reproductive maturity of this taxon (see section 6.3).

7.4 Translocation

In 1993, Mt Annan Botanic Gardens received eight (8) *P. mollis* ssp. *maxima* seedlings from the NSW Herbarium, which were translocated from the Cockle Creek population following a wildfire, to safeguard genetic material. In November 1997, three (3) of the eight plants were planted in the ground (R. Johnston pers comm). As at the preparation of this plan, it is not intended for these seedlings to be re-introduced as the population is recovering. However, should further disturbance

threaten the population with extinction, reintroduction may be considered a suitable recovery action.

7.5 Fire management

Hornsby Shire Council is currently developing a Threatened Biota Management Plan which records the distribution and conservation status of threatened species, including *Persoonia mollis* subspecies *maxima*, for amongst other purposes, fire management. Hornsby Shire Council, Hornsby Rural Fire Service and NSW NPWS is further developing information on the fire history of Berowra Valley Regional Park, which will be an important data-source for integrating the ecological requirements of *P. mollis* ssp. *maxima* into the planning of future fire regimes (T. Jackson, NSW RFS pers comm).

Key fire management documents affecting *P. mollis* ssp. *maxima* habitat are currently being drafted. These include the Hornsby Bush Fire Risk Management Plan, and the Ku-ring-gai Chase National Park and Berowra Valley Regional Park Fire Management Plans. The information in this recovery plan should supplement these documents and provide for an appropriate ecological fire regime for *P. mollis* ssp. *maxima*.

7.6 On-ground management

Berowra Valley Regional Park is managed by the Berowra Valley Regional Park Trust. Prior to The Trust assuming care, control and management of the Park, Berowra Valley was managed by Hornsby Shire Council in accordance with the *Berowra Valley Bushland Park Plan of Management* (1996). Hornsby Shire Council has conducted low impact bush regeneration in Berowra Valley since 1996. Bush regeneration activities in Berowra Valley has focused on noxious weed control, and the promotion of conditions for natural regeneration (J. Burton, HSC pers comm).

7.7 Establishment of a recovery team

A *Persoonia mollis* subspecies *maxima* recovery team has been established to advise the DG of NP&W during the preparation of this plan, and to supervise and monitor recovery actions. The following organisations and individuals were involved in the development of the recovery plan:

- NSW NPWS;
- Royal Botanic Gardens, National Herbarium of NSW, Mt Annan Botanic Garden;
- Hornsby Shire Council;
- Transgrid;
- Conservation Geneticist Kings Park Botanic Garden WA; and
- Community conservation representative.

7.8 Cowan Catchment Weeds Strategy

- The Cowan Catchment Management Committee has prepared the Cowan Catchment Weeds Strategy (1998) to address weed invasion in the Cowan Catchment. This strategy includes reference to *Persoonia mollis* subspecies *maxima* habitat in the Cockle Creek Catchment.
- The strategy attempts to put weed management in the catchment in a long term framework by identifying the need for cooperative management of all land managers in the catchment. As a result of the strategy, action plans for Pampas Grass Eradication, Riparian Bushland Rehabilitation and Transport Corridors have been prepared.

7.9 Profile and environmental impact assessment guidelines

A plant profile and environmental impact assessment guidelines have been prepared by the NSW NPWS to advise on the Statewide conservation status of *P. mollis* ssp. *maxima*, and to assist decision makers addressing the factors specified in s5A of the EP&A Act 1979 (NSW) and s110 of the TSC Act 1995 (NSW). A copy of the profile and guidelines is included as Appendix 3 to this recovery plan.

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 (Clarke *et al*, 1993).

As such, this section identifies the management issues affecting *Persoonia mollis* subspecies *maxima*, including:

- limits of current understanding of the taxon's biology and ecology;
- threats and reasons for decline; and
- social and economic factors which may influence the success or otherwise of the recovery plan.

8.1 Understanding of biology and ecology

The *Persoonia mollis* complex has been the subject of considerable scientific investigation (eg. Krauss & Johnson 1991; Krauss 1994a, 1994b, 1996, 1997, 1998, 1999; Krauss & Peakall 1998). These studies, while not specifically directed at subspecies *maxima*, have provided considerable understanding of the taxon's biology and ecology. There remains several issues requiring further investigation. These include:

- systematic survey throughout the known catchments to determine the extent of existing populations;
- targeted survey in adjacent catchments to determine if any new populations exist;
- age specific fecundity and mortality in *P. mollis* ssp. maxima;
- biological research and investigations into seed ecology, germination and dormancy in the *Persoonia* genus;
- molecular genetic investigations into patterns of mating and inbreeding depression within and among populations of *P. mollis* ssp. *maxima*; and
- pollination biology in *P. mollis* ssp. maxima.

A more detailed understanding of key attributes of this plant's distribution, biology and ecology is essential to managing known and potential habitat in order to reduce the likelihood of extinction. This recovery plan identifies the need to develop and implement a program of biological and ecological investigation into attributes of *P*. *mollis* ssp. *maxima*, in order to make confident landuse decisions which may affect this plant's future conservation in nature.

8.2 Threats and reasons for decline

Appendix 4 summarises the threats to each of the *Persoonia mollis* subspecies *maxima* populations. The Binya Close subpopulation is the only occurrence of this taxon which is known to have declined in recent years, having experienced a 50% reduction in size since 1993 (P. Pike, Hornsby Conservation Society pers comm). While reproductively mature plants have been recently destroyed as a result of fire (Lyrebird Gully, Chase Trail subpopulations), these subpopulations are recovering as a result of seedling recruitment.

For the purposes of this recovery plan, threats are prioritised following the classification developed by Keith *et al.* (1997). This classification prioritises threats according to the following criteria:

- Class I threat is a process capable of causing sudden, substantial, and possibly irreversible loss of individuals or habitat.
- Class II threat is a process capable of causing gradual, substantial and possibly irreversible loss of individuals or habitat; and which may be reversible, but mitigation may be technically difficult or expensive to achieve.

A discussion of threatening processes is presented below.

8.2.1 Habitat loss

Threatened species are best conserved when the ecological processes which underpin the viability and health of their respective habitat (eg. pollination, nutrient cycling) are maintained. This is termed *in situ* conservation, and necessarily involves the retention and management of a taxon's habitat. Since the majority of *Persoonia mollis* subspecies *maxima* habitat occurs within Regional and National Park tenures, and/or secure zoning, habitat loss poses little threat to the future conservation of this taxon in nature.

The Binya Close subpopulation of *P. mollis* ssp. *maxima* occurs on Vacant Crown land that is currently zoned Residential A - Low Density. While this subpopulation is comparatively small in numbers to the larger Calna Creek subpopulation, the site has conservation value for the following reasons:

- it is atypical of *P. mollis* ssp. *maxima* habitat, and a potential hybrid formerly occurred on the site representing an important scientific opportunity lost;
- the site constitutes an important buffer between existing urban development and the more extensive Calna Creek subpopulation; and
- the site contains important habitat for other threatened species, including the Giant Burrowing Frog (*Heleioporus australiacus*), Red-crowned Toadlet (*Pseudophryne australis*), and Powerful Owl (*Ninox strenua*).

Any future development at Binya Close which would involve the loss of either *P*. *mollis* ssp. *maxima* individuals and/or habitat represents a Class I threat to this subpopulation.

8.2.2 Habitat degradation

Persoonia mollis subspecies *maxima* occurs at the interface of an urban-natural landscape, in the northern suburbs of Sydney. Despite all of the known populations (except Binya Close) occurring on land that is reserved under the NPW Act, or has secure zoning, the proximity of the populations to residential areas means that there are a suite of management issues affecting *P. mollis* ssp. *maxima* and its habitat, at both site-specific and catchment-based spatial scales.

Following Keith *et al* (1997) habitat degradation is considered a Class II threat to this taxon. A discussion of the processes which may potentially degrade the habitat of *P. mollis* ssp. *maxima* is presented below.

Water quality and nutrient levels

Water quality in the catchments of the Hornsby Heights-Mt Colah-Mt Kuring-gai area is affected by point-source and non-point-source pollutant discharges. These include urban stormwater runoff, rubbish dumping (along the back of ridge-top housing) and upstream sewage treatment works (eg. Hornsby Heights Sewerage Treatment Plant in the Calna Creek Catchment results in increased chlorine levels in discharge and occasional overflows or bypasses). The Galston Creek subpopulation is potentially vulnerable to reduced water quality flows due to its proximity to Galston Road and several stormwater outlets which are directed into the plant's habitat (R. Doig, pers comm).

Reduced water quality potentially affects *P. mollis* ssp. *maxima* directly, as a consequence of increased nutrient levels, and indirectly, by encouraging weed establishment and growth in riparian zones.

Weed invasion

Weed invasion presents an acute problem in each of the known populations of *Persoonia mollis* subspecies *maxima*. For example, the Cowan Catchment Management Committee (1998) considers the Cockle Creek Catchment to be the most degraded creek within the Cowan Catchment. Weed invasion occurs as a result of:

- seed dispersal, by birds, stormwater, wind, rubbish dumping and the movement of soil by vehicles and other sources;
- urban runoff, originating from stormwater outlets;
- vegetative spread of weeds by rubbish dumping; and
- frequent disturbance, such as slashing and fire.

The causes of weed invasion often originate upstream or upslope of where the impact is most observable. Exotic species compete with, and interrupt the

recruitment of, seedling and adult plants, preventing them from reaching reproductive maturity. Weed invasion in riparian zones may have further negative impacts on aquatic habitats (Cowan Catchment Management Committee 1998).

Weed invasion in *P. mollis* ssp. maxima habitat can be classified broadly as:

- invasions which occur at the interface or boundaries of bushland with urban development; and
- invasions which are restricted to riparian zones, along watercourses and drainage depressions.

The most common weed species in *P. mollis* ssp. *maxima* habitat are Small-leaved Privet (*Ligustrum sinense*), Large-leaved Privet (*L. lucidum*), Water Primrose (*Ludwigia peruviana*), Pampas Grass (*Cortaderia selloana*), Mistflower (*Ageratina riparia*), Lantana (*Lantana camara*), Wandering Jew (*Tradescantia albiflora*), Camphor Laurel (*Cinnamomum camphora*), Blackberry (*Rubus fruticosus*), Whiskey Grass (*Anisopogon virginicus*), and Crofton Weed (*Ageratina adenophora*) (Cowan Catchment Management Committee 1998).

The management of weeds in, and adjacent to, the habitat of *P. mollis* ssp. *maxima*, will require the combination of targeted bush regeneration efforts and broader catchment based solutions to improving water quality. There is a need for both short and long term actions to be implemented in a cooperative manner by all of the relevant land managers in the catchment (Cowan Catchment Management Committee 1998).

Rubbish dumping

Dumping of greenwaste (eg household garden clippings) occurs along the back of ridge-top development throughout the Hornsby Heights-Mt Colah-Mt Kuring-gai area. Greenwaste dumping encourages weed invasion downslope of the ridge (by increasing nutrient levels), and potentially affects directly the infrequent occurrence of *P. mollis* ssp. *maxima* on the upper slopes of these catchments.

More serious dumping of household rubbish and construction materials occurs at the Binya Close site, within the Calna Creek population. Dumping of such material potentially affects *P. mollis* ssp. *maxima* by physically destroying individuals, and encouraging habitat degradation through weed invasion and other disturbance.

Rubbish dumping may also increase the risk of unplanned fire, which is considered a Class I threat to this taxon.

Infrastructure maintenance

There are several powerlines which traverse the gully catchments of the Hornsby Heights-Mt Colah-Mt Kuring-gai area, including areas of known or potential habitat for *Persoonia mollis* subspecies *maxima*. The land under these lines is subject to a formal easement currently vested with Transgrid, which is responsible for the

maintenance of these areas. Although *P. mollis* ssp. *maxima* individuals have been recorded as occurring along these easements, the clearing of vegetation underneath the lines is unlikely to represent a significant management issue or threatening process for this taxon because:

- gully vegetation rarely approaches a height where clearing would be a necessary maintenance requirement; and
- understorey species are generally not cleared, with efforts focusing mainly on the tall tree species such as the *Eucalyptus* and *Angophora* species (T. Chambers, Transgrid pers comm).

P. mollis ssp. *maxima* does, however, occur infrequently on the upper slopes and ridgetops, where intensive easement maintenance is likely to be required. In January 1997, a routine tree lopping exercise by Transgrid successfully protected *P. mollis* ssp. *maxima* plants in the Binya Close subpopulation. This site is likely to require future maintenance of powerline easements and the previous actions of Transgrid (ie, preparation of an REF, including a prior site inspection and plant tagging) are instructive for future works. Future monitoring of this site will focus on the potential impacts of weed invasion as a result of increased disturbance.

Recreation

P. mollis ssp. *maxima* occurs predominantly in areas that are either gazetted as Regional Park or National Park under the NP&W Act 1974 (NSW). Although one of the principal objectives of reservation under this legislation is the conservation of biodiversity, nature-based tourism is encouraged on lands managed by NSW NPWS. This is particularly the case with Regional Parks, where reservation is intended to provide recreational opportunities for people living in primarily urban settings.

Various recreational pressures potentially impact upon the populations of *P. mollis* ssp. *maxima* and its habitat. These may include walking trail maintenance and construction, and increases in the volume and types of recreational pursuits conducted in the parks such as bushwalking, horse riding and mountain-bike riding. One of the subpopulations occurs in close proximity to an existing walking track. This and other walking trails may have to be modified should future monitoring reveal any deleterious impacts on the plant, or its habitat, such as increased erosion, vandalism, or physical destruction of individuals.

8.2.3 Fire and fire management activities

Following Keith *et al.* (1997), fire is considered a Class I threat to this taxon. The potential threat from fire to *Persoonia mollis* subspecies *maxima* arises as a result of:

- wildfire and frequent hazard reduction burning; and
- inappropriate fire management, such as mechanical disturbance (including slashing, and "turbo-mowing") and fire trail maintenance and construction.

Wildfire and frequent planned burning

P. mollis ssp. *maxima* is fire sensitive. Since fire permanently destroys individual plants, persistence of the taxon after a fire event is totally reliant on seed regeneration and/or immigration from unburnt areas (Wasley 1997). Frequent successive fires which destroy individual reproductively immature plants, whether as a result of unplanned wildfire or frequent planned burning, will interrupt the process of seed production and seedbank replenishment within a subpopulation, and potentially lead to its extinction.

The potential consequences of an inappropriate fire regime on *P. mollis* ssp. *maxima* include:

- the extinction of subpopulations due to frequent successive fires which destroy reproductively immature individuals and/or the seedbank;
- a reduction in flower/fruit production, by burning when the plants are in flower or have immature fruits;
- development of a homogeneous population age structure, placing populations at risk of catastrophic disturbance events;
- alteration of the structure, composition, and diversity of species within *P. mollis* ssp. *maxima* habitat. In particular it may lead to a reduction in the occurrence of other fire sensitive species;
- inadequate seedling germination, depending on the characteristics of the fire and germination requirements; and/or
- increased weed invasion.

While there is a range of age classes among the *P. mollis* ssp. *maxima* populations, the mean age of each population indicates that a substantial proportion (40%) of the total number of plants is reproductively immature. Furthermore, two of the subpopulations (Lyrebird Gully, Chase Trail) are considered to be extremely vulnerable to extinction due to the fact that they consist almost entirely of seedlings and/or juvenile plants.

It is essential that the biological requirements and disturbance history of *P. mollis* ssp. *maxima* are considered during the planning of prescribed burns, including an analysis of the previous fire history in the proposed burn area. It is important that planned fire events (either ecological or HR) consider the population dynamics, in particular age structure, of both the subpopulation/ population affected and the overall impact on the total population. For example, the Calna Creek subpopulation, which has a mean age of 10 years, is likely to be able to recover from fire, however, the impact on the total population would be deleterious due to the current vulnerability of the other populations.

Mechanical disturbance

Slashing, and "turbo-mowing" activities involve the clearing and removal of understorey vegetation. These methods of hazard reduction are intended to maintain

fire-trails and/or prevent or slow the movement of wildfire. These activities are usually conducted on the edges of reserve boundaries and at the interface of urban/natural landscapes.

Several *P. mollis* ssp. *maxima* individuals have been located in close proximity to fire trails and urban areas, and are thus threatened by fire trail maintenance and hazard reduction activities. Disturbance associated with hazard reduction includes slashing and "turbo-mowing", grading of trails, and poison/herbicide application on trail margins.

Mechanical disturbance potentially impacts on *P. mollis* ssp. maxima by:

- physically destroying individual plants;
- altering the structure and composition of suitable habitat, particularly understorey vegetation;
- removing/destroying *P. mollis* ssp. *maxima* seeds stored in the seedbank (see Wasley's (1997) conclusion regarding the location of *Persoonia* seeds in the litter layer);
- facilitating weed invasion through increased disturbance; and
- altering sympatric *in situ* relationships (eg. between plants and their pollinators) and degrading broader ecosystem processes (eg. erosion and reduced water quality).

Slashing and "turbo-mowing" has reduced the understorey species diversity at the Binya Close site, and facilitated invasion by several weed species (including Lantana, Crofton Weed, and Whiskey Grass). It is likely that *P. mollis* ssp. *maxima* seeds stored in the seedbank may be removed/destroyed during turbo-mowing operations which disturb the leaf litter layer of the soil profile.

The frequency with which turbo-mulching and slashing may need to be conducted in the Hornsby Heights area underscores the importance of maintaining accurate information indicating the known and likely occurrence of threatened species, such as *P. mollis* ssp. *maxima*. It further highlights the need for conducting thorough environmental impact assessment of all hazard reduction activities, including a prior site inspection and analysis of the previous fire and disturbance history of sites.

8.2.4 Genetic variation

The evolutionary potential of *Persoonia mollis* subspecies *maxima* is potentially threatened as a consequence of (i) reduced genetic variation because of small population size, and (ii) increased mating amongst close relatives leading to inbreeding depression within the subpopulations (Dr S. Krauss, pers comm). *"Inbreeding depression"* is defined as the production of inherited deleterious traits in progeny as a consequence of a close relationship between their parents (Caughley & Gunn 1996). Preliminary data (Krauss 1994a) suggests the possibility of an

increase in mating between close relatives in *P. mollis* ssp. maxima compared to other populations of *P. mollis*.

The potential long term consequences of reduced genetic variation and inbreeding depression in *P. mollis* ssp. *maxima* include reduced mating success, the production of fewer and less viable seeds (Dr S. Krauss, pers comm), and an increased susceptibility to environmental disturbance. An understanding of genetic variability in *P. mollis* ssp. *maxima* is therefore important for several reasons, including:

- defining more accurately the genetic boundaries of subpopulations, which has conservation implications for habitat management (eg fire planning) and decision making;
- understanding the genetic significance of small subpopulations and isolated individuals;
- determining the range of individuals required to be sampled from the *in situ* populations to adequately represent the genetic diversity of the taxon, should a translocation program be necessary; and
- understanding and managing the taxon's long term evolutionary potential.

There is currently no information on the genetic variation within and among the P. *mollis* ssp. *maxima* populations. Krauss (1999) has developed and tested DNA fingerprinting techniques for P. *mollis* that allow detailed analysis and characterisation of mating patterns, including the degree and importance of mating among close relatives.

8.3 Consideration of social and economic consequences

8.3.1 Intrinsic ecological value

Persoonia mollis subspecies *maxima* has intrinsic ecological value as a distinct taxon that is capable of affecting, and is affected by, other living biological organisms. This taxon has the right to exist and evolve in its natural environment, free from pressures which may increase the likelihood of human-induced extinction.

8.3.2 Scientific and taxonomic value

Persoonia mollis subspecies *maxima* is a member of a complex taxon that has scientific importance in understanding morphological variation associated with ecological habitats. The *P. mollis* complex has been the subject of considerable scientific research, used as a model for studying evolutionary processes and understanding the processes of gene flow in plant breeding systems (Dr P. Weston pers comm; see publications by Krauss in reference list). The development of powerful new techniques in conservation genetics underscores the scientific and taxonomic value of this taxon.

8.3.3 Social considerations

Social issues raised by this recovery plan are primarily related to fire management at the urban-natural interface of the Hornsby Heights-Mt Colah-Mt Kuring-gai area. For example, this recovery plan recommends that the prescribed burning regime of the Hornsby Heights-Mt Colah-Mt Kuring-gai area be modified to take into account the biological requirements of *Persoonia mollis* subspecies *maxima* and its habitat.

This is likely to involve a reduction in the frequency with which preventative burns are carried out in *P. mollis* ssp. *maxima* habitat. The NPWS acknowledges the important need to protect human life and property from the impacts of wildfire, and the role of local volunteer bushfire brigades in providing this community service. However, it is also crucial that other community values, such as the protection of biodiversity and threatened species, be given consideration in the management of the interface between urban and natural areas.

This recovery plan acknowledges and seeks to address community concerns and potential adverse social consequences by recommending that key fire management strategies such as the Hornsby Shire Bush Fire Risk Management Plan, consider alternative methods of reducing fuel loads which both meet community expectations and are sensitive to the biological requirements of this taxon and its habitat.

8.3.4 Economic considerations

The economic consequences of this recovery plan are those that are associated with its implementation. These include on-ground habitat management, conducting biological research and monitoring, establishing and disseminating to land managers ecological and population dynamics information, improved environmental assessment of activities which potentially impact on populations (including hazard reduction activities), establishment of an *ex situ* program if required, community education, and on-going recovery team coordination. These costs can be minimised by:

- implementing a long-term strategic framework for managing the taxon and its habitat;
- seeking funds from external sources, including research grants;
- maintaining accurate information on the distribution and status of populations; and
- adopting a cooperative approach to management with the relevant land managers and the local community.

All of the known populations (except the Binya Close site) are located on lands reserved as National or Regional Park under the NPW Act, or which have secure zoning. The reservation of public lands for nature conservation highlights the importance of managing habitat which provides opportunities for refuge of species from historical and current threatening processes. As such, the economic costs of managing the habitat of *Persoonia mollis* subspecies *maxima* should be reflected in the respective plans of management for each reserve.

8.3.5 Biodiversity benefits

The preparation and long term implementation of recovery plans for threatened species, populations and ecological communities, contributes to, and highlights the importance of, conserving biodiversity. The conservation of biodiversity has a number of wider community benefits. These include:

- provision and maintenance of a range of ecosystem services on which we and other species depend;
- contributing to increased ecological knowledge of species, habitats and broader ecosystems;
- potential medical, economic, agricultural and industrial products; and
- cultural, aesthetic and spiritual biodiversity values.

The appropriate ecological management of *P. mollis* ssp. *maxima* habitat will contribute to the conservation of several other threatened species and ROTAP flora which have been recorded in, and adjacent to, known populations, including amongst others: *Acacia bynoeana, Ancistrachne maidenii, Darwinia biflora, Darwinia peduncularis, Eucalyptus camfieldii, Lasiopetalum joyceae, Melaleuca deanei* and *Tetratheca glandulosa* (see, for example, Smith & Smith 1990; Coombes 1995; Atlas of NSW Wildlife 1998).

8.4 Translocation

Translocation is defined as the "deliberate transfer of plants or regenerative 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.

As at April 2000, the translocation of *Persoonia mollis* subspecies *maxima* is not considered to be an appropriate conservation mechanism for the following reasons:

- the majority of known threatening processes are likely to be able to be controlled through improved habitat management;
- the distribution of *P. mollis* ssp. *maxima* outside the known populations is poorly understood;
- there is currently no information on the genetic variation within or between populations; and
- although approximately 40% of the total number of plants recorded (adults/juveniles/seedlings) are reproductively immature none of the *P. mollis* ssp. *maxima* populations as a whole is considered to be in imminent danger of extinction.

However, due to the restricted distribution and small population sizes of *P. mollis* ssp. *maxima*, the NPWS recommends that should any of the populations be threatened with extinction following catastrophic disturbance (eg unplanned fire), the translocation of seedlings and/or seed to preserve genetic material is a desirable contingency plan.

8.5 Ability to recover

8.5.1 Justification for listing

Persoonia mollis subspecies *maxima* is considered to be endangered for the following reasons:

- distribution is highly restricted, with a north-south range of approximately 5.75km and east-west range of approximately 7.5km;
- the total number of individuals (adults/juveniles/seedlings) consists of approximately 930 plants, however just 550 (60%) are considered to be reproductively mature individuals;
- 73% of mature individuals occur in just one population (Calna Creek), with the other two populations (Cockle Creek, Berowra Creek) supporting 14.5% and 12.5% respectively;
- a large proportion (40%) of the total individuals are reproductively immature;
- the taxon is fire sensitive, and all populations are subject to threat from wildfire and inappropriate fire management. Recent fire events in two catchments has affected the *P. mollis* ssp. *maxima* populations, and one subpopulation consists entirely of seedling plants;
- one of the subpopulations (Binya Close) has experienced a 50% decline in numbers since 1993;
- all populations are subject to Class II threats (following Keith *et al* 1997) from habitat degradation as a result of weed invasion and other catchment-scale processes. Inbreeding depression has been identified as a potential threat, and requires further investigation; and
- key aspects of the taxon's biology are currently unknown.

Apart from the observed decline in numbers of one subpopulation (Binya Close), there is no conclusive evidence which suggests that the current distribution or population size is the result of human interference. There is some evidence that the population may have been reduced as a consequence of past inappropriate fire management, however the extent of this impact is unclear. Alternatively, the taxon's rarity may be the result of natural biological factors.

Furthermore, it is possible that new populations of *P. mollis* ssp. *maxima* exist in adjacent catchments, and that future targeted survey may reveal a broader distribution than that which is currently known.

8.5.2 Likelihood of extinction

The objective of this recovery plan encompasses the concept of maintaining the *evolutionary potential* of *Persoonia mollis* subspecies *maxima*. Evolutionary potential involves examining the *viability* of a taxon, which is broadly defined as the ability to be self replacing in nature. That is, the taxon consists of reproductive individuals producing seed, which germinate into seedlings under natural conditions, and that those seedlings grow into mature reproductive adults and produce germinable seed, and so on.

Preliminary investigations into the population dynamics of the *P. mollis* ssp. *maxima* taxon indicates that there appears to be a range of age classes within each population. This suggests that reproductively mature individuals are producing germinable seed under natural conditions and that those seedlings are maturing into reproductive adults and so on. However, this observation is based on an assessment of age structure at a given point in time and may not be a suitable indication of the taxon's long term viability.

The consequences of not implementing the provisions of this recovery plan are such that the probability of extinction of *P. mollis* ssp. *maxima* in nature within the next 10-20 years is high. In the absence of appropriate *in situ* habitat management, populations of *P. mollis* ssp. *maxima* are likely to be adversely impacted on by inappropriate fire management and/or habitat degradation. Without further biological research, key attributes of the taxon's population biology will remain uncertain and not applied to management. Without further survey, the broader distribution and the true importance of the existing populations in terms of the plant's conservation will remain unknown.

8.5.3 Likelihood of recovery

"Recovery" is a concept that is dependent on the conservation objective for each taxon. The object of "recovery" in relation to *Persoonia mollis* subspecies *maxima* is to maintain the current legislative status of the taxon (Schedule 1, Part 1 Endangered) and to prevent it from moving into a less desirable conservation status (ie. Schedule 1, Part 4 Presumed Extinct). If further populations are not discovered through additional survey, it is unlikely that *P. mollis* ssp. *maxima* will be suitable for downlisting to a more desirable conservation status (ie. Schedule 2, Vulnerable) due to the factors identified above.

The management of fire in *P. mollis* ssp. *maxima* habitat is the most critical factor in determining the likelihood of this taxon's extinction and potential for recovery. This recovery plan has discussed how an inappropriate fire regime is likely to have significant deleterious consequences for the populations. Other major factors affecting the likelihood of recovery include the ability to manage degradation of habitat and long term consequences of reduced genetic variation.

This recovery plan does not attempt to "recover" *P. mollis* ssp. *maxima* from a human-induced decline through propagating additional individuals. Rather, the plan is directed towards developing:

- improved *in situ* habitat management, including recommendations for fire management and environmental impact assessment;
- a greater understanding of the taxon's biology to inform current management practices;
- a greater understanding of the taxon's distribution; and
- safeguards for the populations against extinction in the event of catastrophic disturbance.

The likelihood of maintaining *P. mollis* ssp. *maxima* in its existing conservation status (Schedule 1, Part 1 Endangered) and thus preventing it from becoming extinct in nature is considered high.

The success of the recovery plan will in part be reliant upon the cooperative management of populations by the land managers NSW NPWS, Berowra Valley Regional Park Trust, Hornsby Shire Council, Hornsby Rural Fire Service and support from other relevant stakeholders. The success of this recovery plan will also be dependent upon the will and ability of government land managers and regulators to provide the financial resources required to implement the plan.

9. Recovery objectives & performance criteria

9.1 Objectives of the recovery plan

The broad objective of this recovery plan is:

To protect the populations of *Persoonia mollis* subspecies *maxima* from decline, and to implement a management regime, based on current knowledge, designed to promote the plant's conservation and evolutionary potential in nature.

Specific objectives of this recovery plan are:

- minimising the risk of *P. mollis* ssp. *maxima* from declining in the long term;
- establishing the full extent of the taxon's distribution;
- improved management of *P. mollis* ssp. *maxima* and its habitat based on biological understanding of the taxon; and
- safeguarding populations against extinction in nature as a result of catastrophic disturbance events.

9.2 Recovery criteria

Recovery criteria are that:

- natural populations do not decline in the long term as a consequence of human induced threats;
- potential habitat is surveyed and a greater understanding of the plant's distribution is known;
- management strategies are informed by relevant biological information; and
- contingency arrangements are implemented in the event of catastrophic disturbance.

More specific recovery criteria are detailed in Appendix 5.

9.3 **Recovery actions**

In order to achieve these objectives, a number of specific actions are identified by this recovery plan. Recovery actions will be directed towards:

- habitat management to ameliorate threatening processes, and thorough assessment of activities which may impact on the taxon;
- targeted survey to determine the extent of known populations and whether new populations exist;
- undertaking a monitoring program and facilitating research which investigates key attributes of the taxon's biology; and

• ensuring that appropriate contingency arrangements are implemented to protect populations from imminent extinction.

10. Recovery actions

10.1 Habitat management

Threatened species are best managed in perpetuity when conserved in their natural habitat. This is termed *in situ* habitat conservation, and 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.

This recovery plan has identified both the long and short term habitat management issues affecting *Persoonia mollis* subspecies *maxima*. Habitat management in relation to *P. mollis* ssp. *maxima* should aim to:

- maintain the current distributional range;
- maintain the continuity and connectivity of individuals within existing populations;
- avoid artificially creating new populations through inappropriate management;
- ameliorate catchment-scale threatening processes such as nutrient enrichment and weed invasion;
- maintain a range of age classes within and among populations; and
- take a precautionary approach to assessment of activities which potentially impact on the taxon.

Specific actions

- 1. The NPWS will maintain the *P. mollis* ssp. *maxima* Recovery Team and liaise with key stakeholders, including Berowra Valley Regional Park Trust, Hornsby Shire Council, Hornsby Rural Fire Service, Transgrid and Landcom, in relation to the management of *P. mollis* ssp. *maxima* habitat. The composition of the recovery team is not fixed, and should reflect the current needs of the taxon and management interests affected.
- 2. The NPWS and Berowra Valley Regional Park Trust will ensure that the known populations and habitat of *P. mollis* ssp. *maxima* is subject to a minimum planned fire-free interval of 12-15 years. In order to give effect to this action,
 - the NPWS and Berowra Valley Regional Park Trust will, in preparing the Kuring-gai Chase National Park and Berowra Valley Regional Park Fire Management Plans, provide that the major populations of *P. mollis* ssp. *maxima* are included in conservation zones, where feasible; and

- the NPWS will liaise with the Hornsby Bush Fire Risk Management Committee during the preparation of the Hornsby Bush Fire Risk Management Plan, in order that the major populations of *P. mollis* ssp. *maxima* occurring outside of the conservation reserves be included in conservation zones, where feasible.
- In preparing these documents, the NPWS will investigate the possibility of a contingency plan in order to minimise the potential impacts of unplanned wildfire on *P. mollis* ssp. *maxima* populations. Fire management plans for *P. mollis* ssp. *maxima* habitat should investigate measures which can be implemented in the event of wildfire to protect populations of *P. mollis* ssp. *maxima*.
- 3. The NPWS, Berowra Valley Regional Park Trust, Hornsby Shire Council, and Transgrid will ensure that the distribution and ecological requirements of *P. mollis* ssp. *maxima* are considered in the planning and implementation of hazard reduction proposals (including burning, slashing, "turbo-mowing", trail maintenance and construction) and other activities which may impact on *P. mollis* ssp. *maxima*.
- In order to give effect to this action, public authorities will ensure that activities (in particular, fire trail maintenance and construction and hazard reduction) are undertaken with reference to Appendix 3 of this recovery plan, and any future advice from the NPWS regarding the distribution and ecology of *P. mollis* ssp. *maxima*.
- 4. The NPWS and Berowra Valley Regional Park Trust will take steps to ameliorate habitat degradation caused by weed invasion in the Cockle Creek, Calna Creek and Berowra Creek catchments.
- In order to give effect to this action, NPWS, Hornsby Shire Council and Berowra Valley Regional Park Trust will:
 - map the extent of weeds, particularly riparian weeds in *P. mollis* ssp. *maxima* habitat;
 - conduct low impact bush regeneration, involving community groups, to target weeds which can be appropriately controlled; and
 - investigate the means of minimising the ongoing causes of weed invasion such as stormwater discharges into bushland.
- 5. The NPWS will maintain a *P. mollis* ssp. *maxima* database with details and, where available, maps of at least the following information:
 - locations of known *P. mollis* ssp. maxima populations and individuals;
 - size and approximate maturity of populations;
 - habitat and threatening process details;

- disturbance history of sites, including previous fire histories and hazard reduction activities; and
- date of last site inspection.
- 6. The NPWS, Berowra Valley Regional Park Trust, Hornsby Shire Council, and any other relevant land managers will ensure that the contents of this recovery plan are considered during the preparation and implementation of strategic landuse planning documents such as NPWS Reserve Plans of Management, Local Environmental Plans, Regional Environmental Plans and State Environmental Planning Policies.
- 7. The NPWS and Berowra Valley Regional Park Trust will not construct any new walking tracks or fire trails within 80m of known populations of *P. mollis* ssp. *maxima*. The NPWS and Berowra Valley Regional Park Trust will modify existing walking tracks and fire trails, where feasible, in areas where physical disturbance is identified as detrimentally affecting *P. mollis* ssp. *maxima*.
- 8. The NPWS will develop public information, designed to increase public awareness of *P. mollis* ssp. *maxima* and the management of the taxon's habitat.

Outcome

P. mollis ssp. *maxima* habitat is managed in such a way as to minimise the risk of population decline and the taxon's extinction in nature.

10.2 Survey

The current known distribution of *P. mollis* ssp. *maxima* is detailed in section 3 of this recovery plan. Survey for the preparation of this recovery plan concentrated on confirming and investigating existing records, survey of new areas of potential habitat, and obtaining population-dynamics information for the populations. It is essential that managers of *P. mollis* ssp. *maxima* habitat have a clear understanding of the actual and potential distribution of this taxon to make confident land-management decisions. There is therefore a need to conduct further survey in suitable habitat in areas not yet surveyed.

Future survey for *P. mollis* ssp. maxima should be conducted in such a way that:

- targets areas of suitable habitat in both the existing and adjacent catchments;
- involves all of the authorities responsible for managing *P. mollis* ssp. maxima habitat; and
- communicates results to land management authorities efficiently.

Specific actions

- 1. The NPWS will survey priority areas of potential habitat for *P. mollis* ssp. *maxima*. This survey effort will be designed to investigate:
 - a) the full distribution of *P. mollis* ssp. *maxima* within the three known catchments to clarify existing distribution for management purposes; and
 - b) whether there are any new populations in suitable habitat in adjacent catchments.
- Priority areas for further *P. mollis* ssp. maxima survey should focus on areas of suitable habitat (see section 5) not searched during this recovery plan. In order to maximise survey outcomes, the NPWS and Berowra Valley Regional Park Trust will organise community-based surveys for *P. mollis* ssp. maxima in suitable habitat. The NPWS will ensure that sufficient instruction in the identification of *P. mollis* ssp. maxima is available to community volunteers during the implementation of this action.
- 2. Any new records of *P. mollis* ssp. *maxima* known to any relevant public authorities should be reported to the NPWS. An ATLAS of NSW Wildlife data card and a voucher specimen will be lodged with the NPWS Wildlife Data Unit and National Herbarium of NSW respectively upon the discovery of new populations or individual plants.
- 3. NPWS will record census and population dynamics data of new sites as soon as is practicable following a new site's discovery.
- 4. The NPWS will, in consultation with the recovery team, model potential habitat for *P. mollis* ssp. *maxima*, if the habitat requirements become sufficiently known.

A site assessment proforma is included in this recovery plan as Appendix 6.

Outcome

A greater understanding of *P. mollis* ssp. *maxima* distribution is achieved and applied to management.

10.3 Biological research and monitoring

Key attributes of the biology of *Persoonia mollis* subspecies *maxima* are currently unknown. A program of biological research, combined with low-impact *in situ* monitoring is required to systematically collect and analyse biological information concerning *P. mollis* ssp. *maxima* and its habitat. This information will be essential for land managers to make confident scientific judgments as to the status and viability of populations in each catchment. Future biological research and monitoring actions should aim to:

- investigate biological attributes which are relevant to the practical management of *P. mollis* ssp. *maxima* and its habitat, or which increases understanding of the evolutionary potential of the taxon;
- involve post-graduate students from an appropriate Tertiary institution to maximise outcomes;
- investigate new techniques which might be translated to other threatened flora; and
- keep the NPWS, Berowra Valley Regional Park Trust, Hornsby Shire Council and other relevant land managers informed of major research outcomes and milestones.

Specific Actions

- 1. The NPWS and RBG will contribute to the funding and supervision of two Australian Research Council PhD research scholarships. The two projects will investigate the ecology and genetics of fire sensitive Persoonias, including *P. mollis* ssp. *maxima*. This action will be implemented through a partnership developed between the University of Wollongong, RBG and the NPWS.
- 2. The NPWS and Berowra Valley Regional Park Trust will conduct *in situ* monitoring of the known populations to investigate the response of *P. mollis* ssp. *maxima* to fire and other disturbance events. Monitoring will be conducted annually to investigate:
 - seedling recruitment and survivorship;
 - seedling growth rate;
 - age to reproductive maturity and peak flowering/fruit production; and
 - impacts of weed invasion as a result of hazard reduction activities and rubbish dumping.

A population monitoring proforma is included in this recovery plan as Appendix 6.

Outcome

A greater understanding of *P. mollis* ssp. *maxima* biology is achieved, results communicated to stakeholders and new information applied to management.

10.4 Contingency arrangements: *ex situ* conservation and critical habitat

- The establishment of a representative *ex situ* collection of, and declaration of critical habitat for, *P. mollis* ssp. *maxima* are two actions which may be necessary as a contingency to safeguard the populations against extinction. *Ex situ* conservation is designed to preserve genetic diversity, while critical habitat ensures a high level of environmental assessment (through a mandatory species impact statement and NPWS concurrence) prior to activities being conducted in sensitive areas of habitat.
- The NPWS considers that the establishment of a broader *ex situ* conservation program and declaration of critical habitat for *P. mollis* ssp. *maxima* are not necessary or priority actions to assist in the conservation of this taxon at present. However, in the event of unforeseen catastrophic population declines (eg as a result of wildfire), the NPWS recommends that contingency plans to safeguard the populations from extinction should aim to:
 - establish an *ex situ* collection of *P. mollis* ssp. *maxima*; and/or
 - investigate a declaration of critical habitat;

where the DG of NP&W considers these actions are necessary.

Specific actions

1. There is a need to maintain *P. mollis* ssp. *maxima* individuals currently growing at Mt Annan Botanic Garden for future research purposes and to safeguard the Chase Trail subpopulation from extinction. At the preparation of this recovery plan, these seedlings are not intended to be reintroduced and will only form part of Mt Annan's living collection.

Accordingly, the Royal Botanic Gardens will undertake to:

- maintain the current *P. mollis* ssp. *maxima* individuals growing *ex situ* at the Mt Annan Botanic Garden, as part of the living collection;
- maintain information on the location, status, use, and origin of the *ex situ P*. *mollis* ssp. *maxima* individuals and material (eg. seed/cuttings) currently maintained by Mt Annan Botanic Garden; and
- liaise with the NPWS concerning the progress and success of the *ex situ* individuals at Mt Annan. The recovery team provides the appropriate forum for this liaison to occur.

- 2. Where the threat of population extinction is high (eg following unplanned fire), the NPWS will investigate whether establishing a translocation (*ex situ*) program to safeguard genetic material (eg seedlings and/or seed) of *P. mollis* ssp. *maxima* is necessary to conserve the taxon. In the event that a translocation program is deemed necessary, the NPWS will seek funding to establish an *ex situ* collection of *P. mollis* ssp. *maxima*, and negotiate with an appropriate Botanic Garden to maintain the *ex situ* collection.
- 3. Where current management arrangements fail to adequately conserve *P. mollis* ssp. *maxima* with the result that a substantial decline in the number of mature individuals in populations is observed, the DG of NP&W will reassess critical habitat as a conservation option for this taxon.

Outcome

Existing *ex situ* individuals are maintained, and contingency arrangements are implemented, where appropriate, in the event of population declines which imminently threaten the extinction of populations.

11. Implementation

11.1 Implementation schedule

Table 2 allocates responsibility for the implementation of recovery actions specified in this recovery plan.

The following abbreviations have been used:

NPWS = NSW National Parks and Wildlife ServiceBVT = Berowra Valley Regional Park TrustHSC = Hornsby Shire CouncilRBG = Royal Botanic Gardens, Mt AnnanTR = Transgrid

 Table 2 Implementation schedule.

Action	Description	Responsibility for implementation	Timeframe	$\mathbf{Priority}^{\dagger}$
11.1	Habitat Management			
	NPWS liaison	NPWS	Life of Plan	Essential
	Fire management Environmental Assessment	NPWS, BVT NPWS, BVT, HSC, TR	Year 1 Life of Plan	Essential Essential
	Weed control	NPWS, BVT, HSC	Life of Plan	Essential
	Information database	NPWS	Life of Plan	Essential
	Strategic planning	NPWS, BVT, HSC	Life of Plan	Essential
	Track maintenance	NPWS, BVT	Life of Plan	Essential
	Public information	NPWS	Year 1	Highly Desirable
11.2	Survey			
	Targeted survey	NPWS	Years 1-3	Essential
	Reporting	NPWS, BVT, HSC, TR	Life of Plan	Essential
	Population census	NPWS	Life of Plan	Highly Desirable
	Habitat modeling	NPWS	Year 3	Highly Desirable
11.3	Research and monitoring			
	Biological research	NPWS, RBG	Years 1-3	Highly Desirable
	Monitoring	NPWS	Life of Plan	Highly Desirable
11.4	Contingency arrangements			
	Maintain <i>ex situ</i> individuals	RBG	Life of Plan	Highly Desirable
	Translocation Critical habitat	NPWS NPWS	Life of Plan Life of Plan	Essential Essential

[†] All of the recovery actions identified in this recovery plan are required to be implemented in order to ensure recovery success. However, actions have been prioritised in order that funding be allocated to those actions which require immediate or priority implementation.

11.2 Implementation costs

The recovery actions and recommendations identified in this plan state what must be done to ensure the recovery of the endangered species *Persoonia mollis* subspecies *maxima*. Appendix 7 identifies the costs needed to implement those actions which require funding for implementation.

12. Preparation details

12.1 Persons responsible for plan preparation

This recovery plan was prepared by Christopher Lacey, in consultation with the *Persoonia mollis* subspecies *maxima* Recovery Team.

12.2 Date of last amendment

This document is the first recovery plan for *Persoonia mollis* subspecies *maxima*. No amendments to the plan have been made.

12.3 Review date

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

13. Contacts

The coordinator of the *Persoonia mollis* subspecies *maxima* Recovery Team can be contacted at the following address:

Coordinator - *Persoonia mollis* **subspecies** *maxima* **Recovery Team** NSW National Parks and Wildlife Service - Central Directorate PO Box 1967, HURSTVILLE 2220

ph.02 95856678fax02 95856442

Other useful contacts:

Organisation	Postal address	Co	ntact numbers
NSW NPWS Sydney North Region	Ku-ring-gai Chase National Park, PO Box 50 ASQUITH 2072	ph. fax	02 94579322 02 94579054
Water Catchments Team,	296 Pacific Highway	ph.	02 98476666
Hornsby Shire Council	HORNSBY 2077	fax	02 98476999
Hornsby Rural Fire	143 Galston Road	ph.	02 94771122
Service	HORNSBY HEIGHTS 2077	fax	02 99874039
National Herbarium of NSW, Royal Botanic Garden Sydney	Mrs Macquaries Road SYDNEY 2000	ph. fax	02 92318111 02 92517231
Mt Annan Botanic Garden	Mt Annan Road	ph.	02 46482477
	MT ANNAN 2567	fax	02 46482465
Transgrid	PO Box 87	ph.	02 42610616
Metropolitan Area	HORSLEY PARK 2164	fax	02 42610605
Hornsby Conservation Society	c/- President PO Box 1643, NORTHGATE, 1635		

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Appendices

- Appendix 1 Site details for Persoonia mollis subspecies maxima
- Appendix 2 Population Dynamics Information
- Appendix 3 P. mollis ssp. maxima profile and EIA guidelines
- Appendix 4 Summary of threatening processes and management issues
- Appendix 5 Specific recovery criteria
- Appendix 6 Survey and monitoring proforma for *P. mollis* ssp maxima
- Appendix 7 Implementation costs

Appendix 1: Population site details

Calna Creek Catchment population

Binya Close subpopulation

Data source:	1998 Recovery plan field survey
Tenure & security:	Crown Land, Residential A (Low Density)
Habitat description:	In dry forest community on upper slopes of gully. Sparse, open
	understorey due to slashing for HR; Alt 180; Sl <15; Asp 120-180
Species associations:	Eucalyptus punctata, Corymbia gummifera, Eucalyptus piperita,
	Angophora cosata. Understorey of Banksia serrata, Hakea sericea,
	Persoonia pinifolia, Xanthorrhea sp., Pteridium esculentum, Callitris
	sp., Grevillea linearifolia.
Fire history:	Date of last fire unknown, turbo-mowing and trail maintenance conducted in 1995-97.
Notes:	Pat Pike supplied 1993 map of plants (total = 39). Site inspected
	1998 and only 20 of the 39 plants located. One plant on Transgrid
	easement located at end of fire trail. Site atypical of other habitat
	recorded. Threats include weed invasion, insecure tenure, dumping,
	and fire management.

Calna Creek subpopulation

Data source:	1995 Herbarium survey, 1998 Wildlife Atlas, 1998 Recovery plan field survey
Tenure & security:	Berowra Valley Regional Park, Open Space B (Public Recreation - District)
Habitat description:	Open forest community, with variable understorey usually to 2.5-3m. Population generally continuous along creek, with localised absences possibly due to drier aspects. Borders warm temperate rainforest in sections. Alt most 40-100; SL >30; Asp 90-120 & 240-270
Species associations:	Angophora costata, Eucalyptus piperita, Corymbia gummifera bordering gallery rainforest of Ceratopetalum apelatum, C.gummiferum, Callicoma seratifolia. Understorey variable with Acacia sp., Grevillea sp., Hakea sp., Leptospermum trinervium, Phebalium dentatum, Gleichenia dicarpa, Smilax glyciphylla.
Fire history:	Hazard reduction burn conducted 1986.
Notes:	Information on this sub-population represents data collected from field survey conducted in 1995 and 1998. It includes survey by Dr Peter Weston (1995); Recovery Plan field survey (1998) and Ross Doig (1998). Population densities highest between creekline and first
	escarpment bench, with scattered individuals along ridgetops

Lyrebird Gully subpopulation

1998 Recovery plan field survey
Berowra Valley Regional Park, Open Space B (Public Recreation - District)
Tall forest with understorey to 1m. In sheltered gully along creek side and below first bench escarpment. Skeletal sandy soils; Alt 60; Sl
>45; Asp 220-250
Angophora costata, Eucalyptus piperita, Allocasuarina distyla, with
Callicoma serratifolia along creek line. Understorey of
Ceratopetalum gummiferum, Xanthorrhoea sp, Pteridium esculentum,
and various seedlings not identified.
Hazard reduction, April 1995.
Collection made at the site of population studied by Krauss (1994). No adult plants located. 61 were seedlings identified and tagged for future monitoring, seedbank is likely to be exhausted.

Mt Kuring-gai subpopulation

Data source:	1998 Recovery plan field survey
Tenure & security:	Berowra Valley Regional Park, Open Space B (Public Recreation -
	District)
Habitat description:	Dry, open vegetation community, with few sheltered sites in upper
reaches	of gully. Creek-side understorey very thick. Habitat suitable, but
	few plants found. Alt 70-150; S1 >30; Asp 230
Species associations:	Angophora costata, Eucalyptus piperita, Eucalyptus punctata,
	Corymbia gummifera, Ceratopetalum gummiferum borders
	drainage lines, with some stands of Allocasuarina sp. Understorey
	varies, with Banksia spinulosa, B.serrata, G.linearifolia, Hakea sp.,
	Isopogon sp., Leptospermum sp., Persoonia pinifolia, P. levis.
Fire history:	Date of last fire unknown.
Notes:	Very dry community, plants concentrated close to drainage lines.
	Several plants subject to immediate threat from weed invasion
	(Privet).

<u>Cockle Creek Catchment population</u>

Chase Trail subpopulation

Data source:	1998 Recovery plan field survey
Tenure & security:	Ku-ring-gai Chase National Park
Habitat description:	Tall closed forest, sheltered location. Alt 150-200; Sl >30; Asp 140- 180
Species associations:	Syncarpia glomulifera, Angophora costata, Eucalyptus pilularis, Allocasuarina torulosa, Ceratopetalum apelatum, C. gummiferum, Astrotricha floccosa, Dianella caerulea, understorey with Backhousia myrtifolia.
Fire history:	Wildfire, December 1990.
Notes:	Very sheltered moist location with warm temperate rainforest influence along creek. Plants located along creeklines, drainage depressions and up to first major escarpment. Majority of plants reproductively immature, with very few large adult plants surviving in sheltered refuge areas. Seedlings
from this subpopulation are held at the Mt Annan Botanic Garden.

Unnamed drainage depression subpopulation

Data source:	1998 Recovery plan field survey					
Tenure & security:	Ku-ring-gai Chase National Park					
Habitat description:	Tall forest community to 25m, very sheltered location with adjacent warm temperate rainforest dominated by Coachwood and Turpentine. Asp 150-200, Sl >30; Asp 140-180, 45					
Species associations:	Angophora costata, Syncarpia glomulifera, Allocasuarina sp., Corymbia gummifera, Ceratopetalum gummiferum. Understorey species variable, from rainforest influence to typical Sydney Sandstone Gully Forest.					
Fire history:	Wildfire, December 1990.					
Notes:	Very sheltered, moist location with warm temperate rainforest influence. Plants located right up close to scarp. Population not continuous, with local absences due to dry communities in exposed locations. Majority of adult plants survived in sheltered refuge areas, however, some juveniles present.					

Berowra Creek Catchment population

Tunks Creek/Cabbage Tree Hollow subpopulation

Data source:	1998 Recovery plan field survey
Tenure & security:	Berowra Valley Regional Park, Open Space B (Public Recreation -
	District)
Habitat description:	Tall forest with understorey to 3m, bordering creek up to escarpment.
	Skeletal sandy soils. Alt 50; Sl >45; Asp 270-290
Species associations:	Angophora costata, Allocasuarina distyla, Corymbia gummifera,
	Ceratopetalum apelatum along creek. Understorey of Ceratopetalum
	gummiferum, Grevillea linearis, Persoonia pinifolia, Dianella spp,
	Glochidion fernandi, Gleichenia dicarpa
Fire history:	Wildfire probably >25 years ago.
Notes:	Isolated collections made on south bank of Tunks creek and junction
	with Cabbage Tree Hollow. Cabbage Tree Hollow occurrence
	bordering creek-side rainforest, in dry forest community with tall
	open understorev to 3m. No evidence of recent fire.
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Galston Creek subpopulation

Data source:	1999 Recovery plan field survey
Tenure & security:	Freehold, Environmental Protection B (River Catchment)
Habitat description:	Tall forest on steep rocky slope with dense understorey.Alt 90m, Sl
	20-40, Asp 33
Species associations:	Eucalyptus piperita, Angophora costata, Syncarpia glomulifera,
	Corymbia gummifera, E. punctata, Ceratopetalum gummiferum, C.
	apelatum, Grevillea linearifolia, Pultenaea flexilis, Hakea
	dactyloides, Acacia longissima, Leptospermum trinervium,
	Astrotricha floccossa, Lomandra longifolia, Smilax glyciphylla
Fire history:	

Notes:	Collections made on both southern and northern banks of the creek, though highest population densities on the southern bank.
	Conservative estimate of plant numbers due to inaccessibility
of site.	Threats include urban runoff (roadside), weed invasion, rubbish
	dumping, road maintenance, insecure, tenure/potential development
	for part of the population.

Waddells Gully subpopulation

Data source:	1999 Recovery plan field survey
Tenure & security:	Berowra Valley Regional Park, Open Space B (Public Recreation -
	District)
Habitat description:	Tall gully forest, with adjacent warm temperate rainforest, understorev dense Alt 100m, SI 20-40, Asp180
Species associations:	Eucalyptus piperita, Angophora costata, Corymbia gummifera, Callicoma serratifolia, Ceratopetalum gummiferum, C. apelatum, B. serrata, Leptospermum trinervium, Hakea dactyloides, Caustis flexuosa, Pultenaea sp., Smilax glyciphylla, Gleichenia dicarpa, Pteridium esculentum, Phebalium dentatum, creek-side thicket with Tristaniopsis laurina
Fire history:	
Notes:	Recorded off the first escarpment bench on upper slope with few plants scattered on descent. Most occurred in bottom of gully, as scattered/isolated individuals separated by >50m. Few weeds in catchment, fire regime the biggest threat.

Matthew Close gully subpopulation

Data source:	1999 Recovery plan field survey
Tenure & security:	Department of Urban Affairs and Planning, Open Space B (Public
	Recreation - District)
Habitat description:	Tall gully forest, with adjacent closed canopy rainforest thickets. Alt 120, Asp 180, SI 25-30
Species associations:	Eucalyptus piperita, Angophora costata, Allocasuarina torulosa, Ceratopetalum apelatum, Syncarpia glomulifera, Callicoma serratifolia, Ceratopetalum gummiferum, Banksia serrata, B. spinulosa, Leptospermum trinervium, Persoonia levis, P. linearis, P. pinifolia, Hakea dactyloides, Gleichenia dicarpa, Smilax elyciphylla
Fire history:	
Notes:	Recorded off the first escarpment bench and on descent, but most plants found scattered in bottom of gully in ecotone between rainforest and tall gully forest. Very scattered distribution, mostly as isolated individuals. No weed invasion until the lower reaches of gully near Berowra Creek, major threat is the fire regime.

Appendix 2: Summary of population dynamics

Results of population census 1998-99.

Catchment/popul ation	l Flowering Juveniles/ Mean Age $Adults^{\dagger}$ Seedlings (years)		Mean Age (years)	Age Range (years)	
Calna Creek					
Binya Close Calna Creek ^{††} Mt Kuring-gai Lyrebird Gully Cockle Creek	20 376 10 0	0 68 0 61	6 10 7.5 < 2	3 16 3 <2	
Chase Trail Unnamed Drainage Berowra Creek	14 67	114 29	3 7	17 11	
Tunks Creek Galston Creek Waddells Gully Matthew Cl Gully	4 47 17 7	2 94 8 10	7 not recorded 7 7	8 not recorded 10 8	

[†] The age at which *Persoonia mollis* subspecies *maxima* individuals are reproductively mature is unknown.

†† Data are for the mid-section of Calna Creek.

THREATENED SPECIES INFORMATION

Persoonia mollis subspecies maxima

Krauss & L. Johnson

Conservation Status

Persoonia mollis subspecies *maxima* is listed as an endangered species on Schedule 1 of the *Threatened Species Conservation Act* 1995 (NSW). *P. mollis* ssp. *maxima* is also listed as a nationally endangered species under the *Endangered Species Protection Act* 1992.

Description

Persoonia mollis subspecies *maxima* is a tall, branching, spreading shrub which grows from 2 - 6 meters high. The buds, and to a lesser extent young branchlets and young leaves, are covered with soft, erect copper coloured hairs which are approximately 2-3 mm long (Krauss & Johnson 1991). Fruits resemble a small plum, and are coloured green, becoming purplish-brown and soft when mature.

Distribution

P. mollis ssp. *maxima* is highly restricted, known from the Hornsby Heights-Mt Colah area north of Sydney, in the Central Coast Botanical Division of NSW. It is occurs in three populations (described on a catchment basis) located over an approximate northsouth range of 5.75 km and east-west distance of 7.5km (NSW NPWS 1999). It is possible that additional locations will be identified, and that these may lie outside the currently known distribution.

Occurrences in conservation reserves

P. mollis ssp. *maxima* occurs within Berowra Valley Regional Park and Ku-ring-gai Chase National Park. Other sites occur on lands managed by State and Local Government authorities and private land owners.

Habitat

P. mollis ssp. *maxima* occurs in deep gullies or on the steep upper hill-sides of narrow gullies incised from Triassic Hawkesbury sandstone. This habitat is characterised by steep sideslopes, rocky benches and broken scarps, with creeks fed by small streams and intermittent drainage depressions.

P. mollis ssp. maxima habitat is characterised by sheltered aspects which support relatively moist, tall forest vegetation communities (Smooth Barked Apple Angophora costata, Sydney Peppermint Eucalyptus piperita, Red Bloodwood Corymbia gummifera), often with warm temperate rainforest influences (Turpentine Syncarpia glomulifera, Coachwood Ceratopetalum apelatum, Black Wattle Callicoma serratifolia). While occurrences of this plant have been recorded on the dry upper-hillsides of gullies and in more exposed aspects (Scribbly Gum Eucalyptus haemastoma, Grey Gum Eucalyptus punctata), population densities in these habitats are generally low.

Ecology

P. mollis is a long lived species, with the oldest individual in the subspecies *maxima* population approximately 18 years of age. Age structure varies across the populations according to fire history, however, a large proportion of the population is reproductively immature.

Reproduction in *P. mollis* is achieved predominantly through outbreeding - self pollination rarely results in successful seedset (Krauss 1994a, 1994b). The peak flowering period for *P. mollis* ssp. *maxima* is usually late December - March and flowers are likely to be pollinated predominantly by native bees (Bernhardt & Weston 1996).

Fruit-set varies markedly across populations of *P. mollis* (NSW NPWS 1999). Low seed germination rates in the *P. mollis* complex have been noted by Krauss (1994b). *Persoonia* seeds have a dormancy mechanism which is poorly understood and this species has not been successfully propagated from seed.

P. mollis ssp. *maxima* is fire sensitive (Krauss 1997). Reproductive maturity of individuals in unlikely to be reached until approximately 8 years, with peak flowering and fruiting unlikely to be reached until individuals are at least 12-15 years (NSW NPWS 1999).

Threats

Immediate threats to *P. mollis* ssp. *maxima* include wildfire and inappropriate hazard reduction burns/fire management activities (eg trail maintenance and turbo-mowing), and habitat degradation through weed invasion, reduced water quality and rubbish dumping. The evolutionary potential of *P. mollis* ssp. *maxima* may be threatened as a consequence of increased mating among close relatives

leading to inbreeding depression (NSW NPWS 1999).

Management

Management actions should include improved habitat management, particularly in relation to planned fire frequencies, amelioration of threatening processes such as weed invasion and rubbish dumping; monitoring of sub-population sizes and recruitment / survival rates; conducting further survey; and implementing contingency actions, where necessary (NSW NPWS 1999).

Recovery Plan

A Recovery Plan has been prepared for *P. mollis* ssp. *maxima*. The recovery plan identifies the actions required to protect and maintain known and potential populations and habitat of *P. mollis* ssp. *maxima*.

For Further Information contact

Persoonia mollis subspecies *maxima* Recovery Team Co-ordinator, Threatened Species Unit Central Directorate NSW NPWS PO Box 1967, Hurstville NSW 2220 Phone 02 9585 6678 www.npws.nsw.gov.au

Persoonia mollis subspecies maxima

Krauss & L. Johnson

The following information is provided to assist authors of Species Impact Statements, development and activity proponents, and determining and consent authorities, who are required to prepare or review assessments of likely impacts on threatened species pursuant to the provisions of the *Environmental Planning and Assessment Act* 1979. These guidelines should be read in conjunction with the NPWS Information *Circular No. 2: Threatened Species Assessment under the EP&A Act: The '8 Part Test' of Significance* (November 1996) and the species profile.

Survey

P. mollis ssp. *maxima* is easily identifiable during both flowering and non-flowering periods of the plant's lifecycle. Therefore, there are no seasonal survey constraints for this plant. Seedlings may not be easily identifiable until they are approximately 0.5-1m in height, particularly 2-4 years following fire.

Survey for *P. mollis* ssp. *maxima* should not be limited to areas within the existing distributional limits, and there should have two objectives:

- 1. to determine presence/absence; and, where the plant is present,
- 2. to determine the spatial distribution and age classes (seedlings, juvenile, adults) of individuals at a site.

If a gully or side slope is being searched, each escarpment bench should be traversed. Creeklines up to the first escarpment bench, and intermittent drainage lines should be intensively searched.

Where *P. mollis* ssp. *maxima* is present, plant heights and approximate age of individuals should be recorded (see NSW NPWS 1999 for method of estimating plant ages).

Viable but dormant *P. mollis* ssp. *maxima* seeds may be present in the soil seedbank, particularly where there are mature individuals within 1km. If *P. mollis* ssp. *maxima* individuals are identified, an investigation into the disturbance history (particularly fire history¹) of the site should be conducted to determine whether the apparent (that is, visible) population size is an accurate indication of the potential population size (that is, including the seedbank).

Life cycle of the species

The biology of *P. mollis* ssp. *maxima* is described in the draft Recovery Plan and summarised in the attached profile. The lifecycle of *P. mollis* ssp. *maxima* is likely to be disrupted should any of the following occur:

Habitat loss - P. mollis ssp. maxima does not reproduce vegetatively, therefore the plant's persistence depends on the production and germination of viable seed. Seeds are stored in the seedbank until germination, however, Persoonia seeds possess a dormancy mechanism which is poorly understood (see Wasley 1997). If suitable habitat is present, P. mollis ssp. maxima seeds may germinate as a consequence of disturbance, however, the triggers which break dormancy and encourage germination are unknown. This plant has not been successfully grown from cuttings or seed, therefore, propagation and replanting is not a suitable ameliorative strategy.

The significance of a particular action which physically destroys individual plants will require (i) an examination of the

¹ Fire history data for the Hornsby Heights area is available from Hornsby Shire Council

number of plants to be destroyed in relation to the proportion of the relevant subpopulation/population sizes²; and (ii) a discussion of whether and how the potential seedbank will be affected. That is, whether the seedbank will also be destroyed permanently or whether seeds are likely to germinate following disturbance.

Fire - disrupts the lifecycle of P. mollis ssp. maxima as a result of halting the process of seed production and seedbank replenishment. P. mollis is fire sensitive, which means that adult plants are killed by fire and a minimum fire-free interval is required for individuals to mature and produce sufficient viable seed to replace the seedbank. Current estimates are that reproductive maturity is not reached until approximately eight years following germination, however, peak maturity is not likely to be reached until 12-15 years (NSW NPWS 1999). Repeated disturbance of populations, particularly at intervals of less than 12-15 years, is likely to result in population declines. Fire intervals of less than 8 years are likely to result in P. mollis ssp. maxima extinction.

In relation to fire management, Wasley (1997) further notes the importance of maintaining for long periods of time unburnt "refuge" areas in *Persoonia* habitat which act as seed sources and facilitate re-invasion of seed.

Seedbank disturbance - as a result of removal of leaf litter layer of the soil profile, may disrupt the lifecycle of *P*. *mollis* ssp. *maxima* as *Persoonia* seeds are predominantly stored in the upper layers of the soil profile (Wasley 1997). An example of this kind of disturbance may include fuel reduction activities such as turbo-mowing and the removal of understorey vegetation. Impacts of this type of disturbance on the *P. mollis* ssp. *maxima* seedbank may be minimised by retaining a proportion of the leaf litter occurring at a site.

Habitat modification - affects the lifecycle of *P. mollis* ssp. *maxima* by altering the ecological processes within suitable habitat. Habitat modification may include: weed invasion, reduced water quality/urban runoff, and increased sedimentation of creek/drainage lines. Since *Persoonia* species are pollinated by relatively few genera of native bees, an activity which resulted in the loss or inhibited movement of native bees within *P. mollis* ssp. *maxima* habitat has the potential to significantly affect the lifecycle of this plant.

Threatening processes

High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition is listed as a key threatening processes listed in the TSC Act. *P. mollis* ssp. maxima is fire sensitive and is thus vulnerable to high frequency fires. Other identified threats to the *P. mollis* ssp. maxima populations include: inappropriate hazard reduction burning & associated activities (eg trail construction, turbomowing), habitat degradation (eg weed invasion & reduced water quality), and rubbish dumping.

Viable local population

Research on the mating system in *P. mollis* indicates that this plant is partially selfcompatible (that is, not requiring pollen from other plants), however, selfpollination rarely results in successful seedset (Krauss 1994). The nature of reproduction in *P. mollis* indicates that:

- this plant requires pollen from other proximate *P. mollis* ssp. *maxima* individuals to produce viable seed (that is, the breeding system promotes outcrossing);
- pollen dispersal is restricted and genetic neighborhood sizes from pollen are small; and
- seed dispersal (primarily by birds and wallabies), and the germination requirements probably combine to promote a randomly mating population which facilitates gene flow (Krauss 1994a).

The minimum size of a viable local population of *P. mollis* ssp. *maxima* is unknown. However in the absence of external recruitment, isolated individual plants which experience little or no interaction with other *P. mollis* ssp. *maxima*

² A description of populations, including population numbers, age structure and disturbance history is provided in the draft Recovery Plan.

individuals are unlikely to be viable in the long term.

Significant area of habitat

Due to the restricted natural distribution of this species, all areas of habitat for the three major populations are considered significant.

Isolation/fragmentation

Three populations of *P. mollis* ssp. maxima have been described in the Recovery Plan (NSW NPWS 2000). These populations are isolated from each other as a consequence of ridgetop urban development. These populations have been further described as management subpopulations (NSW NPWS 2000). Within each subpopulation *P. mollis* ssp. *maxima* generally has a continuous distribution, of varying densities. Management of P. mollis ssp. maxima habitat should aim to maintain the continuity of habitat between individuals within subpopulations, and avoid artificially creating new subpopulations/ populations.

Precise estimates for pollen/seed dispersal distances are unknown for *P. mollis* ssp. maxima, however, Krauss (1994a) has suggested that gene flow is facilitated by seed dispersal over greater distances than pollen dispersal (that is, pollen pool sizes are low). Fragmentation /isolation of P. mollis ssp. maxima individuals/ subpopulations is likely to result in disruption to the plant's lifecycle as a consequence of reduced reproductive success by producing fewer opportunities for outbreeding, and ultimately inbreeding depression in small populations as a consequence of consanguineous mating, that is, mating among close relatives³.

Regional distribution of the habitat.

P. mollis ssp. *maxima* habitat occurs in the Sydney Basin Bioregion, in vegetation communities that are restricted to the steep dissected gullies on the Hornsby plateau and Hawkesbury Sandstone. This vegetation has been described by Benson & Howell (1994) as the Sydney Sandstone Complex (Map Units 10ag & 10ar) on the Sydney 1:100,000 map sheet. These communities are generally associated with sheltered hillsides and moist gullies (10ag) and dry plateaus and ridges (10ar), and often intergrade with each other. *P. mollis* ssp. *maxima* appears to be restricted to sheltered aspects, which limits the availability of suitable habitat across the region.

Limit of known distribution

The distributional limits of *P. mollis* ssp. *maxima* are described in the draft recovery plan (NSW NPWS 1999). The northern limit occurs at Lyrebird Gully (Berowra Valley Regional Park) and the southern limit occurs at Cockle Creek (Ku-ring-gai Chase National Park). Further survey may identify additional occurrences of *P. mollis* ssp. *maxima* resulting in range extensions.

The restricted distribution of *P. mollis* ssp. *maxima* may be explained through natural evolutionary development, lack of targeted survey or alternatively restricted habitat requirements which are currently unknown⁴.

There is some evidence that the *P. mollis* ssp. *maxima* populations have been reduced as a consequence of past inappropriate fire management, however, the extent of this impact is unclear.

The loss of individuals from the limits of the plant's distribution may result in a range contraction, further isolation, and potentially the loss of genetic diversity.

Adequacy of representation in conservation reserves

Individuals within each population of *P. mollis* ssp. *maxima* are represented in conservation reserves across their range. The populations occurring in the Calna Creek and Cockle Creek catchments, are considered to be adequately conserved⁵. The Berowra Creek population of *P. mollis* ssp. *maxima* is not considered to be adequately conserved across its range.

³ Preliminary data (Krauss 1994a) suggests the possibility of an increase in mating between close relatives in *P. mollis* ssp. *maxima* compared to other populations of *P. mollis*.

⁴ see (NPWS 1999)

⁵ *P. mollis* ssp. *maxima* individuals in atypical ridgetop vegetation communities are not considered to be adequately conserved.

Critical habitat

Critical habitat has not been declared for *P*. *mollis* ssp. *maxima*.

For further information contact:

Persoonia mollis subspecies *maxima* Recovery Team Co-ordinator, Threatened Species Unit Central Directorate NSW

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Catchment/population			Threa m	itening processes anagement issue	s and es	
	Rubbish Dumping	Weed invasion	Fire management	Tenure insecure [†]	Easement maintenance	Recreation
Calna Creek						
Binya Close	Х	Х	Х	Х	Х	
Calna Creek		Х	Х			Х
Mt Kuring-gai	Х	Х	Х			
Lyrebird Gully			Х			Х
Cockle Creek						
Chase Trail		Х	Х			Х
Unnamed Drainage		Х	Х			Х
Berowra Creek						
Tunks Creek / Cabbage Tree Hollow		Х	Х			
Galston Creek	Х		Х			
Waddells Gully			Х			
Matthew Close Gully			Х			

Appendix 4: Summary of threatening processes

[†] For the purposes of this recovery plan, "insecure tenure" refers to lands which are not reserved under the NP&W Act and/or lands which have zoning that is considered to be inconsistent with nature conservation objectives.

Appendix 5: Summary of specific performance criteria

	Action	Performance criteria
1	Habitat	• NPWS maintains the Recovery Team and liaises with key land managers;
	management	• public authorities ensure that <i>P. mollis</i> ssp. <i>maxima</i> populations are subject to a minimum planned fire frequency of 12-15
		years;
		• statutory environmental assessment of activities in <i>P. mollis</i> ssp. <i>maxima</i> habitat is conducted with reference to Appendix 3 of the recovery plan;
		• threatening processes, in particular habitat degradation through weed invasion, are ameliorated by BVRPT, HSC & NPWS;
		• database of <i>P. mollis</i> ssp. <i>maxima</i> locations and population dynamics is maintained by NPWS;
		Recovery Plan is considered during the preparation of statutory planning documents;
		• proposed new walking tracks are not constructed within 80m of <i>P. mollis</i> ssp. <i>maxima</i> populations, and existing walking tracks modified in the event of impacting on populations; and
		• educational material prepared and published by NPWS.
2	Survey	• priority areas of potential habitat are surveyed and a greater understanding of distribution is achieved;
		 public authorities report new individuals/ populations to NPWS;
		 census and population dynamics data of new individuals/ populations recorded by NPWS;
		• potential habitat modeled by NPWS, if feasible.
2	Biological research	• NDWS PRC & RVPPT applies for funding to conduct biological research:
5	and monitoring	• NPWS, KBO, & BVKPT applies for funding to conduct biological research,
		• monitoring program is commenced, and a greater knowledge and understanding of key attributes of the taxon's biology is achieved and applied to management;
4	Contingency	• current ex-situ <i>P. mollis</i> ssp. <i>maxima</i> individuals maintained in the living collection of Mt Annan Botanic Garden;
	arrangements	• translocation (ex-situ) and critical habitat contingencies considered following catastrophic disturbance;
		• translocation/critical habitat implemented, if appropriate.

Appendix 6: Site assessment and monitoring proforma

Site assessment

A site assessment proforma should be completed upon the discovery of new individuals of *P. mollis* ssp. *maxima*. This proforma is designed to provide location, population details, habitat and threatening process information in a systematic and consistent manner. A copy of the completed proforma should be forwarded to the *P. mollis* ssp. *maxima* Recovery Team Coordinator.

Monitoring procedures

Monitoring of existing populations is required on an annual basis to develop a record of biological information and response of *P. mollis* ssp. *maxima* to disturbance and management actions. Monitoring should be conducted at a range of times during the plant's lifecycle. That is, monitoring should occur at both peak flowering and fruiting times.

The following procedures should be followed:

- 1. Individual plants should be consecutively numbered with brass fire-proof tags. Tags should be staked in the ground at the base of each plant, in the same location for each individual;
- 2. The status of each plant should be recorded. The following codes are suggested: A=Alive, D=Dead, M=Tag Missing, W=Withered, FL = flowers, B= buds, Fr=fruits;
- 3. The height of each individual plant should be estimated to measure annual grow rates;
- 4. The number of whorls present on each plant should be recorded to estimate plant age (for method see 6.1);
- 5. General notes should be made including: evidence of predation, fauna interactions (including pollinators), recent disturbance, threatening processes, other general observations.

Monitoring results should be summarised, and a copy of the proformas sent to the *P*. *mollis* ssp. *maxima* Recovery Team Coordinator.

1. Threatened Flora Site Assessment (New Site)

DATE:

RECORDER:

THREATENED SPECIES:

LOCATION (description):

- Map number/sheet:
- Grid Reference:
- Accuracy:

SITE DESCRIPTION:

- Land Tenure: local/state/federal government/freehold/National Park/other
- Topography: ridge/upper slope/mid slope/gully/wetland/other
- Understorey: developed/suppressed
- Current Land Use:
- Past Land Use:
- Time Since Last Fire/ Fire History:

POPULATION DETAILS: (follow with an E if an estimate)

- Local Abundance: frequent/occasional/rare
- Number of adult plants:
- Number of seedling plants:
- Area covered by population/subpopulation:
- Plant Distribution: small scattered clump/large continuous clump/other
- Breeding Status: buds/flowers/fruit
- Plant Height(s):
- Estimated Age of Plants:

HABITAT CHARACTERISTICS:

GEOLOGY:

- Soil Landscape/Type:
- Texture: sand/loam/clay
- Drainage: waterlogged/damp/well drained dry/well drained moist
- Depth: skeletal/shallow/deep
- Disturbance: intact/topsoil removed/landfill/other

ASPECT: SLOPE: ALTITUDE:

VEGETATION STRUCTURAL FORMATION: TD (Closed Forest), TM (Open Forest), TS (Woodland), TV (Open Woodland), (refer to Atlas of NSW Wildlife Field Data Book)

SPECIES ASSOCIATIONS (list dominant species):

- Canopy:
- Understorey:
- Groundcover:
- Vines/Climbers:
- Other Threatened Flora/Fauna Species Recorded:

THREATS:

- Weed Invasion (specify species): % cover
- Trampling/Grazing: feral/domestic/native
- Isolation/fragmentation
- Erosion:
- Inappropriate Fire Regimes:
- Fire trail maintenance:
- Rubbish dumping:
- Other (specify):

OTHER RECORDS:

- Collection Made: Yes/No
- Type of Collection: seed/cutting/plant
 Photographs Taken: Yes/No
- Extent of Survey: complete/incomplete/unknown

OTHER OBSERVATIONS:

2. Persoonia mollis subspecies maxima monitoring proforma

DATE :

RECORDER:

Population:							
Subpopulation:							
Monitoring year:	1	2	3	4	5		

Total number of adult plants: Total number of seedling plants:

Plant population census

Plant No.	Status	Height	No. whorls	Notes

Plant No.	Status	Height	No. whorls	Notes

Appendix 7: Implementation Costs

Action	Description	Year of implementation						Source of funding				
		1	2	3	4	5	Total	NSW Recurrent funds	NPWS Program funds	BEROWRA VALLEY REGIONAL PARK TRUST	RGB SYDNEY	FEDERAL GOV'T
1	Habitat management											
	Stakeholder liaison	2,000	2,000	2,000	2,000	2,000	10,000		$10,000^1$			
	Fire management		\checkmark	\checkmark	\checkmark		-					
	Environmental impact assessment		\checkmark	\checkmark	\checkmark		-					
	Weed management	21,000	11,000	11,000	11,000	11,000	65,000	$30,000^1$		$35,000^2$		
	Information database		\checkmark	\checkmark	\checkmark		-					
	Planning		\checkmark	\checkmark	\checkmark		-					
	Track maintenance						-					
	Educational display	3,000					3,000		$3,000^{1}$			
2	Survey											
	Targeted survey	6,000	4,000	2,000			12,000		$6,000^{1}$	$6,000^2$		
	Reporting		\checkmark	\checkmark	\checkmark		-					
	Population census	1,000	1,000	1,000	1,000	1,000	5,000	$5,000^{1}$				
	Habitat modeling				3,000		3,000		$3,000^{1}$			
3	Research and monitoring											
	Research project	23,667	23,667	23,667			71,000		6,000		5,000	$60,000^3$
	Population monitoring	1,000	1,000	1,000	1,000	1,000	5,000	$5,000^{1}$				
4	Contingency actions											
	Maintain ex-situ collection		\checkmark	\checkmark	\checkmark		-					
	Translocation	\checkmark		\checkmark	\checkmark		-					
	Critical habitat			\checkmark	\checkmark		-					
	Total (\$)	57,667	42,667	40,667	18,000	15,000	174,000	40,000	28,000	41,000	5,000	60,000

Key

 \sqrt{No} direct cost

¹ Central Directorate Recurrent & Operational Funds ² Funding subject to annual budgetary constraints

³ Funded by Federal Government's ARC SPIRT research grants program. (NPWS & RBG contribution towards research includes cash and inkind support)



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