Approved Recovery Plan

Somersby Mintbush
Prostanthera junonis
Recovery Plan

October 2000

Natural Heritage Trust
Helping Communities Helping Australia

NSW NATIONAL PARKS AND WILDLIFE SERVICE

NSW National Parks and Wildlife Service
43 Bridge Street
(PO Box 1967)
Hurstville NSW 2220
Tel: 02 95856678
www.npws.nsw.gov.au

For further information contact
Threatened Species Unit, Central Directorate.
NSW National Parks and Wildlife Service
P.O. Box 1967
Hurstville NSW 2220
Tel 02 9585 6678

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NSW National Parks and Wildlife Service Recovery Planning Program

Somersby Mintbush
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Recovery Plan

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

October 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 (NSW) (TSC Act) provides the framework to conserve and recover threatened species, populations and ecological communities through the preparation and implementation of recovery plans.

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

This plan describes our current understanding of the Somersby Mintbush, *Prostanthera junonis,* documents the research and management actions undertaken to date, and identifies the actions required and parties responsible to ensure the ongoing management of the species in nature.

The Somersby Mintbush *(Prostanthera junonis)* Recovery Plan was prepared with the assistance of a recovery team comprising relevant land management and research interests, and was placed on public exhibition during January-February 2000. Fourteen public submissions were received by the Director-General of National Parks and Wildlife and were considered during the final preparation of the plan. I thank all of these people for their efforts to date and 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

Prostanthera junonis B.J. Conn is a low spreading shrub 0.1-0.3 m high, with small pale mauve flowers. It has dull green leaves on long branches generally entwined amongst other vegetation. Outside of its main flowering season, *P. junonis* is cryptic amongst the other understorey plants of the sclerophyllous woodland in which it occurs. *P. junonis* B.J. Conn (Lamiaceae) has previously been known as *Prostanthera* sp. 8 and *Prostanthera* sp. Somersby (Conn 4024).

Current Species Status

P. junonis is listed as nationally endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). It is also listed as endangered on Schedule 1 of the New South Wales *Threatened Species Conservation Act* 1995 (TSC Act). *P. junonis* is currently known from a north-south range of 19 km on the Somersby Plateau, north west of Gosford, NSW. The total number of individuals is currently estimated to be greater than 3200, distributed in nine populations.

Legislative context

The EPBC Act 1999 (Cth) and the TSC Act 1995 (NSW) are the principal legislative frameworks to protect and encourage the recovery of threatened species, populations and communities in Australia and NSW respectively. Under the EPBC Act 1999 (Cth) and the TSC Act 1995 (NSW), the Commonwealth Minister for the Environment and the Director-General of National Parks and Wildlife have certain responsibilities, including the preparation of recovery plans for threatened species, populations (NSW) and ecological communities. Both legislative instruments include specific requirements for 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 both the EPBC Act 1999 (Cth) and the TSC Act 1995 (NSW) and as such there will only be one recovery plan in operation for *P. junonis.*

Preparation of Plan

This Recovery Plan has been prepared with the assistance of a recovery team, a non-statutory group of interested parties with relevant expertise, established to discuss 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 prepared.

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 National Parks and Wildlife Service) are to take appropriate action available to them to implement those measures in a recovery plan for which they are identified as being responsible. In addition a Minister or public authority must not undertake actions inconsistent with an approved recovery plan. Public authorities identified as having responsibilities within this plan are the NPWS, Gosford City Council, Wyong Shire Council, and the NSW Department of Land and Water Conservation (DLWC). Consequently, these public authorities agree to manage *P. junonis* and its habitat in accordance with this recovery plan. Other public authorities likely to be involved in the future management of the species are the NSW Rural Fires Service, NSW State Forests and the Royal Botanic Gardens, Sydney (RBG).

Recovery objectives

The overall objective of the recovery plan is to identify policies and programs which protect and conserve *P. junonis* and which reduce the risk of extinction of the species.

Specific objectives of the plan are to:

- ensure that *P. junonis* populations are not destroyed as a consequence of habitat loss, and that an increased level of security is provided over lands which support *P. junonis* populations (Reservation/Conservation Status of Populations);
- minimise the risk of *P. junonis* populations from declining in the long term through encouraging the implementation of appropriate threat and habitat management practices (Threat and Habitat Management);
- establish the full extent of the distribution of *P. junonis* (Survey);
- ensure the management of *P. junonis* habitat is informed by essential aspects of the species' biology and ecology (Biological Research);
- determine whether a declaration of critical habitat for *P. junonis* will provide greater protection for the species than which currently exists (Critical Habitat);
- understand the requirements for safeguarding genetic diversity of *P. junonis* for the purpose of reintroduction, following the extinction or irreversible decline of natural populations (*Ex situ* Conservation); and
- raise awareness among the broader community about the conservation status of *P. junonis*, and to involve the community in the species' recovery program (Education/Awareness and Involvement).

Recovery criteria

The overall performance criteria of the recovery plan, is that the risk of extinction of *P. junonis* is decreased through the implementation of recovery actions to protect the known populations. Specific performance criteria are:

- all viable populations of *P. junonis* are maintained *in situ*;
- all viable populations of *P. junonis* are managed to ensure that factors detrimentally affecting the species are reduced to a level that is unlikely to compromise the recruitment and survival of populations;
- potential habitat is surveyed and a greater understanding of the plant's habitat is known, documented in relevant databases and communicated to relevant land managers;
- a greater understanding of *P. junonis* biology and ecology is achieved through targeted research, and management strategies are informed by research outcomes;
- critical habitat is assessed as a management option for *P. junonis;*
- the most effective and efficient method of storage of *ex situ P. junonis* material is investigated and understood and, if necessary, an *ex situ* program is implemented;
- information is disseminated to the community, in particular private landholders, of the conservation status and management issues affecting *P. junonis* and its habitat; and the community is actively involved in key aspects of the recovery program.

Recovery actions

The recovery plan consists of seven specific objectives, which aim to achieve the overall recovery objective. Each of these objectives has a series of specific supporting actions, which identify the agency responsible for implementation and a timeframe in which the action will be completed (see implementation schedule). Recovery actions will be directed towards:

- securing protection of populations of the species from habitat loss;
- habitat management initiatives, including: the storing and communication of site locations, consideration of development applications and environmental assessment guidelines, fire management, and site specific management actions;
- targeted survey to determine the extent of known populations and whether there are new undiscovered populations;
- undertaking research which investigates key attributes of the species' biology relevant to management;
- assessing the appropriateness and feasibility of declaring critical habitat for the species;
- investigating the requirements for *ex situ* storage, if required; and
- a greater community involvement in the recovery program for the species.

Estimated cost of recovery

The following table indicates those costs over and above the recurrent operating budgets for the statutory authorities responsible for the implementation of actions identified in the plan. The total cost to implement this plan is estimated to be $81,500 over five years.

Action Description	Funding Source			
	NPWS	**DLWC**	**Land holders**	**Unsecured**
Conservation status of populations	13000			3000
Habitat Management	8000	3000	20000	2000
Survey	7000			
Biological Research	16500			
Critical habitat				3000
Ex situ conservation				6000
Education				
TOTAL ($)	44,500	3,000	20,000	14,000

Biodiversity Benefits

The conservation of areas of habitat in which *P. junonis* occurs will enhance protection of some of the remaining plateau-top vegetation remnants on the Somersby Plateau. Protection of *P. junonis* habitat also assists in the protection of two other threatened plant species *(Tetratheca glandulosa* and *Eucalyptus camfieldii)* and a regionally significant plant species *(Darwinia glaucophylla).*

BRIAN GILLIGAN
DIRECTOR-GENERAL

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1 Introduction

Prostanthera junonis (the 'Somersby Mintbush') is a small shrub species with its dominant flowering period between October and mid-December. Targeted survey conducted by the NSW National Parks and Wildlife Service (NPWS) has resulted in the identification of nine populations of *P. junonis*, restricted to a north-south range of 19km on the Somersby Plateau, in the Gosford and Wyong Local Government Areas. These populations occur on both public and private land, and in a variety of landuse planning zones. Survey has estimated the total number of individuals to be greater than 3200, however, approximately 85% of the total population is restricted to a single locality. While historical populations of *P. junonis* are likely to have been destroyed as a result of extensive development of the Somersby Plateau, further populations may be discovered in conservation reserves or in remnant vegetation on private land, with additional survey.

Management issues and threatening processes affecting *P. junonis* are many and varied. Development applications have been lodged for properties that contain five of the nine populations. Habitat loss is thus the principal threat to *P. junonis.* In some cases, the assessment process has resulted in the successful reconfiguration of development footprints and/or conditions such as the preparation of management plans and monitoring of individual plants. Consent conditions to protect *P. junonis* have, however, had mixed success. Other threats include habitat degradation from unrestricted access, weed invasion and dumping, and the introduction of plant pathogens.

This recovery plan focuses on the need for public authorities to manage known populations and potential habitat under their control, and to work cooperatively with landholders in order to secure sympathetic management of populations on private land. Investigations into the biology and ecology of the species are recommended to inform management practices. Investigations into the feasibility of and requirements for establishing an *ex situ* program are recommended in order to safeguard the species from extinction. Critical habitat is proposed to be investigated following additional survey and research.

The recovery plan describes the current understanding of *P. junonis,* documents the management and research actions undertaken to date, and identifies the parties responsible for the actions required to be implemented to ensure the long term conservation and management of the species. A Recovery Team has been established, which assisted in the preparation of the recovery plan, and will oversee its review and implementation. The preparation and implementation of this recovery plan was funded by the NSW NPWS, Environment Australia, and Gosford City Council.

2 Legislative context

2.1 Legal status

P. junonis is listed as a nationally endangered species on the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). *P. junonis* is also listed as endangered in NSW on Part 1, Schedule 1 of the NSW *Threatened Species Conservation Act* 1995 (TSC Act). Among the consequences of listing as a threatened species on the EPBC Act 1999 (Cth) and the TSC Act 1995 (NSW), are that a recovery plan must be prepared and consideration be given to the species in assessing the impacts of developments and activities.

2.2 Recovery plan preparation

The EPBC Act 1999 (Cth) and the TSC Act 1995 (NSW) require the Commonwealth Minister for the Environment and the Director-General of National Parks and Wildlife to prepare recovery plans for all Commonwealth listed species and communities, and State listed species, populations and ecological communities respectively. Both legislative instruments include specific requirements for the matters to be addressed by recovery plans and the process for preparing recovery plans. This plan satisfies the provisions of both the EPBC Act 1999 (Cth) and the TSC Act 1999 (NSW), and as such there will only be one recovery plan operating for *P. junonis*.

2.3 Recovery plan implementation

The TSC Act 1995 (NSW) requires that a government agency must not undertake actions inconsistent with an approved recovery plan. The government agencies relevant to this plan are: the NPWS, Gosford City Council, Wyong Shire Council, NSW Department of Land and Water Conservation (DLWC), NSW State Forests and the Royal Botanic Gardens, Sydney (RBG). Consequently, the actions outlined for each of these agencies must be implemented as described in the plan.

2.4 Relationship to other legislation

The lands on which *P. junonis* occur include those that are owned and/or managed by the NSW NPWS, Gosford City Council, Wyong Shire Council, Department of Land and Water Conservation (DLWC), and private landholders. Relevant legislation which affects the *P. junonis* populations, includes:

- *National Parks and Wildlife Act* 1974 (NSW)
- *Threatened Species Conservation Act* 1995 (NSW)
- *Environmental Planning and Assessment Act* 1979 (NSW)

- *Local Government Act* 1993 (NSW)
- *Rural Fires Act* 1997 (NSW)
- *Native Vegetation Conservation Act* 1997 (NSW)
- *Environment Protection and Biodiversity Conservation Act* 1999 (Cth)

2.5 Critical habitat

The EPBC Act 1999 (Cth) and the TSC Act 1995 (NSW) make provision for the identification and declaration of critical habitat for species, populations and ecological communities listed as endangered. Critical Habitat, as defined in the TSC Act 1995 (NSW), is considered to be "the whole or any part or parts of the area or areas of land comprising the habitat of an endangered species ... that is critical to the survival of the species". Once declared, it becomes an offence to damage critical habitat (unless the action is specifically exempted by the TSC Act 1995). A species impact statement is also mandatory for all developments and activities proposed within critical habitat and the concurrence of the Director General of the National Parks and Wildlife Service is required before any approval is given. Under the EPBC Act 1999 (Cth) the Federal Minister for the Environment must keep a register of habitat critical to the survival of a species or ecological community listed under that Act.

To date there has been no critical habitat declared for *P. junonis.* This recovery plan identifies the need to further understand the species' distribution and biology, prior to investigating the feasibility of critical habitat as a management option.

2.6 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). Although the precise fire ecology of *P. junonis* is unknown, high frequency fire is likely to be threat to the species and its habitat (see section 6).

2.7 Environmental assessment

2.7.1 State environmental assessment

The TSC Act 1995 (NSW) amendments to the environmental assessment provisions of the NSW *Environmental Planning and Assessment Act* 1979 (EP&A Act), require that consent and determining authorities, and the Director General of National Parks and Wildlife (as a concurrence authority), consider relevant recovery plans when exercising a decision making function under Parts 4 & 5 of the EP&A Act 1979 (NSW). Decision-makers must consider known and potential habitat, biological and ecological factors, and the regional significance of individual populations.

The following authorities are currently known to have a decision making function in relation to *P. junonis* and its habitat under NSW environmental assessment processes:

- Gosford City Council in relation to lands within the Gosford Local Government Area;
- Wyong Shire Council in relation to lands within the Wyong Local Government Area;
- The NSW NPWS in relation to lands reserved under the *National Parks and Wildlife Act* 1974 (NSW) and where a concurrence role under the EP&A Act 1979 (NSW) is required;
- The Department of Land and Water Conservation in relation to Crown Land, subject to the provisions of the *Crown Lands Act* 1989 (NSW) and vegetation clearing in accordance with the provisions of the *Native Vegetation Conservation Act* 1997 (NSW).

When exercising a decision making function under the EP&A Act 1979 (NSW) for any development or activity which may affect *P. junonis* or its habitat, these and other relevant public authorities (should additional populations be found) must consider the content and objectives of this recovery plan.

2.7.2 Commonwealth environmental assessment

Threatened species and communities listed in the EPBC Act 1999 (Cth) are considered to be a matter of national environmental significance. Under the Commonwealth EPBC Act (1999), an action will require the approval of the Commonwealth Minister for the Environment (in addition to any State or Local Government approval), if the action will have, or is likely to have, a significant impact on a matter of national environmental significance.

The EPBC Act 1999 (Cth) criteria for determining whether a significant impact on a threatened species or community is likely, differ from those applied under the NSW environmental assessment process (ie. s5A of the EP&A Act 1979). If the proposed action is likely to have a significant impact on a nationally listed threatened species or community (according to the Commonwealth criteria), the matter must be referred to the Commonwealth Minister for the Environment for consideration. If the Minister decides that a significant impact is likely, the EPBC Act 1999 (Cth) environmental assessment procedure will apply (in addition to that of any State or Local Government process and approval, subject to any bilateral agreement between the Commonwealth and the State). The Commonwealth Minister may decide to either approve or reject the application to conduct the action.

Further information concerning the operation of the EPBC Act 1999 (Cth) environmental assessment requirements can be obtained from Environment Australia.

3 Conservation status

Prostanthera junonis B.J. Conn, the Somersby Mintbush, is currently known from nine populations on the Somersby Plateau, in the Central Coast Botanical Division, southeastern Australia. Surveys carried out since spring 1997 have estimated the total number of individuals to be greater than 3200. Approximately 85% (ie. c.2700 plants) of the total number of individuals is restricted to a single population in Brisbane Water National Park. That the remaining 15% of the total population is spread across eight populations highlights the vulnerability of the species as a whole.

Briggs & Leigh (1996) coded the conservation status of *P. junonis* as 2E, which indicates that the geographic range is less than 100km (2), and that the species is at serious risk of disappearing from the wild over the next 10-20 years if present threats continue (E). Following survey conducted for the preparation of this recovery plan, this code should be revised as 2ECa, to reflect the fact that there is at least one population in a conservation reserve (C), and that there are 1000 plants or more known to occur in a conservation reserve (a).

4 Description

4.1 Taxonomy

Taxonomic hierarchy:

Order:	Lamiales
Family:	Lamiaceae
Tribe:	Prostanthereae
Genus:	*Prostanthera*
Section:	*Prostanthera*
Species:	*junonis*
Author:	B.J. Conn
Date:	1997

Prostanthera junonis belongs to the plant family Lamiaceae (within the Order Lamiales). This cosmopolitan family consists of many culinary herbs such as basil, mint and rosemary. The genus *Prostanthera* is one of the six genera of the Tribe Prostanthereae that are all endemic to Australia, and includes *Westringia*, *Hemigenia*, *Hemiandra*, *Microcorys* and *Wrixonia* (Conn 1992a). *Prostanthera junonis* also belongs to Section *Prostanthera* of the genus *Prostanthera*, which is distinct in floral shape to species contained in the other section of the same genus (section *Klanderia*).

4.2 Previous names

Although *P. junonis* has been recognised as a distinct species for a number of years, its scientific name and botanical description have only recently been published (Conn 1997). *P. junonis* has previously been known as *P.* sp. 8 (Briggs and Leigh 1996) and *P.* sp. 'Somersby' (Conn 4024) under the TSC Act 1995 (NSW). Although it was not described as a distinct species in the Flora of New South Wales (Conn 1992b) or in the Flora of the Sydney Region (Carolin & Tindale 1994), it is referred to as the "Mangrove Mountain population" of *P. marifolia* (refer Conn 1997). The species name, "*junonis*" was officially published in 1997 to honour June Gay, a volunteer worker at the Royal Botanic Gardens Sydney. The species is commonly known as the "Somersby Mintbush".

4.3 Scientific description

P. junonis is a low spreading shrub, 0.1- 0.3 m high and, in open areas, up to 1 m in diameter. Some plants have been observed to be connected by underground stems (rhizomes). The leaves are dull green above, paler below, and non-aromatic. Leaf shape varies from elliptic to narrowly elliptic (8-14 mm long by 3-6 mm wide); the broader leaves dominate on younger plants and are generally only found towards the base of branches on older plants. Although square branches and aromatic stems and foliage are often noted as being characteristic of this family, this does not hold true for many species of *Prostanthera* including *P. junonis*.

The habit of individual plants growing in open or closed habitats can appear quite different. In open areas the plants tend to be very low and prostrate growing. In areas of more dense vegetation (such as dense sedges or shrubs) the plants have long spindly branches which weave through other vegetation and can be found growing up to 1 m high when supported by other plants.

The shape of flowers within the genus *Prostanthera* is described in terms of the length of their floral tube and the form of the lobes. The upper lip of the corolla is divided into two lobes, usually held erect, whereas the lower lip is divided into three lobes and is extended forward. The inner surface of the lower lip and upper part of the tube is frequently covered in brown spots. The corolla is held within a green calyx, which is tubular and two lipped. *P. junonis* has a corolla 8-12 mm long, pale mauve to almost white. The calyx is green, often tinged with maroon, and sparsely hairy. Flowers occur singly in leaf axils, although they are actually part of a complicated leafy inflorescence consisting of 4-14 flowers. Species in the Lamiaceae family have dry fruits (schizocarps) that usually break into four one seeded units (mericarps). Most of the species in the genus *Prostanthera*, including *P. junonis*, have a persistent calyx throughout the fruiting stage. Figures 1a and 1b show the typical appearance of *P. junonis*.

Figure 1a: Typical appearance of *Prostanthera junonis* in flower, Raverson Close Summer 1997. Photograph: Tom O'Sullivan

Figure 1b: *Prostanthera junonis* entwined among understorey vegetation, December 1998. Photograph: Merrin Tozer.

4.4 Similar species: *Hemigenia purpurea*

Hemigenia purpurea is frequently confused with *P. junonis* due to their similar flower shape. *H. purpurea* is a common species that occupies the same habitat. Both *Hemigenia* and *Prostanthera* are classified in the tribe Prostanthereae of the family Lamiaceae.

H. purpurea is a small erect shrub 0.1 - 2 m high, with mauve flowers similar in shape and size to *P. junonis*. The two species can be readily distinguished using the following characteristics:

- *Hemigenia purpurea* has a calyx with five long teeth as opposed to two lips in *P. junonis*;
- *Hemigenia purpurea* has linear leaves, in whorls of three occurring densely along the branches;
- *P. junonis* has elliptic to narrowly elliptic leaves, opposite and widely spaced along the branches.

Figures 2a & 2b show illustrations of *P. junonis* and *H. purpurea* distinguishing identification characteristics of both species.

Since non-flowering plants of each species are the most frequently confused, the arrangement of leaves (i.e. whorled leaves in *H. purpurea* and opposite on *P. junonis*) should be used to distinguish these two species.

4.5 Other *Prostanthera* species on the Somersby Plateau

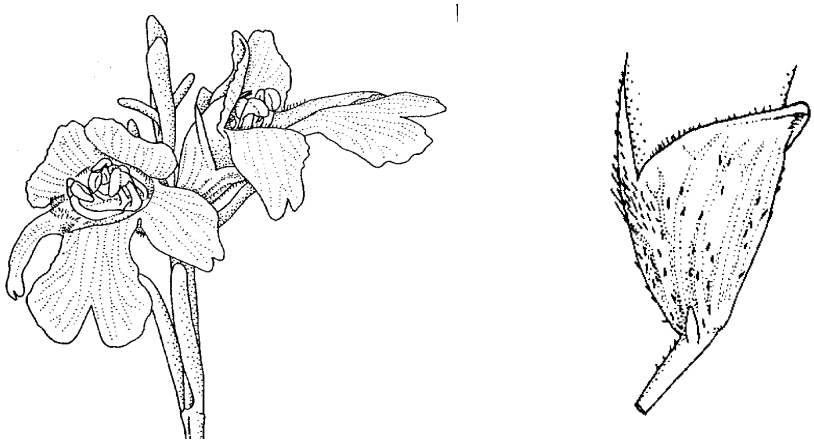
There are two other *Prostanthera* species which occur in the same general area as *P. junonis* (*P. linearis* and *P. askania*). *P. junonis* can be easily distinguished from these species by its habit and leaves (refer to Conn 1992b):

- *P. linearis* is an erect shrub (1-3 m), with dark green faintly aromatic foliage growing in moister habitats, such as near water courses;
- *P. askania* (= *P.* sp *G* (Conn 1992b) & = *P.* "Strickland State Forest" (TSC Act 1995) is also an erect shrub, with dull mid green leaves with prominent rounded teeth.

Figures 3a & 3b show illustrations of *P. linearis* and *P. askania.*

Figure 2. Distinguishing characteristics of *P. junonis* and *H. purpurea*

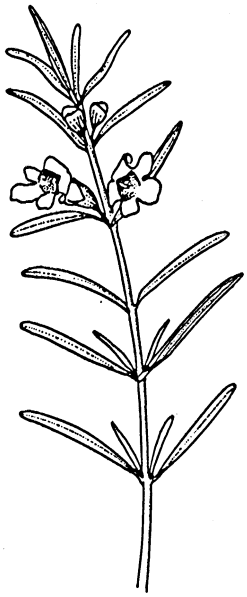
2a Corolla shape of *P. junonis*: line drawing showing detail of the corolla lobing, and the two-lipped calyx. Illustrations used with permission from Conn (1997).



2b Characteristics of *Hemigenia purpurea,* which distinguish it from *Prostanthera junonis:* line drawing showing the difference in leaf arrangement (generally in whorls of three) and placed densely along the stem; and five toothed calyx.

Figure 3. Illustrations of *Prostanthera askania* (a) and *Prostanthera linearis* (b). Drawings used with permission from Conn (1997) and Conn (1992b) respectively.

3a. *Prostanthera askania*



3b. *Prostanthera linearis*

5 Distribution and habitat

5.1 Populations and sub-populations: definitions

Populations have been defined by the International Union for the Conservation of Nature and Natural Resources (IUCN) (1994 in Keith *et al.* 1997) as "geographically or otherwise distinct groups between which there is little [genetic] exchange, typically less than one migration per year". A migration in the case of plant species is considered the movement of seed propagules or pollen between populations. For *P. junonis,* there is inadequate information with which to assess the extent to which genetic material is exchanged, therefore a population is defined using the "rule of thumb" given by Keith *et al.* (1997) as "geographic discontinuity of more than 1 km".

For this recovery plan, discrete groups of *P. junonis* plants which are not separated from other discrete groups by more than 1 km and have no effective barrier to dispersal between the groups (such as a six lane freeway or tracts of developed land) are considered together into single populations. Discrete individual groups of plants within 1km of each other are therefore referred to as "sub-populations".

5.2 Historical collections

The first herbarium collections of *P. junonis* were made in 1926 from three locations on the Somersby Plateau. The locations of the three collections were given as:

- 'Mangrove Mountain' (18 July 1926)
- 'Wiseman's Ferry Road, near the 4 Mile Post from Gosford' (September 1926); and
- 'Long Ridge between Piles Creek and Mooney Mooney' (October 1926).

The first two specimens collected do not contain fertile material and hence it is possible that the collectors revisited the area in successive months with the intent of acquiring fertile material to confirm the new species (R. Miller, ASGAP *Prostanthera & Westringia* Study Group, pers. comm.). All three locations noted on the collections refer to the same general area - it is possible that they also refer to the same site - however, their exact position is unknown (Payne 1997).

Despite these early collections, *P. junonis* was not formally re-collected until November 1993, when a large population was rediscovered within the Somersby Industrial Estate by R. Miller. This population has been extensively surveyed and studied, the results of which are documented in Tierney (1994, 1996) and AMBS (1997).

5.3 Current and historical distribution

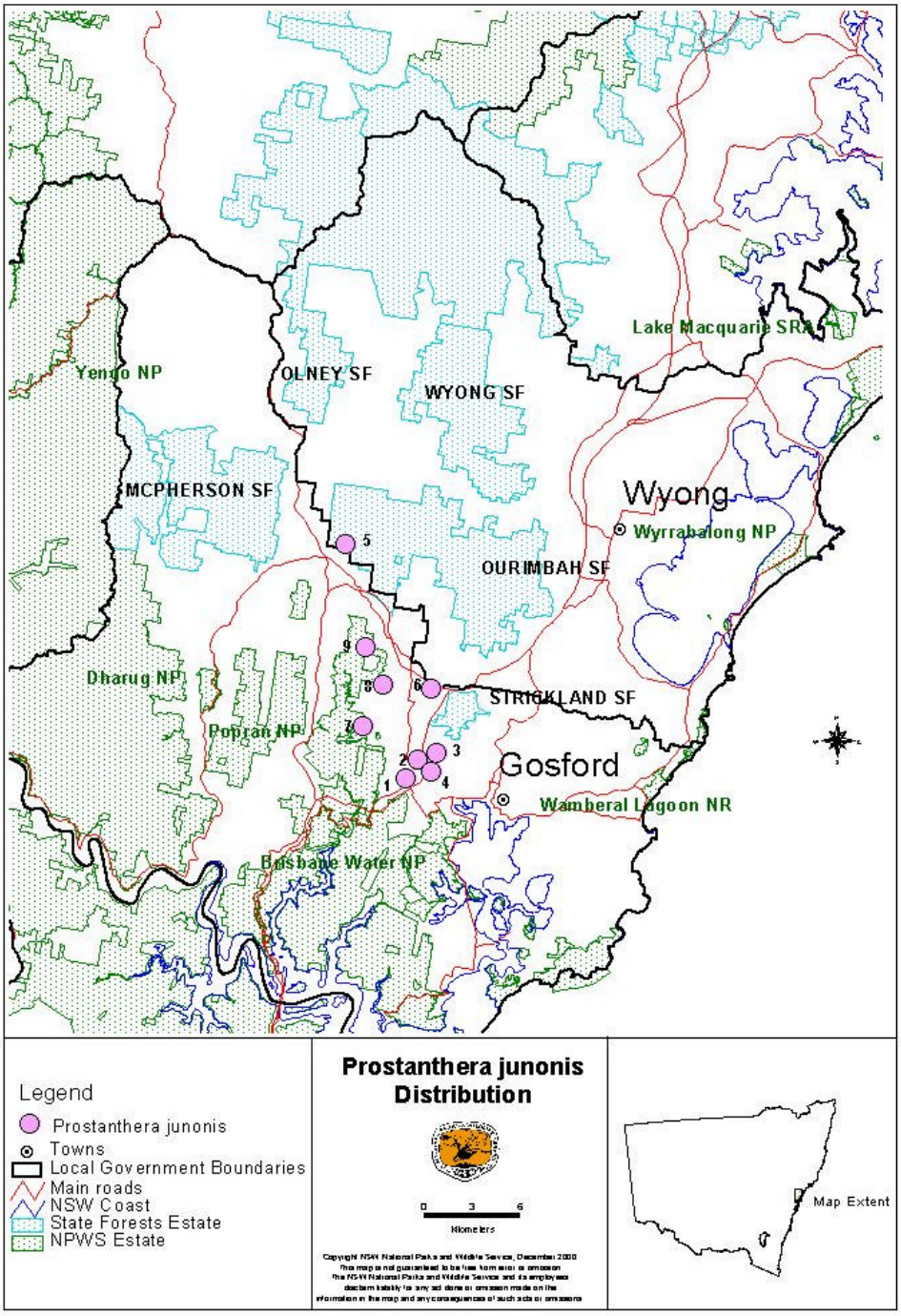
P. junonis is endemic to NSW. The species is currently known from nine populations within a total north-south range of approximately 19 km on the Somersby Plateau, in the Gosford and Wyong Local Government Areas. Eight of the populations occur over a north-south range of approximately 10km, with the northern-most population currently a disjunct outlier approximately 9km to the north of the eight other populations.

All populations are currently restricted to the eastern extremity of the Somersby Plateau, within a narrow east-west range of approximately 7km. It is noted that *P. junonis* has not been recorded during previous surveys conducted in the west of the Somersby Plateau (eg. Clarke & Benson 1987, S. Bell 1998 pers. comm.), and that targeted surveys by the NPWS in Spring 1998 also failed to locate the species in Popran National Park.

Figure 4 shows the distribution of *P. junonis* and Appendix 1 summarises the site location details. Information regarding these localities has been lodged with the NSW Wildlife Atlas and with the relevant land manager for each of the sites. Specimens and information have also been lodged with the National Herbarium of NSW. The current distribution shows that *P. junonis* has an extremely narrow extent of occurrence (c. 4700ha). The total area of occupancy of the species' populations is even further restricted at just approximately 41.75ha.

Although there is no direct evidence, it is possible that *P. junonis* was once more widespread on the Somersby Plateau. The distribution of *P. junonis* may have suffered from a human induced decline due to the loss of large amounts of habitat through clearing of native vegetation, and/or alteration of habitat by activities such as grazing.

Figure 4. Distribution of *Prostanthera junonis*



5.4 Land tenure and land-use zoning

Eight of the nine populations (1-4, 6-9) occur in the Gosford Local Government Area (LGA) and one of the populations (5) occurs in Wyong LGA. The nine known populations of *P. junonis* occur on land with a variety of public and private tenure. The relevant Local Government planning instruments, which outline the range of permissible uses to which land may be put, determines zoning classifications. Tenure and zoning of lands on which *P. junonis* occurs are summarised in Table 1.

It is important to note that several populations (eg 7, 8) consist of discrete sub-populations, which occur on different tenures. An Aboriginal land claim has been made over lands containing population 3 (Algis Sutas, Department of Land and Water Conservation pers. comm.). If the claim is successful then the tenure of the site will change from Crown Reserve to freehold.

Table 1 indicates that five of the nine *P. junonis* populations occur on public lands, but that only two of those five are currently managed for nature conservation (Brisbane Water National Park). There is, therefore, a need to appropriately manage other public land populations in addition to securing sympathetic management of populations located on private land.

Table 1. Tenure and land-use zoning of *P. junonis* populations.

POPULATION	NAME	LGA	TENURE	ZONING
1	Wiseman's Ferry Road	Gosford	Gosford City Council	4(a) Industrial
2	Raverson Close	Gosford	Private	4(a) Industrial
3	Reeves Road	Gosford	Crown Reserve	7(b) Scenic Protection
4	Gindurra Road	Gosford	Private	7(b) Scenic Protection
5	Barnes Road	Wyong	Private	1(a) Agricultural
6	Mangrove Tower	Gosford	Private	1(a)/1(b) Highway protection and Agricultural
7A	Reservoir Road	Gosford	Private	1(a) Agricultural
7B	Reservoir Road	Gosford	National Park - Brisbane Water	8 National Park Reservation
7C*	Reservoir Road	Gosford	National Park - Brisbane Water	8 National Park Reservation
8A	Silvesters Road	Gosford	Gosford City Council	5 (a) Special uses - Water Supply
8B+	Silvesters Road	Gosford	Private	1 (a) Agricultural
8C+	Silvesters Road	Gosford	Private	5 (a) Special uses - Water Supply
9	Konda Road	Gosford	National Park - Brisbane Water	8 National Park Reservation

* The draft Recovery Plan for *Prostanthera junonis* described four sub-populations for population 7 on a tenure basis. The sub-population 7D was formerly Crown Land, but was gazetted as an addition to Brisbane Water National Park on 31 December 1998 and is now included in 7C.

+ The draft Recovery Plan for *Prostanthera junonis* described only one sub-population for population 8. Surveys conducted during the draft plan's exhibition period subsequently identified two new sub-populations. These are described in Appendix 1.

5.5 Habitat

5.5.1 Climate

The climate of the Somersby Plateau is temperate with coastal influence (Hawkins *et al.* 1984). The average daily temperature for Kulnura in the north of the region reaches a maximum of 26.3 degrees in January compared with an average daily maximum of 15.2 degrees in June (Bureau of Meteorology 1997). Rainfall is highest on average in February (169.3 mm) and the lowest in July and September (51.7 mm) (Bureau of Meteorology 1997). Dominant winds are light and southerly to southwesterly and northeasterly in direction (Benson and Falding 1981).

5.5.2 Landscape and topography

The current known distribution of *P. junonis* is contained upon the Somersby Plateau. The Somersby Plateau is the elevated northern portion in the Hornsby Plateau (which adjoins the Cumberland Basin of Sydney) and, in a broad sense, consists of three elongated smaller plateaus divided by Mooney Mooney Creek, Popran Creek and their tributaries (Hawkins *et al.* 1984). Although the known occurrences of *P. junonis* are restricted to the eastern part of the Somersby Plateau, the habitat in which it is likely to be found is located across the whole of the Somersby Plateau.

The Somersby Plateau area has been described as a distinct physiographic region (Murphy 1993) and expresses a unique combination of geology, vegetation and climate. The distinctness of this area has implications for the distribution of *P. junonis* in that if its distribution is influenced by the physiographic characteristics of the region, then it is likely that it is restricted to the Somersby Plateau.

5.5.3 Soil landscapes

The Somersby Plateau consists of two main soil landscape units: Somersby and Sydney Town (*sensu* Chapman & Murphy 1993). *P. junonis* is found on both of these soil landscapes.

- ***Somersby Soil Landscape*** (Murphy 1993)

The Somersby Soil Landscape consists of gently undulating to rolling rises on deeply weathered Hawkesbury Sandstone. Slopes are less than 15%, and outcropping rock is generally absent. The soils are distinctly two layered, with a yellow earth overlying remnant red and grey mottled soils (Hawkins *et al.* 1984). Areas of gravel also occur intermittently throughout the area (Hawkins *et al.* 1984). Soil depth on the gentler slopes is up to 3 m, whereas on steeper slopes soil depth is often more shallow (0.5-1 m). This soil landscape has low soil fertility and is moderately vulnerable to erosion.

- ***Sydney Town Soil Landscape*** (Murphy 1993)

The Sydney Town soil landscape consists of rolling hills and slopes of Hawkesbury Sandstone, with components from the Narrabeen Group, and joining the Somersby Soil Landscape. Slopes are steeper than the Somersby Soil Landscape (5-25%) and rock outcrops are frequent. The crests and slope areas generally support soils of brown loamy sand to depths of 30cm that overlay up to 150cm of brown sandy clay loam. This soil landscape has low fertility, and is highly vulnerable to erosion thus it is relatively undeveloped compared to the Somersby Soil Landscape.

5.5.4 Vegetation communities

The natural vegetation of the Somersby Plateau consists of the Hawkesbury Sandstone Complex of Open-forest/Low woodland/Open-scrub (vegetation unit 10a in Benson 1986). Benson (1986) maps the broad scale distribution of this vegetation community (Map Unit 10a), however, small remnants are not indicated. The vegetation consists of five main structural components according to topographic sequence, drainage and aspect (Benson 1986, description follows). Open forest occurs in more sheltered positions and is dominated by *Eucalyptus piperita* and *Angophora costata*. This grades into drier low woodland dominated by *Corymbia gummifera, C. exima, E. punctata* and *E. haemostoma* in the more exposed locations. Open scrub, dominated by *Banksia ericifolia* and *Hakea teretifolia*, occurs in poorly drained situations. Open heath dominated by *Allocasuarina distyla*, *Baeckea* species and *Darwinia* species, and sedgeland dominated by species in the Cyperaceae and Restionaceae, and *Banksia robur* also occur scattered through out the Plateau.

P. junonis occurs predominantly in the low woodland component of the Hawkesbury Sandstone Complex dominated by *Eucalyptus haemostoma* with *Banksia ericifolia* or *B. serrata* in the understorey. The fire history of the areas is reflected by the vegetation composition and density (most notably in the height and density of *B. ericifolia*). The occurrence of *P. junonis* is not restricted to either open or dense shrubby understorey.

P. junonis has also been found in the ecotone between low woodlands and open forest or the open scrub/open heath components of the Hawkesbury Sandstone Complex. It has not been found in sedgelands, although it often occurs among sedges in the understorey of the woodland community. Likewise it has not been found in the *Allocasuarina distyla* open heath. Species commonly associated with the habitat of *P. junonis* are given in Table 2.

5.5.5 Microsites

A targeted survey for *P. junonis* on the Somersby Plateau during Spring 1997 provided no evidence that *P. junonis* inhabits any particular fine scale niche within the low woodland community (and ecotones) of the Hawkesbury Sandstone Vegetation Complex (*sensu* Benson 1986). As described above, *P. junonis* was found in areas of both dense and open understorey, and areas that have been recently burnt and those that have not experienced fire for at least 20 years. Therefore, *P. junonis* does **not** appear to be restricted to habitat that has been recently disturbed through fire or mechanical means, **nor** is it restricted to water soaks and rock outcrops as indicated by Payne (1997), Conn (1997) and Tierney (1996). Their conclusions were based on the few populations that were known at the time.

Table 2. Species commonly associated with the habitat of *P. junonis.* (source: Payne 1997 and M.E. Tozer, NPWS, pers. obs.)

TREES	SHRUBS	GROUND LAYER
Myrtaceae	**Casuarinaceae**	**Apiaceae**
Corymbia gummifera	*Allocasuarina littoralis*	*Actinotus minor*
Eucalyptus capitellata	**Epacridaceae**	**Colchicaceae**
E. haemastoma	*Epacris pulchella*	*Burchardia umbellata*
E. sieberi	**Fabaceae**	**Cyperaceae**
	Dillwynia floribunda	*Ptilothrix deusta*
	Acacia myrtifolia	**Goodeniaceae**
	A. oxycedrus	*Dampiera stricta*
	A. suaveolens	**Lamiaceae**
	A. terminalis	*Hemigenia purpurea*
	Myrtaceae	**Loganiaceae**
	Darwinia fascicularis	*Mitrasacme polymorpha*
	D. glaucophylla	**Lomandraceae**
	Lambertia formosa	*Lomandra filiformis*
	Leptospermum spp.	**Poaceae**
	Proteaceae	*Entolasia stricta*
	Banksia ericifolia	*Anisopogon avenaceus*
	B. oblongifolia	*Anisopogon avenaceus*
	B. serrata	
	Grevillea buxifolia	
	G. linearifolia	
	G. sericea	
	Hakea teretifolia	
	Isopogon anemonifolius	
	Persoonia levis	
	P. pinifolia	
	Petrophile pulchella	
	Rutaceae	
	Boronia pinnata	

Note: This species list is indicative only. The list of species recorded from vegetation communities in which *P. junonis* populations occur is larger than provided above.

5.6 Potential habitat

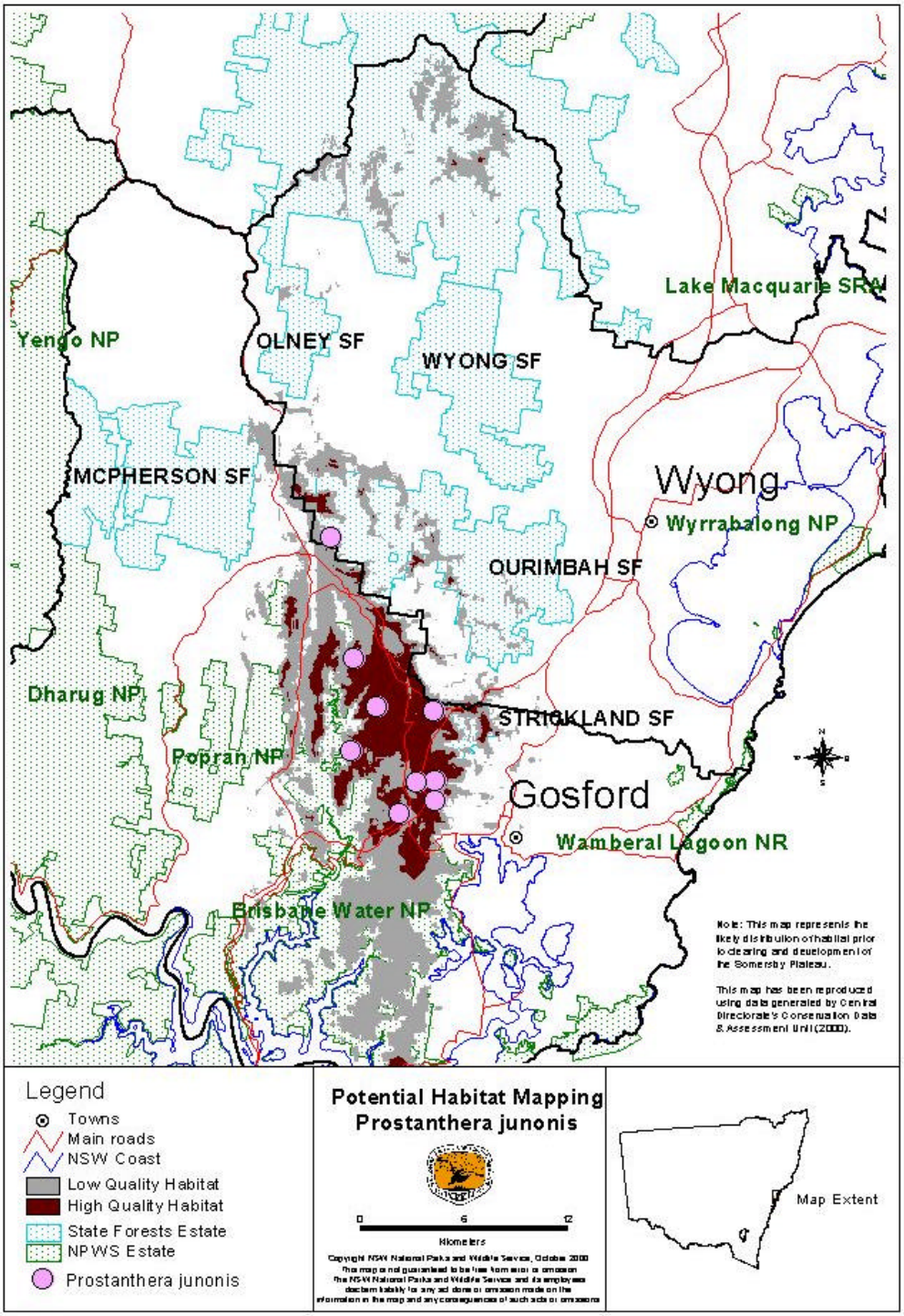
The distribution of the Hawkesbury Sandstone Vegetation Complex (10a, following Benson 1986) and distribution of the Somersby and Sydney Town Soil Landscapes (following Chapman & Murphy 1983) provide an overview of the likely extent of potential habitat for *P. junonis* on the Somersby Plateau. Within these areas the most likely positions in which *P. junonis* will occur are areas of *Eucalyptus haemostoma* woodland and an understorey containing *Banksia ericifolia* or *B. serrata*. Nevertheless, it is still probable that *P. junonis* may be found in other parts of this vegetation community. The presence of *P. junonis* at Barnes Road (population 5) indicates that it is possible for *P. junonis* to occur in small patches of

remnant vegetation within grazed farmland. Such areas should not therefore be excluded from consideration as potential habitat.

Recent vegetation mapping in the Lower Hunter and Central Coast (NSW NPWS 2000) indicates that *Prostanthera junonis* habitat can be identified as occurring within areas mapped *"Map Unit 26 Exposed Hawkesbury Woodland"* and *"Map Unit 29 Hawkesbury Plateau Banksia Scrub"*. The data obtained from this project, in conjunction with a range of other biophysical factors, has been used to generate a predictive habitat model for *P. junonis.* The model is indicative only and is based on current understanding of the species' habitat requirements and distribution. Figure 5 displays this model. Further survey is expected to assist in understanding the fine scale distribution of the species.

Techniques for surveying in potential habitat are described in the Environmental Impact Assessment guidelines appended to the recovery plan (Appendix 2).

Figure 5 Predictive habitat model for *Prostanthera junonis.*



6 Biology and ecology

6.1 Source of information

There is a field of international experts who have carried out research in the family Lamiaceae. A volume of research and review papers about the Lamiaceae family was published by Harley & Reynolds (1992). However, there has been little research into the biology and ecology of the Australian members of the Lamiaceae. A taxonomic revision of *Prostanthera* section *Klanderia* (Conn 1984) provides some details, including the author's personal observations of the biology of the whole genus.

Tierney (1994, 1996) has carried out reproductive studies of *P. junonis*. These studies concentrated on aspects of pollination and propagation of the species, using the population at Raverson Close as the *in situ* study site and source of *ex situ* vegetative material. At the time of Tierney's study, the Raverson Close population occurred in a disturbed habitat and was the only known large population of the species. Given the subsequent discovery of new populations, it is inappropriate to assume that the information obtained from Tierney's results is characteristic of the whole species. Whilst forming a strong basis for future studies, this work should to be replicated and augmented in other populations.

6.2 Growth rate and longevity

Potted *ex situ* specimens of *P. junonis* appear to show a rapid growth rate, with the appearance of flowers after two years on plants grown from seed (Tierney, pers. obs.), however, the longevity of plants is unknown. Plants growing in both recently burnt and long unburnt areas have a range of plant sizes. Recruitment may be restricted to the immediate post-fire period (in common with many species in dry sclerophyll forest types) but the highly variable size structure exhibited by populations of all ages means that recruitment in the absence of fire cannot be ruled out. Vegetative reproduction (to whatever extent it is exhibited) further complicates determining the age structure and longevity of populations.

Adult plants within the Konda Road population have been observed growing in the understorey of dense tall *Banksia ericifolia* shrubland. These areas of shrubland have not been burnt for > 20 years and the soil underneath would have had little opportunity for disturbance. If plant recruitment is solely related to fire or soil disturbance, then it is possible that the plants growing in these areas date to the last episode of fire. While this is difficult to confirm, it provides some evidence that *P. junonis* may have longevity of at least 20 years.

6.3 Vegetative reproduction

Prostanthera junonis is stoloniferous/rhizomatous (Conn 1997, Tierney 1994, 1996) although to what extent is unknown. Tierney (1994) collected data on the occurrence of stolons between plants at the Raverson Close population by digging around clusters of plants to determine if they were clonal. Of the 153 plants tested, six plants were found to be connected and another 15 that were growing close to each other were suspected of being connected. Thus, that population was at least 14% clonal. The ability to reproduce vegetatively increases the chances for small isolated populations of the species to persist in the absence of proximate populations and/or recruitment from seed, at least in the short term (ie. for the longevity of the parent plant).

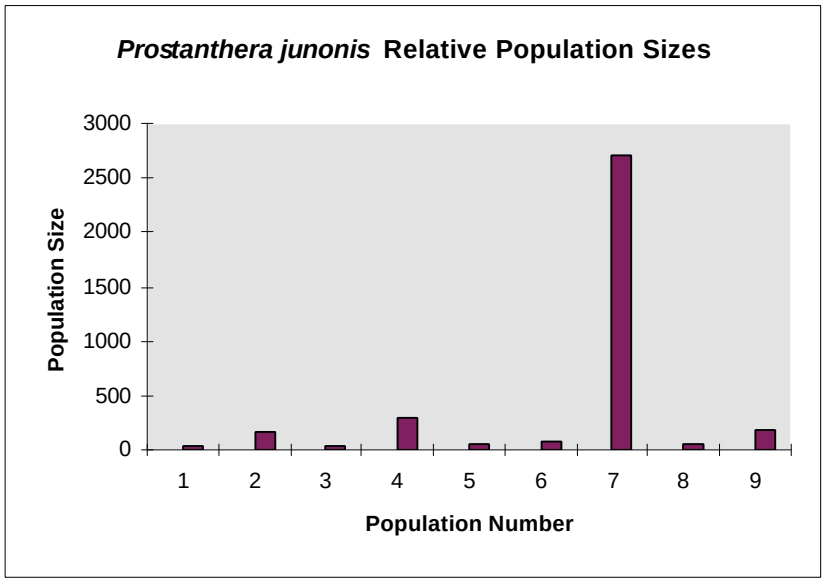
The Raverson Close population studied by Tierney (1994, 1996) has been severely degraded since its discovery, which may have affected its biological behaviour. Degradation has occurred as a result of slashing, development, clearing and soil removal. It is possible that this population has responded to stem removal by forming rhizomes. Clonal growth in *P. junonis* may therefore be one response to severe disturbance.

6.4 Population size and structure

6.4.1 Population size

Details regarding the size of *P. junonis* populations are included in Appendix 1. The total known population of *P. junonis* is estimated to be greater than 3200 plants, distributed over nine populations. Approximately 85% of the total population is restricted to one locality (population 7), with the remaining 15% of the total population spread throughout the eight other populations. These statistics highlight the vulnerability of the vast majority of the *P. junonis* populations, due to their relatively small size, and of the species as a whole. Figure 6 illustrates the relative size of populations known at the preparation of the recovery plan.

Figure 6. Relative population sizes of *P. junonis*



6.4.2 Age of populations

Determining the age of plants, and thus the age structure of a population, is sometimes possible using techniques such as measuring stem width (e.g. *Acacia* spp.) or some other measure of size such as the number of fruiting bodies along a stem (e.g. *Banksia* spp.). Size is calibrated with reference to populations whose age is known. In the case of *P. junonis* it is difficult to determine the age structure of a population. *P. junonis* is a small shrub and like many small understorey shrubs, the width of its stems does not appear to increase significantly with age. Its fruits are not persistent on the stems, and the overall size of the plant may be more related to site exposure and past disturbance rather than age. Further complications arise from the ability of *P. junonis* to grow from rhizomes. Tierney (1994) and Conn (1997) have suggested that the broader elliptic leaves (as opposed to the almost linear leaves) dominate on younger plants. In the older plants, these broader leaves are only persistent near the base of the plant.

Tierney (1994) investigated the effect of varying environmental conditions on plant growth. Plants growing in open conditions appear to be more compact and multi-branched in habit, whereas those growing in dense habitats had a more spreading and open habit. This phenomenon has been noted in other species within the Lamiaceae (e.g. *Westringia fruiticosa*, see Conn and Tozer 1993) and observed by the authors during field surveys for *P. junonis* (Tozer & Lacey NPWS, pers. obs.).

6.5 Reproductive biology

6.5.1 Breeding system

Of those species in the Lamiaceae whose breeding systems have been investigated, self-compatibility is a common feature (Owens & Ubera-Jimenez 1992). Tierney (1994) carried out investigations into the breeding system of *P. junonis* at the Raverson Close population. This trial consisted of the comparison of successful seed set in bagged flowers (to test self compatibility); flowers whose anthers had been removed (to test for apomixis i.e. the formation of seeds without pollination); and control flowers (flowers left open for pollination from all pollen sources). The results suggest that *P. junonis* exhibits a degree of self-compatibility, with 18.3 % of bagged flowers producing fruits. Greater fruiting success was observed in control (open pollinated) flowers (29.9 %). No fruit was produced in flowers whose anthers had been removed (0 %).

Tierney's (1994, 1996) studies show, therefore, that fruit set in *P. junonis* can result from both outcrossing and self-reproductive strategies. However, it is noteworthy that higher seedset was achieved by outcrossed flowers. The discovery that at least one *P. junonis* population consists partially of clonal plants increases the importance of understanding reproductive strategies in the species. A clonal population will generally have a lower degree of genetic diversity than the number of apparent individuals present, and is generally more vulnerable to reproductive failures and sudden changes in environmental conditions (eg. habitat degradation, introduction of disease).

6.5.2 Flowering season

Tierney (1996) reported that the Raverson Close population flowered throughout the year, but that 95% of the population was observed to be flowering during March. Whilst statistical data comparable to that of Tierney's has not been collected for other populations, the authors have observed the dominant flowering time to be October to mid-December (M.E. Tozer, NPWS, pers. obs.), with residual *P. junonis* individuals flowering until late January-early February (Lacey, NPWS, pers. obs.). Monitoring of tagged populations to replicate the data collected by Tierney is required to accurately determine peak flowering periods in *P. junonis.*

The timing and duration of flowering is likely to be influenced by the seasonal conditions of a particular year and the exposure of each particular site. Scattered flowers may be observed on plants throughout the year, as is common in many species of the Lamiaceae in the Sydney region. However, the presence of flowers is unpredictable, and searching for the species outside of the observed main flowering time is not recommended.

6.5.3 Pollination vectors

Conn (1984) reports that bees and wasps have been observed visiting flowers of several species of *Prostanthera* sect. *Prostanthera* (although no observations of *P. junonis* were made). Keighery (1980) further recorded 11 species of *Prostanthera* that were insect pollinated. Tierney (1996) has observed the introduced Honey Bee *(Apis mellifera)* foraging on flowers of *P. junonis*, however, its success as a pollinator in aiding reproduction of individual plants is unclear.

Self-pollination may or may not require the aid of a pollen vector. Tierney (1996) found that plants produced some seeds when inflorescences were bagged, which suggests that the species is capable of reproduction in the absence of a pollen vector. However, only 12% of seed collected from bagged (ie selfed) plants was viable. Given the extent of fruiting observed at several of the populations, it is unlikely that pollination failure is responsible for the rarity of the species.

6.5.4 Fruiting

The dry fruit (schizocarp) consists of four one-seeded nutlets (mericarp) formed within the persistent calyx. The lobes of the calyx enclose (but do not seal) the developing fruit, and the intact schizocarp generally falls from the shrub when mature. Tierney (1994) collected data on the success of fruiting in the Raverson Close population. Of 144 flowers observed, 50 % formed fruits. Plants in open areas were significantly more successful in forming fruits than plants in densely vegetated sites (64 % and 12 % respectively; $P < 0.05$).

6.5.5 Seed Bank

An understanding of the dynamics of the seed bank of rare species including fecundity, dispersal, predation, viability and germinability, is essential for predicting the species capacity for self-replacement and long-term viability.

Fecundity

There have been no empirical studies which document fecundity of *P. junonis* or any other *Prostanthera* species, however, field observations of *P. junonis* indicates that fecundity is likely to be linked to shading. That is, seed production appears to be greatest in open exposed sites, compared with plants occurring in denser habitats.

An understanding of fecundity (the quantity of seed produced) is important as it provides a picture as to the extent to which a population is reproducing. Obviously, the more seed which is produced, the more seed that can be dispersed, and probably, the larger amounts of viable and germinable seed available for recruitment. Although it is not always necessary to know exactly how much seed is produced, it is

important to know whether a population provides an input into the seed bank each year. This is particularly important in understanding the viability of small populations.

Seed dispersal

There have been no empirical studies that document the dispersal of seeds of *P. junonis* or seed of other species within the genus *Prostanthera*. Tierney (pers. obs.) has observed that seeds are dropped to the ground quickly after maturity. The *P. junonis* calyx is covered in oil-rich glands, and it is possible that the whole fruiting calyx is eaten by birds or other animals. The occurrence of this species in relatively discrete populations suggests that seed is not dispersed over large distances. Seed dispersal experiments carried out *in situ* may provide a greater understanding of the fate of seeds.

Seed predation

The level and impact of seed predation on *P. junonis* is not known. It is probable that at least some seed is lost though both pre and post-dispersal predation. An understanding of this component of the seed cycle may be important if it is shown, through studies on fecundity, that although large amounts of seed are produced, much of it does not make it through to the seed bank, and thus is not available for regeneration of a population.

Seed viability and longevity

Tierney (1996) studied seed viability and longevity of *P. junonis* at the Raverson Close population. Freshly harvested seeds were found to vary in viability (10 % - 70.8 %) with a mean of 35.8 %. After 12 months of storage, the seeds were found to be non-viable. The loss of viability after 12 months may be explained by the soft-coated nature of *P. junonis* seed (Tierney, pers. obs). Alternatively, it is possible that the storage conditions and/or sample size (six plants) influenced the results. Further trials sampling from several populations would provide a more representative view of seed viability exhibited by the species as a whole.

Seed longevity trials incorporating storage *in situ* are required to gain an indication as to the fate of seed under natural conditions. *Ex situ* trials should also be repeated so as to validate Tierney's earlier findings, as well as to gauge the usefulness of the seed for long term germplasm storage.

Seed germinability and dormancy breaking mechanisms

Prostanthera seeds possess a dormancy mechanism, which is poorly understood (Jusaitus 1991). Tierney's (1996) seed experiments indicated that the level of seed germination in *P. junonis* was low. Trials were carried out which compared the rates of germination of seeds treated with smoke, gibberellic acid (GA) and water. Chemical constituents of smoke have been found to stimulate germination in a range of species (Brown and van Staden 1997). To test for a response to smoke, seeds are watered with a solution of water infused with smoke. GA is part of a group of plant growth hormones, which stimulate germination. It is thought that exposure to light stimulates the formation of GA, thus treating seeds with GA simulates a light response (Tierney 1996).

Tierney (1996) found that seeds treated with GA only, smoke only and both GA + smoke all exhibited higher germination than those that were treated only with distilled or buffered water (13-15 % compared to 5% germinated after 15 days). No significant effect was detected between the three treatments (GA, smoke, GA+ smoke). These results indicate that the seeds of *P. junonis* exhibit some dormancy, which is possibly broken by exposure to smoke and light. It is also possible that the seeds of *P. junonis* may germinate in response to heat (a treatment which has not been tested) or some interaction between smoke, light and heat, as has been demonstrated in other fire prone species (Keith 1997b, Enright *et al.* 1997).

Many of the species occurring in sclerophyllous habitats have a dormant seed bank that is stimulated by smoke or heat associated with bushfires. This ensures that seeds germinate at a time when conditions are conducive to seedling establishment. In this context, a loss of viability of *P. junonis* seed within 12 months (as indicated by Tierney 1996) is unusual for a species occurring in a fire-prone environment. The result may be explained by a low level of replication in Tierney's (1996) studies, with seeds collected from only 10 plants (4-13 seeds per plant per treatment) and the large amount of variation in germinability that was encountered between plants. Alternatively, seeds may enter secondary dormancy (P. Adam, NSW Scientific Committee pers. comm).

If Tierney's (1996) results are confirmed, and seed viability is indeed lost after 12 months, the complete removal of the above-ground population (eg. by fire) could result in local extinction if conditions for seedling establishment did not arise within 12 months, or if the disturbance occurs before seed was set but after the length of time when seed loses its viability. Given the habitat in which the plant occurs, this would appear to represent a precarious reproductive strategy, which is complicated by the consequences of potentially low levels of genetic diversity in a population resulting from clonal growth (see above).

Further validation of Tierney's (1996) results incorporating samples from additional populations should be undertaken to confirm the results. A comprehensive seed germination experiment should investigate the role of and interaction between various dormancy triggers (the comprehensiveness however will depend on the amount of seed available). Further investigation of germination cues will contribute

to understanding the conditions and circumstances that are needed to promote regeneration of this species. This will become particularly relevant to those populations that are found within isolated vegetation remnants (such as the Barnes Road population) and may require artificial habitat manipulation.

6.5.6 Seedling recruitment

It is expected that natural disturbance regimes are the trigger for seedling recruitment in *P. junonis*. However, given the uncertainties in estimating population structure, it is difficult to determine if recruitment occurs only after disturbance or if there is a continual addition of plants to a population.

The results of Tierney's (1996) seed trials indicate that seeds germinate in response to smoke and possibly light (through the application of GA). This implies that recruitment will probably occur in response to fire, and also in response to soil disturbance which exposes the seeds to light. It must be noted, however, that only low levels of germination occurred.

Populations 4 (Gindurra Road) and 7 (Reservoir Road) were both burnt in 1994. Populations at both sites are relatively dense and individuals show no signs of having resprouted following fire (such as dead, burnt stem bases). Therefore, it is considered likely that these populations are the result of post-fire recruitment of seedlings.

Recruitment in response to soil disturbance has possibly occurred at Raverson Close (population 2) following bulldozing of the vegetation. In addition, populations 3A, 6, & 9, contain individuals that are found along the track-sides, possibly indicating that germination occurred in response to track side disturbance.

6.6 Fire Ecology

The exact response of *P. junonis* to fire is unknown. Adult plants lack obvious mechanisms to survive and resprout after fire (such as lignotubers) and thus are likely to be killed by fire, although there has been no empirical data collected to confirm this. No evidence was found of resprouting in sites that had been relatively recently burnt. Other *Prostanthera* spp. have been reported to be killed by fire (eg. *P. lasianthos* and *P. spinosa*, A.M. Gill. pers. comm.), and as being capable of resprouting in some situations (eg. *P. linearis*, Benson & McDougall 1997).

As described above, there is some evidence that seed dormancy may be broken by smoke. However, there is some uncertainty as to the occurrence of a perennial soil seed bank. A species which does not resprout after fire and lacks a persistent seed bank would be very unusual, and would make it vulnerable to local extinction after a

fire event. Recruitment after fire would depend solely on the viable fraction of the previous season's seed output.

Burning trials and further studies into the seed ecology of the species are required before firm conclusions can be reached as to the response of *P. junonis* to fire. Until more information is known about the fire response of *P. junonis*, the general guidelines for fire management of sandstone communities should be followed (described in Appendix 3).

6.7 Summary of known biology and ecology

P. junonis is a small shrub species with its dominant flowering period (seasonally dependent) between October and mid-December. The seeds of *P. junonis* germinate in response to light and smoke and it is likely that recruitment is linked to natural disturbance such as fire. The occurrence of populations of the species adjacent to fire trails suggests that favourable light conditions as a result of reduced vegetative competition may also promote recruitment. Precise fire ecology is unknown.

Preliminary studies into the species' reproductive biology by Tierney (1994, 1996) indicate that *P. junonis* is capable of surviving by utilitising both outbreeding and self-pollination syndromes. Higher seedset and viability resulted from outcrossed seeds, however, selfed seeds have also been shown to be viable. Thus, self-pollination and clonal growth may be a bet hedging response of the species in circumstances of severe disturbance, whereby, if outcrossed pollen is not available, plants can continue to produce offspring (see for example, Krauss 1994).

These studies provide a strong foundation for future research, however, there remains substantial uncertainties in relation to key aspects of the plant's basic biology and ecology which require further investigation for the application of successful *in situ* habitat management actions.

7 Previous management actions

7.1 Recovery Team

A recovery team for *P. junonis* was established in October 1997.

The team consists of:

National Parks and Wildlife Service:	Threatened Species Unit & ; Central Coast & Hunter Ranges Region, Central Directorate.
Royal Botanic Gardens Sydney:	Mt Annan Botanic Garden; National Herbarium of NSW
Gosford City Council:	Environmental Control and Planning
Environment Australia:	Threatened Species & Communities Section

Consultation about the protection and management of *P. junonis* has also occurred with Wyong Shire Council, the Department of Land and Water Conservation, NSW State Forests and private landholders during the preparation of this plan.

7.2 Survey

7.2.1 Threatened species assessment of the Somersby Industrial Park

During late 1996 Gosford City Council commissioned a flora and fauna assessment of the Somersby Industrial Park (AMBS 1997). The final report details the known distribution of *P. junonis* (and other threatened species) and areas of potential habitat within the Industrial Park. The results of this report have been passed on to the landholders of the Industrial Park. Whilst the report is instructive for identifying potential habitat, it should not be relied upon as a definitive review of the location of the species across the Industrial Estate.

7.2.2 Threatened species review

The NPWS conducted a threatened species review of *P. junonis*, which was completed in April 1997 (Payne 1997). This review gathered information about known localities of *P. junonis* across its whole distribution, and provided a starting point for further survey.

7.2.3 Targeted survey

To further investigate the distribution of *P. junonis*, targeted survey has been carried out on the Somersby Plateau by the NPWS during each spring since 1997. The surveys have so far concentrated mainly on the eastern extremity of the Plateau. These surveys identified two additional populations, and expanded the extent of four of the previously known populations. Preliminary surveys of the western Somersby Plateau (eg Popran National Park, by S. Bell in 1998, NPWS in 1998) have failed to locate the species there, despite the presence of apparently comparable habitat conditions.

The methodology employed in the targeted survey is limited, as it does not conclusively determine the absence of the species in a certain area. The method aims to sample areas of vegetation, by searching along random meander transects (Given 1994). The benefit of this technique is that diverse and expansive areas of vegetation can be sampled during the same flowering season. However, the intensity to which a single area is searched is reduced.

7.3 Biological research

As outlined in section 6, Tierney (1994, 1996) has undertaken some biological research.

7.4 Propagation

The Royal Botanic Gardens, Sydney have carried out some emergency salvage of plants from the Raverson Close population. Seeds and cutting material were taken from the site. Details of the current holdings are as follows: of the 23 clones collected, seven failed in propagation, five failed during initial propagation and 11 clones have been maintained (a clone consists of cuttings taken from one plant, thus their genetic identity is the same). Sixteen plants from two clones were planted into the garden beds at Mount Annan, and all have failed to survive (G. Errington, Mount Annan Botanic Garden, pers. comm.).

7.5 Environmental assessment

7.5.1 ***Environmental Planning & Assessment Act*** 1979 (NSW)

Prostanthera junonis has been the subject of several environmental assessment documents prepared in association with development applications lodged in accordance with the EP&A Act 1979 (NSW). The environmental assessment

process has resulted in several outcomes for the future management of *P. junonis* populations on private land. These outcomes are summarised in Table 3.

Table 3. Summary of development assessment outcomes for *P. junonis*

POPULATION	CONSENT AUTHORITY	MANAGEMENT OUTCOME
2. Raverson Close	Gosford CC	• fencing of individuals, management plan & monitoring (Lot 1); • individuals excluded from development footprint (Lots 1, 6) but subsequently destroyed*; • 5m building setback to retain plants in vegetative buffer (Lot 7); but subsequently destroyed*.
4. Gindarra Road	Gosford CC	• development application (DA) for caravan park refused, 1995
5. Barnes Road	Wyong SC	• re-configuration of development footprint to exclude population, consent condition requires preparation and implementation of threatened flora management plan.
6. Mangrove Tower+	Gosford CC	• DA for rural subdivision resulted in a grazing exclusion area for the protection of *P. junonis* population.
7. Reservoir Road	Gosford CC	• DA for quarrying adjacent to *P. junonis* population, consent condition requires preparation and implementation of a site management plan and monitoring of the population.

* *P. junonis* individuals occurring on Lots 6 & 7 appear have been destroyed despite consent conditions requiring their protection.
+ The NPWS is aware that a proposed quarry for the site is currently undergoing Environmental Assessment by the property owner.

7.5.2 Forestry Licence - *Forestry and National Park Estate Act* 1998 (NSW).

In September 1999, the Integrated Forestry Operations Approval (IFOA) for the Lower North East Region was granted under Part 4 of the *Forestry and National Park Estate Act* 1998 (NSW). This approval covers areas of State Forest Estate in which *P. junonis* may occur (eg. Ourimbah, McPherson and Strickland State Forests) and includes several conditions for the protection of threatened flora. Where *P. junonis* is detected within a compartment to be harvested, or within 50m of the boundary of the compartment, condition 6.22 of the Threatened Species Licence requires the following:

(a) An exclusion zone of at least 50 metres radius must be implemented around all individuals;

(b) An exclusion zone of at least 50 metres wide must be implemented around all groups of individuals. A group is defined as more than one individual located less than 20 metres apart.

As an alternative to this condition, the Threatened Species Licence states that State Forests NSW may choose to develop a Species Management Plan. The Species Management Plan must be submitted in writing for approval by the NPWS prior to its implementation.

7.6 Fencing

The Wiseman's Ferry Road population (1) occurs on a vacant lot in the Somersby Industrial Estate and has been degraded (principally rubbish dumping and weed invasion) through unrestricted access. The recovery team identified this as a threat to the habitat and population of *P. junonis* that occurs there. In response, Gosford City Council fenced the site to restrict access in February 1998. Monitoring by NPWS in November 1999 indicated that the fence remained in tact but that the site is subject to illegal collection of native flowers (eg. *Banksia* spp.).

8 Management issues

The following sections identify the current understanding and/or limitations of the biology and ecology of *P. junonis*, outlines the threats operating on the known populations, and considers the social and economic factors that have an ability to affect the success of the recovery program. Translocation is another issue that is often raised in relation to the management of threatened species, therefore section 8.4 provides a discussion of this with respect to *P. junonis*.

8.1 Understanding of biology and ecology

As outlined in section 6, there are significant gaps in our understanding of the biological and ecological functioning of *P. junonis*. The most significant is a lack of knowledge of the seed bank. Active site management (particularly of isolated remnants) would be greatly assisted with improved understanding of the conditions required for recruitment.

The preliminary targeted survey (carried out in Spring 1997) has significantly increased our understanding of the ecology of *P. junonis*. The limited number of known populations before the survey provided only a narrow view of the niche preference of *P. junonis.* Additional survey will help to further define the ecological requirements of *P. junonis* which will assist in managing known populations and their habitats, and further refine the prediction of potential habitat and thus the protection of additional (currently unknown) populations.

8.2 Threats and reasons for decline

Development, and various types of disturbance threaten populations of P. junonis. Table 4 summarises the processes currently threatening each of the known populations. These disturbances and threats are described in more detail below. As new sites are located or as land use changes at the known sites, new disturbances and threats may arise. The management of *P. junonis* must address these threats.

Table 4. Disturbance and threats to the *P. junonis* populations.

POPULATION	DISTURBANCE AND THREATS
1. Wiseman's Ferry Road	access related habitat degradation, weed invasion, isolation and inappropriate fire regime, development
2. Raverson Close	access related habitat degradation, weed invasion, vegetation clearing, adjacent development, development
3. Reeves Road	access related habitat degradation, weed invasion, fire control activities
4. Gindurra Road	access related habitat degradation, weed invasion, fire control activities, development, vegetation clearing
5. Barnes Road	isolation and lack of fire disturbance, weed invasion, up-slope processes
6. Mangrove Tower	access related habitat degradation, vegetation clearing, development
7. Reservoir Road	access related habitat degradation, up-slope processes, development, vegetation clearing, weed invasion
8. Silvesters Road	access related habitat degradation, fire control activities
9. Konda Road	access related habitat degradation, fire control activities, weed invasion

8.2.1 Habitat loss

The principal threat to *P. junonis* populations is further habitat loss as a consequence of vegetation clearing and development on the Somersby Plateau.

Vegetation clearing

As none of the populations occurring on private property currently have formal protection mechanisms, they are all vulnerable to vegetation clearing. The known habitat of *P. junonis* occurs at the rural-urban fringe where active development is occurring. Perceived constraints on potential development caused by the TSC Act 1995 (NSW) has frustrated many landholders in the area, and there have been frequent occurrences of unauthorised vegetation clearance including known and potential habitat sites for *P. junonis*. Clearing of known and potential habitat of *P. junonis* will have an impact on the long-term viability of the species.

Development

Five of the nine populations have been either directly or indirectly affected by development (see 7.5 above). A further three populations (populations 1, 2 & 6) are likely to be subject to development within the next 1-5 years. Consent conditions placed on previous approved development applications to protect populations of *P. junonis* have had mixed success (see Table 3). Although development has not yet knowingly resulted in the complete removal of any of the *P. junonis* populations, the cumulative impacts of development and long term indirect impacts of habitat loss, fragmentation and degradation remain a serious concern for this species.

Despite the discovery of a large population of *P. junonis* in Brisbane Water National Park, the species remains inadequately conserved across its range.

8.2.2 Habitat degradation

In addition to habitat loss, various pressures are currently operating on the *P. junonis* populations, which may affect their long-term viability as a consequence of habitat degradation. These include impacts from adjacent development, fire control activities, unrestricted access, rubbish dumping and weed invasion.

Adjacent development

Adjacent development, particularly up-slope, has the potential to impact on the habitat of *P. junonis* depending on the size, position and proximity of the disturbance. Quarrying and intensive agriculture (such as poultry farming) are two forms of adjacent development occurring in the vicinity of known populations of *P. junonis*.

Adjacent development can significantly alter overland flows and thus impact on adjacent habitat through intensified runoff (leading to erosion canals), increased sediment loads, or in some cases, the diversion of the natural flow of water. Soil erosion and siltation are processes very likely to disrupt the life cycle of *P. junonis*, particularly in relation to a soil-stored seed bank.

Waste management practices associated with intensive agriculture may cause impacts through high nutrient levels contained in runoff. Increase in soil nutrients is likely to have a detrimental impact on the species that comprise the habitat of *P. junonis* and increase the likelihood of successful weed establishment. Building construction on land adjacent to known populations can lead to shadowing, and the interruption of natural processes such as water flow, sediment movement, seed dispersal, and/or movement of pollination vectors. It is unknown to what extent this will impact on the viability of *P. junonis* populations.

Fire management related to adjacent development can lead to the degradation of *P. junonis* and its habitat. Fire management for the protection of life and property often involves the maintenance of fuel free or fuel reduced zones. When land is developed next to populations of *P. junonis*, fire management is a key issue. Fuel-free or reduced zones are often maintained by the reduction in vegetative material in the understorey. As *P. junonis* occurs in the understorey, groups of plants may be easily harmed or destroyed during hazard reduction activities.

Impacts from adjacent development can to some degree be mitigated through pre and post development ameliorative measures, however the extent to which this is possible and the nature of measures used will depend on site specific considerations (eg. nature of development, topography etc).

Fire control activities

Given the occurrence of *P. junonis* along access tracks and property boundaries, there is great potential for populations to be disturbed or destroyed by fire control activities. Populations 7 & 8 have previously had fire control lines placed in their immediate vicinity during wildfires in 1994. Hazard reduction involving bulldozing of areas adjacent to property boundaries may lead to degradation of populations. The construction of control lines during emergency situations may also lead to population destruction. Hazard reduction activities may involve frequent fuel reduction burns; the impact of which is unknown for *P. junonis*. Frequent fire regimes have been shown to be detrimental to biodiversity and is currently listed as a key threatening process in Schedule 3 of the TSC Act 1995 (NSW).

Unrestricted access and rubbish dumping

Uncontrolled site access has lead to the degradation of several of the populations. Rubbish dumping, vegetation crushing, and track widening have lead to habitat degradation. Several of the sites have extensive unofficial tracks through them, which leaves *P. junonis* vulnerable to degradation and possible destruction of plants. In addition, the Great North Walk passes through and near populations of *P. junonis.*

Weed invasion

Weed invasion is a symptom of habitat degradation. Weeds can take the place of other species in the habitat (particularly in the understorey) and eventually change the nature and function of that habitat to the detriment of the species that occur there. Weed invasion is apparent at several of the sites, although at current levels of invasion, they do not require remedial action. Some of the subpopulations at population 7 occur directly downslope of a poultry farm and are suffering from invasion of *Senecio madagascarensis* (fire-weed) and *Andropogon virginicus* (Whiskey Grass). A large area of weed infestation occurs within 10 m of the

Gindurra Road population. The Raverson Close population has been severely degraded and exotic grasses were introduced to provide soil stabilisation.

8.2.3 Inappropriate fire regime

While the precise fire ecology of *P. junonis* is currently unknown, high frequency fires in particular are likely to operate to the detriment of this species. Additional fire research should identify an appropriate fire regime for the species. Fire is a natural disturbance for the sclerophyll woodland in which *P. junonis* occurs. Most of the component species of *P. junonis* habitat require fire for regeneration. After a significant period without fire (>30 years) those plants may begin to senesce without regeneration, including *P. junonis.* The occurrence of the species in long unburnt patches of *B. ericifolia* woodland indicates that it is capable of persisting in these areas, however population numbers appear to be extremely low.

8.2.4 Plant pathogens: *Phytophthora cinnamomi*

Susceptibility of the *Prostanthera* genus to pathogenic organisms such as *Phytophthora cinnamomi* and rootknot nematodes is well documented (eg. Canberra Botanic Gardens 1977; R. Miller, pers. comm.). Such organisms are readily introduced in infected soil or are waterborne. Therefore road and track construction, vehicular access, vegetation clearing, development and adjacent development, drainage works and high levels of visitation are all high potential sources of infection. It will be essential that future environmental impact assessment address this threat to the species by maintaining sufficient vegetative buffer zones and strict controls on site access.

8.3 Social and economic considerations

8.3.1 Biodiversity value

Conservation of areas where *P. junonis* occurs provides habitat for all species occurring in the same community. This is particularly important for species that are under-surveyed or unknown to science. Management of the *P. junonis* populations will provide opportunities for the protection of other rare and threatened flora species, including:

- *Tetratheca glandulosa* (Sch 2 TSC Act 1995), which occurs with *P. junonis* at the Barnes Road population (5);
- *Eucalyptus camfieldii* (Sch 2 TSC Act 1995), which occurs with *P. junonis* at the Mangrove Tower population (6); and
- *Darwinia glaucophylla* (ROTAP 2RCi), a regionally significant species which occurs with *P. junonis* at the Wiseman's Ferry Road population (1).

8.3.2 Social considerations

The conservation of areas of habitat in which *P. junonis* occurs provides for the preservation of some of the remaining plateau top vegetation remnants. These areas provide scenic beauty, which provides tourist attraction to the benefit of local businesses. The route of the Great North Walk, which passes through some of the known *P. junonis* habitat, is enhanced by the conservation of these areas.

8.3.3 Economic considerations

The economic consequences of the implementation of the recovery plan of *P. junonis* are related to the direct and indirect costs. The direct costs are from further survey and research, further liaison with landholders/managers, and studies into the biology and ecology of the species. Some costs will also be involved in the maintenance of an off-site seed store for germplasm storage, if required.

The indirect costs associated with the implementation of this recovery plan may lead to changes in the future development of areas on the Somersby Plateau. Future development may need to be reconfigured to accommodate the conservation of the species at sites where *P. junonis* is known to occur, and in areas of potential habitat where new populations may be found. To some degree, these costs can be mitigated through prior strategic planning measures, and effective cooperation between the community and public authorities.

8.4 Translocation

Translocation is defined as "the deliberate transfer of plants or regenerative plant material" (ANPC 1997), and has been raised as a potential ameliorative measure for several of the sites where populations of *P. junonis* are threatened by proposed development. At this stage, translocation is not considered necessary for the survival of the species or appropriate given the current lack of biological knowledge. It is usually only considered when a conservation outcome is vital to the survival of the species. In addition, the means by which to carry out translocation through propagation are doubtful.

Details regarding the process of translocation are provided in the "Guidelines for the Translocation of Threatened Plants in Australia" published by the Australian Network for Plant Conservation (ANPC) (1997). In general, the process of translocation is lengthy, expensive, prone to failure and involves long term commitment. The steps involved include: biological assessment (population biology, assessment of genetic variability and propagation potential); ecological assessment (identification of potential sites and their suitability); logistical assessment (staff requirements, financial commitment); site preparation (removal of threats); establishment of *ex situ* collection (propagation and long term management of representative individuals); experimental trials; long term trials involving short and

long term site management; and monitoring and management of the translocated individuals.

Previous attempts at translocating threatened flora have often failed due to the unsuitability of recipient sites, poor information in relation to species biology, ecology and genetic variation, and a lack of ongoing commitment to maintenance and monitoring. Translocation of *P. junonis* is not recommended due to the failure of previous attempts, poor information on the species biology and ecology, and the significant risks of introducing pathogens from a nursery environment to a recipient site.

8.5 Ability to recover

8.5.1 Species rarity

P. junonis is considered a threatened species due to its narrow distribution consisting of only nine populations and that all populations are subject to either immediate or long term threat. The number of populations is likely to have been historically decreased through loss or modification of habitat on the Somersby plateau.

8.5.2 Species viability

The overall objective of the recovery plan encompasses the concept of maintaining the viability of populations of *P. junonis*. Broadly speaking, a viable population is one that is successfully self-replacing in the wild. That is, it consists of reproductive individuals that produce germinable seed, that seedlings establish from this seed under natural conditions, and that these seedlings mature to reproductive adults, which produce germinable seed, and so on into the future.

There is currently little information as to the viability of the known populations of *P. junonis*. Although seed set has been observed, the extent to which this seed is germinable and survives in the habitat is unknown. Despite this uncertainty, populations of *P. junonis* should be assumed to be viable unless there is clear evidence to the contrary.

8.5.3 Likelihood of recovery

Prior to the preparation of this recovery plan, *P. junonis* was considered one of the most endangered species in NSW. The most significant population (2) was threatened by industrial development, and the other known populations were small and had no conservation security. The long-term viability of this species was in doubt.

Targeted survey for the recovery plan revealed additional populations occurring in Brisbane Water National Park and lands of other public tenure. Although the distribution of *P. junonis* may have been affected by historical vegetation clearing in the Somersby area, the degree to which *P. junonis* is endangered has been lessened by the location of additional populations in conservation reserves. It must be stressed, however, that *P. junonis* remains inadequately conserved, as the reserved populations only occur in one part of its range. The protection of all populations across the species' entire range is essential to ensure persistence of *P. junonis* in the event of catastrophic human induced and/or natural disturbances to the Brisbane Water National Park population (and other public land populations) and to maintain the species' likely genetic diversity.

Given these circumstances, the aim of the actions in this recovery plan are focused at protecting and maintaining known populations, rather than actions which are directed at manipulating an increase in population size utilising *ex situ* material. Natural regeneration and dispersal will be encouraged through habitat management, including appropriate fire regimes and protection from degradation. Artificial habitat manipulation may be required some time in the future at sites which occur in isolated vegetation remnants, however, there is currently inadequate information to make definitive management recommendations. Research into the species will be directed towards achieving practical outcomes for habitat management.

The consequences of not implementing the recovery program as outlined in the plan is to maintain the high risk of extinction in the wild over the next 10-20 years. A key criteria for success of the recovery program will be to secure the support and cooperation of public land managers and private landowners on the Somersby Plateau to implement a range of conservation measures for the species.

9 Overall recovery aim and recovery strategy

9.1 Overall recovery objective

The overall objective of the recovery plan is to identify policies and programs which protect and conserve *P. junonis* and which reduce the risk of extinction of the species.

9.2 Overall recovery performance criteria

The overall performance criteria of the recovery plan is that the risk of extinction of *P. junonis* is decreased, through the implementation of recovery actions to protect the known populations.

9.3 Individual objectives, criteria and actions

Recovery objectives

Specific objectives of the recovery plan are to:

- ensure that *P. junonis* populations are not destroyed as a consequence of habitat loss, and that an increased level of security is provided over lands which support *P. junonis* populations. (Reservation/Conservation status of populations);
- minimise the risk of *P. junonis* populations from declining in the long term through encouraging the implementation of appropriate threat and habitat management practices (Threat and habitat Management);
- establish the full extent of the distribution of *P. junonis* (Survey);
- ensure the management of *P. junonis* habitat is informed by essential aspects of the species' biology and ecology (Biological Research);
- determine whether a declaration of critical habitat for *P. junonis* will provide greater protection for the species than which currently exists (Critical habitat);
- understand the requirements for safeguarding genetic diversity of *P. junonis* for the purpose of reintroduction, following the extinction or irreversible decline of natural populations (*Ex situ* Conservation); and
- raise awareness among the broader community about the conservation status of *P. junonis* and to involve the community in the species' recovery program (Education/Awareness and Involvement).

Performance criteria

Specific performance criteria are that:

- all viable populations of *P. junonis* are maintained *in situ*;
- all viable populations of *P. junonis* are managed to ensure that factors detrimentally affecting the species are reduced to a level that is unlikely to compromise the recruitment and survival of populations;
- potential habitat is surveyed and a greater understanding of the plant's habitat is known, documented in relevant databases and communicated to relevant land managers;
- a greater understanding of *P. junonis* biology and ecology is achieved through targeted research, and management strategies are informed by research outcomes;
- critical habitat is assessed as a management option for *P. junonis;*
- the most effective and efficient method of storage of *ex situ P. junonis* material is investigated and understood and, if necessary, an *ex situ* program is implemented;
- information is disseminated to the community, in particular private landholders, of the conservation status and management issues affecting *P. junonis* and its habitat; and the community is actively involved in key aspects of the recovery program.

Recovery actions

The recovery plan consists of seven specific objectives, which aim to achieve the overall recovery objective. Each of these objectives has a series of specific supporting actions, which identify the agency responsible for implementation and a timeframe in which the action will be completed (see implementation schedule). Recovery actions will be directed towards:

- securing protection of populations of the species from habitat loss;
- habitat management initiatives, involving the storing and communication of site locations, consideration of development applications and environmental assessment guidelines, fire management, and site specific management actions;
- targeted survey to determine the extent of known populations and whether there are new undiscovered populations;
- undertaking research which investigates key attributes of the species' biology relevant to management;
- assessing the appropriateness and feasibility of declaring critical habitat for the species;
- investigating the requirements for *ex situ* storage, if required; and
- greater community involvement in the recovery program for the species.

10 Reservation/Conservation status of populations

Seven of the nine populations of *P. junonis* occur on land tenures (public and freehold lands) that are not primarily managed for conservation objectives. Populations which occur on such lands are subject to threat from habitat loss (eg. vegetation clearing) and habitat degradation (eg. weed invasion). In order to ensure that these populations are protected and managed in the long term, it is essential that the NPWS undertake to negotiate protection arrangements to increase the security of *P. junonis* habitats.

10.1 Reservation/Conservation status objective

To ensure that *P. junonis* populations are not destroyed as a consequence of habitat loss, and that an increased level of security is provided over lands which support *P. junonis* populations.

10.2 Reservation/Conservation status criteria

All viable populations of *P. junonis* are maintained *in situ* (see assessment guidelines for definition of a "viable population".

10.3 Reservation/Conservation status actions

Actions to increase the conservation status of *P. junonis* populations include:

1 Liaison with public authorities

The NPWS will liaise with public authorities responsible for managing *P. junonis* populations on public lands, and discuss options for increasing the level of legislative protection of those lands. In order to give effect to this action, the NPWS recognises that there are several legislative mechanisms, including joint management agreements, property management plans, and NPWS acquisition among others.

2. Liaison with private land holders

The NPWS will liaise with private landholders to emphasise the conservation significance of populations of *P. junonis* occurring on or adjacent to their properties. The NPWS will seek to secure sympathetic management of *P. junonis* habitat by private landholders. In order to achieve greater protection of populations on private land, the NPWS recognises that there are a variety of measures which may be implemented (eg. property management plans, voluntary conservation agreements),

and that the precise nature of management arrangements will depend largely on the circumstances and cooperation of private land holders.

3. Environmental planning instruments

Gosford City Council and Wyong Shire Council will ensure that the contents of this recovery plan are considered during the preparation of Environmental Planning Instruments under Part 3 of the *Environmental Planning and Assessment Act* 1979 (NSW).

4. Regional Vegetation Management Plan - Central Coast Region

The NPWS will negotiate with the Central Coast Regional Vegetation Management Committee to implement appropriate vegetation clearing controls for known *P. junonis* populations. In order to give effect to this action, the NPWS will ensure that:

- information regarding the location of known populations of *P. junonis* will be lodged with the Central Coast Regional Vegetation Management Committee;
- a copy of this recovery plan is forwarded to the Central Coast Regional Vegetation Management Committee; and
- the NPWS representatives on the Regional Vegetation Management Committee negotiate effective controls on vegetation clearing in areas containing known populations of *P. junonis* and the species' potential habitat.

11 Threat and habitat management

Threatened species are best managed in the long term when conserved in their natural habitat. This is termed *in situ* conservation and involves the combination of long term strategic planning initiatives and short term direct on ground actions to ameliorate actual and potential threatening processes. Habitat management actions in this recovery plan are directed towards the protection of populations on both public and private land. Actions include minimising disturbance which results from track maintenance and fire management activities, securing sympathetic management by private landholders, and ensuring that public authorities have knowledge of the exact position of plants so as to avoid future impacts. The ultimate goal of this suite of actions will be to encourage positive management of *P. junonis* populations and their habitat.

The public authorities involved in the implementation of this action include the National Parks and Wildlife Service, Gosford City Council, Wyong Shire Council and the Department of Land and Water Conservation. In addition, there are several *P. junonis* populations on private land.

11.1 Threat and habitat management objective

To minimise the risk of the *P. junonis* populations from declining in the long term through encouraging the implementation of appropriate threat and habitat management practices.

11.2 Threat and habitat management criteria

All viable populations of *P. junonis* are managed to ensure that factors detrimentally affecting the species are reduced to a level that is unlikely to compromise the recruitment and survival of populations (see assessment guidelines for definition of "viable population").

11.3 Threat and habitat management actions

There are several habitat management issues that need to be addressed. These are outlined below.

1. Permanent record of *P. junonis* populations

The NPWS, Gosford City Council, Wyong Shire Council, and Department of Land and Water Conservation will maintain a permanent record, in an appropriate data

retrieval system, of the exact location of *P. junonis* populations occurring on lands under their management control.

The purpose of maintaining this record is so that the *P. junonis* populations can be given due consideration in relation to future activities such as routine maintenance activities, preparation of plans of management, hazard reduction activities, and emergency fire situations.

2. Section 149 Certificate notification of *P. junonis* populations

s149 Certificates are issued by Local Government in accordance with the EP&A Act 1979 (NSW) and include advice on relevant matters which affect each parcel of land within the local government area.

Gosford City Council and Wyong Shire Council will ensure that an appropriate notation is placed on Council's respective s149 Certificates for each parcel of land on which *P. junonis* is known to occur. Where necessary, the NPWS will assist in identifying the location of *P. junonis* in relation to cadastral boundaries.

If new populations of *P. junonis* are located, Gosford City Council and Wyong Shire Council will amend the relevant s149 Certificates as to the occurrence of *P. junonis* (or other threatened species) on the parcel of land and update their relevant data retrieval system.

3. Submission of new information to the NPWS

If new populations are discovered, Gosford City Council, Wyong Shire Council and the Department of Land and Water Conservation will submit Wildlife Data cards to the NPWS for entry into the NPWS Atlas of NSW Wildlife. The NPWS will ensure that new locality information is distributed to relevant public authorities.

4. Notification of *P. junonis* populations to field staff

Gosford City Council will ensure that relevant sections within Council will be informed as to the location of the known populations managed by Gosford City Council, prior to the implementation of onground maintenance works in *P. junonis* habitat.

The Department of Land and Water Conservation will ensure that field staff who maintain The Great North Walk are familiar with the locations adjoining the track where *P. junonis* has been found, and are able to identify the species in the field.

The NPWS will ensure that relevant sections within the Service will be informed as to the location of the known populations managed by the NPWS, prior to the implementation of onground maintenance works in *P. junonis* habitat.

5. Consideration of development applications and rezonings, and assessment of activities

Gosford City Council and Wyong Shire Council will ensure that searches for *P. junonis* are carried out by development proponents prior to assessing development applications and/or rezoning applications in areas of potential *P. junonis* habitat. Surveys should be undertaken by a suitably qualified botanist, or person experienced in vegetation surveys, in accordance with techniques described in Appendix 2 and during the main flowering period (October-December).

The NPWS, Gosford City Council, and Wyong Shire Council will ensure that development applications and applications for rezonings under Parts 3 & 4 of the EP&A Act 1979 (NSW), are considered with reference to this recovery plan and any future advice from the NPWS regarding the distribution and biology of the species.

The NPWS, Gosford City Council, Wyong Shire Council, and the Department of Land and Water Conservation will ensure that the assessment of activities under Part 5 of the EP&A Act 1979 (NSW) (including road/track maintenance) is undertaken with reference to this recovery plan, and any future advice from the NPWS regarding the distribution and biology of the species.

6. Environmental impact assessment guidelines

The NPWS has prepared environmental assessment guidelines specific to the management of *P. junonis* and its habitat to ensure that relevant matters are taken into account when public authorities are considering potential impacts on the species. A copy of these guidelines is included as Appendix 2, for consideration by applicants and public authorities in preparing and/or assessing matters under Parts 4 & 5 of the EP&A Act 1979 (NSW) and by the NPWS under Part 6 of the TSC Act 1995 (NSW).

7. Monitoring of consent conditions

Public authorities will ensure that they monitor any conditions of consent that are embodied in an approval or determination under Parts 4 or 5 of the EP&A Act 1979 (NSW) for the protection and management of *Prostanthera junonis.* Where consent conditions have not been implemented in accordance with an approval or determination, the public authorities identified in this plan will, in accordance with their statutory responsibilities, take steps to ensure that those conditions are fully implemented.

8. Fire management

Fire management plans covering the known and potential habitat of P. junonis should consider the potential impacts of fire management activities on populations of P. junonis. As some of the populations occur in positions along tracks, they are vulnerable to destruction from the formation of fire breaks during emergency situations or through hazard reduction activities.

The NPWS will negotiate with the Gosford and Wyong Bush Fire Risk Management Committee and the Rural Fire Services to implement appropriate fire intervals for known and potential habitat of *P. junonis*. In order to give effect to this action, the NPWS will ensure the following:

- Details regarding the identification of potential habitat of *P. junonis* will be lodged with the Bushfire Management Committee so that appropriate assessment takes place prior to hazard reduction activities;
- Information regarding the location of the known and potential habitat of *P. junonis* will be lodged with the Fire Management Committee, so that known populations can be protected during emergency times where ever possible and before hazard reduction activities;
- The NPWS representatives on both the Gosford Bush Fire Management Committee and the Wyong Bush Fire Management Committee, will negotiate the most appropriate technique for the protection of *P. junonis* to be included in relevant Bush Fire Risk Management Plans (prepared under the NSW *Rural Fires Act* 1997). This may be through conservation zoning or other appropriate means. The fire management guidelines outlined in Appendix 3 should be followed until more specific information is available;
- The NPWS Bush Fire Management Committee representatives will negotiate that prior to issuing fire permits and notices on the Somersby Plateau, that assessment of the site for the occurrence of *P. junonis* and its habitat be undertaken, and that the guidelines for fire management of these areas be adhered to.

The NPWS will ensure that *P. junonis* populations occurring on lands reserved under the *National Parks and Wildlife Act* 1974 (NSW) are included in 'Heritage Management Zones', where feasible, under the relevant Fire Management Plans for those reserves.

9. Site specific habitat management actions

9.1 Population 1: Wiseman's Ferry Road.

The NPWS will encourage Gosford City Council to retain this lot in the Somersby Industrial Estate in Council's ownership. Should the land be sold and proposed for

development, the NPWS recommends that the *P. junonis* population be excluded from any development footprint and be managed in the long term by a site specific management plan addressing issues such as weed invasion, unrestricted access, urban stormwater/sedimentation and fire regimes.

9.2 Population 2: Raverson Close.

The NPWS will encourage Gosford City Council and the owner(s) of the various undeveloped Lots containing *P. junonis* to exclude *P. junonis* from any development footprint(s), where possible, and to manage the species in the long term by a management plan addressing issues such as weed invasion, urban stormwater/sedimentation and fire. In order to achieve this outcome, the NPWS considers that a co-operative approach among adjacent lot owners should enable contiguous areas of *P. junonis* habitat to be left aside whilst still meeting their respective development objectives.

- Chivers Road subpopulation.

P. junonis individuals occurring in the Chivers Road subpopulation have been fenced and excluded from development. Conditions of consent imposed by Gosford Council require the preparation of a Management Plan, which is to include a five year *P. junonis* monitoring program and address weed control and fire management. The NPWS will liaise with Gosford City Council and the property owner to ensure that the Management Plan is implemented.

9.3 Population 3: Reeves Road.

Site rehabilitation & management. The NPWS will liaise with the DLWC to address unrestricted access-related habitat degradation and the rehabilitation of degraded bushland from previous landuses. In order to give effect to this action, a site specific rehabilitation strategy should be prepared, with input from the NPWS, DLWC, and Gosford City Council.

*Future use of Crown Land***.** The Department of Land and Water Conservation will ensure, as practical, that current and future management of known and potential habitat of the Reeves Road population of *P. junonis* under their care will not adversely affect this species. In order to give effect to this action, the Department of Land and Water Conservation will ensure that:

- Based on the permanent record of the exact location of *P. junonis*, the DLWC is in a position to require that due consideration be given to protecting the species in relation to future plans of management and activities, such as before hazard reduction activities and/or during emergency fire situations; and

- When assessing the future use of the Reeves Road population and any other Crown Lands on which *P. junonis* is discovered, the DLWC will take the *P. junonis* Recovery Plan into account and will liaise with the NPWS regarding matters which could affect the distribution and biology of the species.

9.4 Population 4: Gindarra Road.

The NPWS is unaware of any future development plans for this land, following the refusal of a development application for a caravan park by Gosford City Council in 1995. The NPWS will liaise with the property owner with a view to (i) determining the development expectations of the owner and (ii) securing the long term protection and management of the *P. junonis* population.

9.5 Population 5: Barnes Road.

Wyong Council granted development consent for a rural dwelling and private road at this location, in 1997. The *P. junonis* population was excluded from the development footprint. Conditions of consent imposed by Wyong Council require the owner to prepare a Threatened Flora Management Plan. The NPWS will liaise with the property owner and Wyong Council to ensure that actions identified in the Management Plan are implemented.

9.6 Population 6: Mangrove Tower.

Quarry development. The NPWS understands that the property owner of this population is seeking to develop a sand quarry in the near future and that an Environmental Impact Statement (which includes Threatened Species Assessment) is currently in preparation. The NPWS will negotiate with the property owner and the Department of Urban Affairs and Planning (the consent authority) to secure an outcome which protects the *P. junonis* population and its habitat in the long term. In order to achieve this outcome, the NPWS considers it will be necessary to ensure that:

- there is sufficient information as to the extent of occurrence, area of occupancy, population size, disturbance history, and potential habitat for *P. junonis* and other threatened flora at the site;
- a sufficient proportion of the *P. junonis* population and areas of potential habitat are excluded from any development footprints such that there is minimal risk of the population's extinction;
- excluded areas are fenced so that unrestricted access both during and after construction is prevented;
- appropriate vegetative buffers exist so as to maintain the functional integrity of retained habitats;

- strict pre and post construction conditions relating to stormwater management, erosion and sedimentation are implemented to protect *P. junonis*; and
- a Threatened Flora Site Management Plan is prepared and implemented to address long term habitat management issues such as weed invasion, fire regimes and monitoring of the *P. junonis* population.

9.7 Population 7: Reservoir Road.

*Maintenance of the Great North Walk***.** In undertaking track maintenance activities of the Great North Walk, the Department of Land and Water Conservation will take care to ensure that no *P. junonis* population or parts of a population and its habitat are destroyed or degraded.

Adjacent development. Gosford City Council granted development consent for a sand quarry immediately adjacent to this population, in May 1999. Conditions of consent imposed by Gosford City Council require the quarry owner to prepare and implement an Environmental Management Plan (EMP). The relevant sections of the EMP relating to *P. junonis* include requirements for weed management, erosion and sediment control, and monitoring. The NPWS will conduct annual site inspections with the property owner to ensure that the EMP is implemented and that remedial actions are undertaken in the event of adverse impacts on the adjacent *P. junonis* population.

9.8 Population 8: Silvesters Road.

The NPWS considers that at the preparation of this recovery plan, there are no site specific management actions necessary for this population. The population will be monitored as recommended by action ten below and any on-ground works will be undertaken as required.

9.9 Population 9: Konda Road.

Liaison with Transgrid. The NPWS will liaise with Transgrid to ensure that it is aware of the location details of the Konda Road *P. junonis* population adjacent to Transgrid-managed transmission lines within Brisbane Water National Park. As necessary, the NPWS will advise Transgrid of any additional *P. junonis* located on or near Transgrid-management easements in the locality, and provide advice on environmental impact assessment matters where requested.

10. Monitoring of populations

The NPWS will establish a monitoring program for those *P. junonis* populations that are not currently subject to site-specific management actions.

12 Survey

The current distribution of *P. junonis* is detailed in section 5 of this recovery plan. Surveys for *P. junonis* were conducted during the flowering seasons of 1997-99 for the preparation of this recovery plan. New populations of this species may be discovered with further survey. It is therefore essential that managers of *P. junonis* habitat have a clear understanding of the actual distribution of this species to make confident land management decisions. In order to achieve this, there is a need to conduct further survey in suitable habitat in areas not yet surveyed.

12.1 Survey objective

To establish the full extent of the distribution of *P. junonis.*

12.2 Survey criteria

Potential habitat is surveyed and a greater understanding of the plant's habitat is known, documented in relevant databases and communicated to relevant land managers.

12.3 Survey actions

Survey actions to be implemented are:

1. Targeted survey

The NPWS will carry out targeted survey for *P. junonis* in areas of potential habitat. In order to maximise survey effort, the NPWS will seek to involve other public authorities, in particular State Forests and the Department of Land and Water Conservation, NPWS volunteers and community groups in the survey. All information gained from this additional survey will be stored in the NSW Wildlife Atlas and specimens will be lodged with the National Herbarium of NSW.

2. Reporting

The NPWS will inform Gosford City Council and Wyong Shire Council (and any other relevant public authority or private landholder) of any new distributional data, so that informed habitat management decisions can be made.

13 Biological research

Current understanding of the biology and ecology of *P. junonis* is detailed in section 6 of this recovery plan. However, there are several critical aspects of the species' lifecycle which are currently unknown and are required to be understood for successful management. For example, section 6 identifies the need to investigate seed bank dynamics as paramount to understanding of the long term viability of each population, and thus the ability to manage areas of habitat. Collection of data on seed viability and dormancy will provide insight into the timing of recruitment, the specific conditions required for seed germination and the ability of populations to be self maintaining.

Monitoring of populations with respect to fecundity and plant longevity will enable land managers to understand the implications of fire regimes and land management practices on the long term viability of plants in isolated remnant bushland.

13.1 Research objective

To ensure the management of *P. junonis* habitat is informed by essential aspects of the species' biology and ecology.

13.2 Research criteria

A greater understanding of *P. junonis* biology and ecology is achieved through targeted research, and management strategies are informed by research outcomes.

13.3 Research actions

Research actions to be implemented are:

1. Research program

The NPWS will co-ordinate a program of biological and ecological investigation into *P. junonis*, which focuses on critical stages of the plant's life cycle. A two year research program is briefly outlined below. The need for further studies will be evaluated and prioritised after this two-year program.

- **Seed ecology**

  Seed ecology will be investigated using seed collected from several populations. The extent to which laboratory and *in situ* buried seed trials are possible will be dependent on the amount of available seed. The following aspects are priority for

investigation: the proportion of seed produced which is viable; seed dormancy mechanisms; the fate of the seed in the soil; and, the rate of input of seed into the soil seed bank.

- **Population dynamics**

Monitoring of tagged populations will provide some insight into the population dynamics of *P. junonis*. Data collected will assist in understanding the frequency of flower and fruit production; whether recruitment occurs outside of times of disturbance; the rate of seedling mortality; and, the time taken for seedlings to mature and begin producing viable fruit.

- **Response to fire**

The response of *P. junonis* to fire will be investigated at population 3 which experienced fire during March 1998. Searching at population 3 will be carried out to look for evidence of resprouting or massive seed germination. An experimental approach to investigate fire response may also be used.

In order to investigate these issues, the NPWS will seek to contract various components of the proposed program to appropriate specialist institutions such as the Royal Botanic Gardens Sydney and Royal Botanic Gardens Mt Annan. The NPWS will encourage tertiary institutions to conduct research into this species consistent with the priorities outlined above.

2. Genetic Investigations

The NPWS will co-ordinate research designed to investigate the genetic diversity within and among populations of *P. junonis.* The purpose of this research is to identify the extent of genetic 'populations' of the species, to assist landuse planning and decision making. In order to implement this action the NPWS will seek to contract this research to an appropriate institution with expertise in the investigation of species genetic diversity.

14 Critical habitat

Critical habitat has not been declared for *P. junonis.* The reason for this is that there is inadequate information about the distribution and biological requirements of *P. junonis* to determine habitat "*that is critical to the survival of the species*". In particular, additional survey work is required to provide a clearer picture of the full extent of the species habitat and distribution. The most appropriate time to determine the need for, and feasibility of, declaring critical habitat for *P. junonis* is following the implementation of survey and research actions identified in this plan.

14.1 Critical habitat objective

To determine whether a declaration of critical habitat for *P. junonis* will provide greater protection for the species than which currently exists.

14.2 Critical habitat criteria

Critical habitat is assessed as a management option for *P. junonis*.

14.3 Critical habitat actions

Critical habitat actions are:

1. Consultation with the *P. junonis* Recovery Team

Following the implementation of survey and research actions identified in this recovery plan, the NPWS will consult with the *P. junonis* Recovery Team to discuss the need for, and feasibility of, declaring critical habitat for the species.

15 *Ex situ* conservation program

While every effort will be made to recover *P. junonis in situ*, an *ex situ* conservation program may be required at some point in the future to conserve genetic diversity from populations that are destroyed or are in irreversible decline. The most effective and efficient means of storing genetic material for *P. junonis* is currently unknown. This action is therefore focused at establishing the most appropriate storage of *ex situ* material.

15.1 *Ex situ* objective

To understand the requirements for safeguarding genetic diversity of *P. junonis* for the purpose of reintroduction, following the extinction or irreversible decline of natural populations.

15.2 *Ex situ* criteria

The most effective and efficient method of storage of *ex situ P. junonis* material is investigated and understood and, if necessary, an *ex situ* program is implemented.

15.3 *Ex situ* actions

Ex situ actions to be implemented are:

1. Investigation into storing genetic material

The NPWS will investigate the most appropriate method of storing *P. junonis* genetic material for an *ex situ* conservation program. In order to determine the most effective method of storing such material *ex situ*, the NPWS will seek to contract this action to a specialist botanical organisation.

2. Ex situ collection

Following the outcome of biological investigations proposed in this recovery plan, the NPWS in consultation with the RBG and the *P. junonis* Recovery Team will assess the need for, and feasibility of, implementing an ex situ conservation strategy for the species.

16 Community awareness and involvement

Perceived constraints on potential development caused by the TSC Act 1995 (NSW) has lead to the spread of misinformation about the species. There is a need therefore to ensure that the community as a whole is aware of the species' conservation status and of opportunities to participate in the species' recovery program.

16.1 Education, awareness and involvement objective

To raise awareness among the broader community about the conservation status of, and involve the community in the recovery program for, *P. junonis* .

16.2 Education, awareness and involvement criteria

Information is disseminated to the community, in particular private landholders, of the conservation status and management issues affecting *P. junonis* and its habitat; and the community is encouraged to participate in key aspects of the recovery program.

16.3 Education, awareness and involvement actions

Education and awareness actions to be implemented are:

1. Species profile

The NPWS will produce a species profile providing information about the conservation status and management issues affecting *P. junonis.* The profile will be distributed to private landholders with *P. junonis* on their properties, and be displayed on the NPWS internet homepage.

2. Liaison with private land holders

The NPWS will liaise with private landholders to emphasise the conservation significance of populations of *P. junonis* occurring on or adjacent to their properties.

3. Survey for new populations

In undertaking survey for new *P. junonis* populations, the NPWS will seek to involve NPWS volunteers and community groups in the survey effort.

17 Implementation

17.1 Implementation schedule

Table 5 allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies.

Table 5. Implementation schedule

Abbreviations: NPWS - NSW National Parks & Wildlife Service; GSC - Gosford City Council; WSC - Wyong Shire Council; DLWC - Department of Land and Water Conservation

Action	Description	Responsibility for implementation	Timeframe
Conservation status of populations	Public authority liaison	NPWS	Life of Plan
	Landholder liaison	NPWS	Life of Plan
	Preparation of EPIs	GCC, WSC	Life of Plan
	Regional Vegetation Management Plan	NPWS, DLWC	Year 1
Habitat Management	Permanent record	NPWS, GCC, WSC, DLWC	Life of Plan
	s149 certificates	GCC, WSC	Life of Plan
	Reporting	GCC, WSC, DLWC	Life of Plan
	Field staff notification	NPWS, GCC, WSC, DLWC	Life of Plan
	DAs and rezonings	GCC, WSC, NPWS	Life of Plan
	EIA guidelines	NPWS	Life of Plan
	Monitoring conditions	GCC, WSC, DLWC, NPWS	Life of Plan
	Fire management	NPWS	Life of Plan
	Site management	NPWS, GSC, DLWC, Landholders	Life of Plan
	Monitoring	NPWS	Years 1, 3 & 5
Survey	Targeted survey	NPWS	Years 1 & 2
	Reporting	NPWS	Year 1
Research	Research program	NPWS	Years 1-2
Critical habitat	Critical habitat decision	NPWS	Year 3
Ex situ	*Ex situ* investigations	NPWS	Years 1&2
	Ex situ collection	NPWS	Year 3
Education	Species profile	NPWS	Year 1
	Liaison with landholders	NPWS	Life of Plan
	Involvement in survey	NPWS	Years 1 & 2

17.2 Implementation costs

The recovery actions and recommendations identified in this plan state what must be done to ensure the recovery of the endangered species *P. junonis.* The total estimated cost of this recovery plan is $81,500 over five years. Appendix 4 identifies the costs needed to implement actions that require funding for implementation.

18 Preparation details

18.1 Persons responsible for plan preparation

This recovery plan was prepared by Christopher Lacey (Threatened Species Unit Central Directorate) and Merrin Tozer (formerly NPWS), in consultation with the *Prostanthera junonis* Recovery Team.

18.2 Date of last amendment

No amendments have been made to date.

18.3 Review date

This recovery plan will be reviewed within five years of the date of publication.

19 Contacts

19.1 Recovery Team

The Threatened Species Recovery Team for *P. junonis* is coordinated by the Central Directorate Threatened Species Unit, NSW National Parks and Wildlife Service, and may be contacted at the following address:

Coordinator - *Prostanthera junonis* Recovery Team
Threatened Species Unit, Central Directorate
NSW National Parks and Wildlife Service
PO Box 1967,
HURSTVILLE 2220

Tel: (02) 9585 6678
Fax: (02) 95856442

19.2 Other useful contacts

ORGANISATION	CONTACT DETAILS
NPWS Central Coast and Hunter Ranges Region	PO Box 1393, GOSFORD NSW 2250 tel: (02) 4324 4911
Mt Annan Botanic Garden	Mt Annan Drive, MT ANNAN NSW 2567 tel: (02) 46482 477
National Herbarium of NSW	Royal Botanic Gardens Sydney, Mrs Macquaries Rd, SYDNEY 2000 tel: (02) 9231 8111
Gosford City Council	PO Box 21, GOSFORD NSW 2250 tel: (02) 4325 8222
Wyong Shire Council	PO Box 20, WYONG NSW 2250 tel: (02) 43505555
Environment Australia	GPO Box 787, CANBERRA ACT 2601. tel: (02) 62741111
ASGAP Prostanthera and Westringia Study Group	c/- 13 Park Road, BULLI NSW 2516

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Appendices

Appendix 1. Known populations of *P. junonis* as of August 2000

Appendix 2. Species Profile and Environmental Impact Assessment Guidelines

Appendix 3. Fire management guidelines

Appendix 4. Implementation costs

Appendix 1.
Known sites of *P. junonis* as of August 2000.

Sites: subdivided to reflect tenure.
Population size: separate numbers under population size indicate the size of distinct sub-populations, the source of information is in brackets. All population sizes have been confirmed for the plan except where noted in the comments section.
Subscript of the population size: $_A$: total population count; $_B$: comprehensive count not completed, population estimate is minimum population size; $_C$: minimum population size estimated with 90% confidence using population density estimates and assuming a log-normal sample distribution (Keith 1997a). The number given here is the lower limit.
Site No *: new populations or subpopulations.

Site No	Site Name	Population size (source)	Tenure	Comments
1	Wiseman's Ferry Road	30 [Conn in AMBS 1997]	Gosford City Council	21 plants located during survey conducted October 1998
2	Raverson Close	$80\text{-}100_A$ [Conn in AMBS 1997] + 90_B additional plants [Tozer pers. obs. January 1998] (total= c. 170)	Private	Three areas were resurveyed during January 1998 and 90 additional plants not marked on the AMBS map were counted.
3A	Reeves Road	$3,1_A$ [Tierney pers. comm 1997]	Crown Reserve for Recreation & Preservation of Flora and Fauna	3 plants track-side, 1 plant in disturbed area. Since survey one side of the track has been burnt by bushfire.
3B *	Reeves Road	$15,16_A$ [Tozer pers. obs. October 1998]	Crown Reserve for recreation & Preservation of Flora and Fauna	Two new sub-populations c. 500 m south of the known plants in relatively undisturbed habitat. Since survey these subpopulations have been burnt by bushfire.
4	Gindurra Road	295_B [Tozer pers. obs. November 1998]	Private	Site previously thought to have only 30 (Allen in Payne 1997)

Appendix 1: continued.

Site No.	Site Name	Population Size	Tenure	Comments
5	Barnes Road	63 [O'Brien 1997]	Private	Site inspected outside of flowering time (Tozer pers. obs January 1998), no plants found.
6	Mangrove Tower	72_A [Tozer pers. obs. December 1998]	Private	Targeted survey re-estimated the numbers. Previous information from an unpublished report by S. Bell (1995) and NPWS Atlas records (Bell 1996)
7A	Reservoir Road	4_A [Conn in Payne 1997]	Private	2 of the known plants were relocated October 1997.
7B *	Reservoir Road	75_A, 150_B, 50_B 2 $_A$ [Tozer pers. obs. November 1998]	NPWS, Brisbane Water National Park	4 new sub-populations.
7C *	Reservoir Road	2253+ $_C$, 122_A, 30_B [Tozer pers. obs November 98] 4_A [Tozer pers. obs October 1998]	NPWS, Brisbane Water National Park	3 new sub-populations. The largest population subsampled using quadrats.
8A *	Silvesters Road	10_A [Tozer pers. obs. October 1998]	Water Catchment Area: Gosford City Council	Area Reserved for water Supply.
8B *	Silvesters Road	20_A [Lacey pers. obs. November 1999]	Private	New sub-population restricted to remnant vegetation on rural-residential property.
8C *	Silvesters Road	25_A [Lacey pers. obs. November 1999]	Private	New sub-population adjacent to disturbed ridgetop cleared area on rural residential property.
9 *	Konda Road	73_B, 37_B, 81_B [Tozer pers. obs. November 1998]	NPWS, Brisbane Water National Park	Brisbane Water National Park - 3 new sub-populations.

Appendix 2.
Species Profile and Environmental Impact Assessment Guidelines

THREATENED SPECIES INFORMATION

Prostanthera junonis

B.J Conn

Other common name(s): Somersby Mintbush

Prostanthera junonis has been previously known as*Prostanthera* sp "8" and *Prostanthera* sp "Somersby". The species name "*junonis*" was published by Conn (1997).

Conservation Status

Prostanthera junonis is listed as an endangered species on Schedule 1 of the *Threatened Species Conservation Act* 1995 (NSW). *P. junonis* is also listed as a nationally endangered species under the *Endangered Species Protection Act* 1992 (Commonwealth).

Description

P. junonis is a low spreading shrub which grows 0.1-0.3m high and in open areas up to 1m in diameter. In exposed sites, branches appear wiry and are often prostrate. In areas of more dense vegetation, the plants have long spindly branches, which weave through other vegetation and can be found growing up to 1m high when supported. Flowers are 8-12mm long, pale mauve to almost white. The calyx is usually green, often tinged with maroon, and sparsely hairy. Flowers occur singly in leaf axils, although they are actually part of a complicated leafy inflorescens consisting of 4-14 flowers. The leaves and stems are non-aromatic (Conn 1997).

Distribution

P. junonis is endemic to NSW. It is known from a north-south range of approximately 19km on the Somersby Plateau, in the Gosford and Wyong Local Government Areas.

Within this range, there are nine populations. Eight of the nine populations occur over a restricted north-south range of c.10km, with the northern limit currently being a disjunct outlier. The Recovery Plan for *P. junonis* (NPWS 2000) outlines the criteria used to determine the extent of a "local population", which may be comprised of one or more "sub-populations" occurring in the locality. Further survey is required to determine whether the plant occurs outside of the current distribution, however surveys conducting during the flowering period between 1997-1999 have not discovered any such populations.

Recorded occurrences in conservation reserves

P. junonis has been recorded from Brisbane Water National Park.

Habitat

P. junonis is restricted to the Somersby Plateau, in the Sydney Basin Bioregion. The Somersby Plateau is characterised by

two main soil landscape units known as "Somersby" and "Sydney Town" (after Murphy 1993). Both landscapes are characterised by gently undulating to rolling rises on weathered Hawkesbury Sandstone. Slopes are generally <25% and rock outcropping and/or rocky fragments may be present. *P. junonis* occurs in vegetation communities that are broadly classified as the Hawkesbury Sandstone complex of Open-forest/Low woodland/Open-scrub (Map Unit 10a, after Benson 1986). Within this vegetation complex, *P. junonis* is most likely to occur in areas of *Eucalyptus haemastoma, E. sieberi, C. gummifera* woodland or open woodland with an understorey containing *Banksia ericifolia* and/or *B. serrata*. Other indicative understorey species include *Darwinia glaucophylla, Hemigenia purpurea, Grevillea buxifolia, G. sericea, Leptospermum polygalifolium, Bauera rubioides, Scaevola ramosissima, Boronia pinnata,* and *Actinotis minor*.

Previously, *P. junonis* was documented to be restricted to habitat types that have been recently disturbed through fire or mechanical means, water soaks and rock outcrops (Payne 1997, Conn 1997, & Tierney 1996). Survey carried out by the NPWS indicates that *P. junonis* can also occur in undisturbed areas, including sites that have not been burnt for many years, although usually the apparent number of individuals is low.

Ecology

The dominant flowering time for *P. junonis* is October to mid-December, however, not all populations appear to begin flowering at the same time. The flowering in any one year is also likely to be influenced by seasonal weather conditions and/or the exposure of each particular site.

The breeding system in *P. junonis* is poorly known. Tierney (1994, 1996) suggests that the species is capable of successful reproduction utilising both outcrossing and self-reproductive strategies. It is unclear whether a pollen vector exists for this species. *P. junonis* is stoloniferous/rhizomatous (Conn 1997, Tierney 1994), which means that parts of an apparent population may be clonal. It is possible that the formation of rhizomes in the population tested by Tierney (1994) is a response to severe disturbance (NPWS 2000).

Seedbank dynamics (fecundity, viability, dispersal, longevity, dormancy etc) are similarly poorly known in *P. junonis*. Preliminary studies by Tierney (1994, 1996) suggest that seed viability is highly variable; longevity and germination rates are low; and that seeds germinate in response to smoke and possibly light. This implies that recruitment will probably occur in response to fire and soil disturbance, which exposes the seeds to light (NPWS 2000). However, the precise details (frequency, intensity, seasonality) of the species' natural disturbance regime is unknown.

The fire response of *P. junonis* is unknown. There is some evidence that seed dormancy may be broken by smoke (Tierney 1994, 1996). Adult plants lack obvious mechanisms to survive and resprout after fire (eg lignotubers) and no vegetative reproduction was observed during inspections of known populations recently burnt (NPWS 2000).

Threats

Threats to *P. junonis* include habitat loss through vegetation clearing or degradation (eg weed invasion, unrestricted access, stormwater erosion). Fire control activities, particularly mechanical fuel reduction and the construction of fire access tracks have impacted on populations through the physical destruction of individuals and the degradation of habitat. Fragmentation of habitat may be threat to populations, however, a further understanding of the plant's breeding system is required to understand the longer term implications of habitat isolation. The Prostanthera genus is susceptible to plant pathogens such as Phytophthora and rootknot nematodes.

Management

Management of *P. junonis* should attempt to minimise habitat loss (in particular vegetation clearance), by retaining vegetation on private land and improving

habitat connectivity within and among populations; minimise and/or prevent habitat degradation vectors (such as large edge-area ratios, urban / agricultural runoff, unrestricted access etc); implement appropriate environmental assessment principles (see attached guidelines); obtaining the support of landholders responsible for managing populations on private land, and ensuring responsible conduct of fire control and track maintenance activities.

Recovery Plans

A Recovery Plan has been prepared for *P. junonis* (NPWS 2000).

Prostanthera junonis

B.J. Conn

Other common name(s): Somersby Mintbush

Prostanthera junonis has been previously known as *Prostanthera* sp "8" and *Prostanthera* sp "Somersby". The species name "*junonis*" was published by Conn (1997).

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. junonis is an inconspicuous plant when not flowering and is very difficult to detect and identify vegetatively. An initial assessment of habitat suitability of the particular site should be made based on the information presented in the Recovery Plan. If suitable habitat is or likely to be present, a targeted survey for the plant should be conducted. Targeted survey for *P. junonis* should be conducted over several days (2-3) spread evenly over the plant's main flowering period (October-mid December). Surveys outside of this period may detect occasional flowers, however should not be relied upon as a confident assessment of the plant's presence/absence and/or population size.

P. junonis flowers are similar in appearance to those of the more common species *Hemigenia purpurea* and the two species are frequently confused Care should be taken to distinguish *H. purpurea* individuals from possible *P. junonis* individuals by examining the calyx, leaf shape, and leaf arrangement. The Recovery Plan for *P. junonis* explains the differences between the two species.

If the survey objective is to determine presence/absence, areas of potential habitat should be sampled using both a "random meander" method (Cropper 1993) and linear transects by a person(s) experienced in the identification of this and similar species. Meanders and transects should occur within both open and closed habitats, and dense thickets of vegetation (eg long unburnt patches of *Banksia ericifolia*) should not be excluded. Any report prepared should map the location(s) of the meanders and transects.

The representative coverage of transects and/meanders will be dependent on the site's size, however, parallel transects spaced 15-20m apart are generally recommended.

If a known population is being surveyed, reference should be made to the Recovery Plan, and the recovery plan coordinator should be contacted. Depending on the survey's objective, repeated seasonal surveys may be undertaken in May, August, November and January in order to ensure that seasonal variation in flowering phenology of the local population is sampled. Results from each season's survey should be presented

separately and an estimate of the total size of the local population made and compared with any previous studies.

The Recovery Plan describes criteria for determining the constitution of a 'local population' and the definition of a 'subpopulation'. Descriptions of *P. junonis* occurrences should be consistent with these definitions. The assessment of significance in relation to a particular development should attempt to determine the extent of the 'local population' by conducting a search of comparable habitat within a 1km radius of the occurrence of the species on the development site. Any report prepared should map the location(s) of these searches and any constraints in undertaking this requirement (eg. refused access to private land).

If a new population is discovered, the surveyor should take a GPS reading of the location, make an accurate population count, map the location of the plants in a site sketch, and complete and lodge an Atlas of NSW Wildlife Flora Record Card with the recovery plan coordinator. More detailed mapping of the location of the population at a site may be required, depending on the nature and scale of the development. If the size of a population is estimated using statistical extrapolation, the method used to derive the population estimate should be fully detailed.

Life cycle of the species

The biology of *P. junonis* is described in the Recovery Plan and summarised in the species profile. The lifecycle of *P. junonis* is likely to be disrupted should any of the following occur:

Habitat loss - Development in or adjacent to *P. junonis* habitat should seek to avoid direct and indirect (eg shading, erosion) impacts on the species which may result in the destruction of individuals. Consideration should be given to siting development envelopes in areas where *P. junonis* individuals do not or are unlikely to occur, or occur in relatively low numbers for the population. Depending on the size of the site and nature of development, a buffer zone of between 20-50m is generally recommended to protect individuals at a site from habitat degradation, and allow the population areas of habitat in which to expand. The nature and size of buffer zones will depend on a range of factors, including the nature of the proposed development, the topography of the site and the position of *P. junonis*, and other measures proposed for controlling run-off, access, and exotic species plantings.

The significance of a particular action which physically destroys *P. junonis* plants and/or known habitat will require (i) an analysis of the proportion of the particular population/sub-population that is proposed to be destroyed; (ii) an understanding of the size and extent of the 'local population' (iii) whether the removal of those plants potentially compromises the long term viability of the remaining population/ sub-population (eg. opportunities for external recruitment, fragmentation, cumulative impact on the population/ sub-population); and (iv) a discussion of how the seedbank will or may be affected. That is, whether the seedbank will be permanently or temporarily destroyed.

Fire - NPWS (2000) suggests that *P. junonis* may be killed by fire, however, the exact fire response of *P. junonis* is unknown. Development that is proposed in areas of *P. junonis* habitat should consider the ability of the site to support an appropriate fire regime in any areas of remaining native vegetation. Fire management guidelines for *P. junonis* are included in the Recovery Plan for *P. junonis.* Fuel reduction zones associated with a particular development proposal should be in addition to rather than being incorporated into any proposed buffer zones to protect *P. junonis* from habitat degradation.

Seedbank disturbance - There have been no studies that document the fecundity (quantity of seed produced) of *P. junonis.* Soil erosion and siltation as a consequence of adjacent development are two specific processes that are likely to disrupt the lifecycle of *P. junonis* through disturbance to the seedbank by increased

runoff (Payne 1997). Other forms of disturbance that remove and/or frequently disturb the soil (eg. track construction, vegetation clearance) may also negatively impact on the species' seedbank.

Fragmentation - There is insufficient information on the breeding system of*P. junonis* to understand in detail the consequences of fragmentation within and among the populations of *P. junonis.* Fragmentation can lead to the break-down of essential ecological processes within ecosystems, with consequences for species such as reduced reproductive success and a subsequent decline in the rate of recruitment. Therefore, if there are components of *P. junonis* habitat which are critical to the species' lifecycle (eg. a pollen vector) then it will be important to ensure that these processes remain intact. In the absence of specific information, development in *P. junonis* habitat should seek to maintain the connectivity of proximate areas of native vegetation both within and between the populations.

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 a key threatening process listed in the TSC Act 1995 (NSW) which is relevant to *P. junonis.* Other identified threats to *P. junonis* include habitat loss (in particular development and vegetation clearance), habitat modification as a consequence of development adjacent to bushland (in particular, unrestricted vehicle access, increased shading from buildings, intensified runoff, soil erosion and sedimentation, and increased weed invasion), and fire control activities (in particular, frequent hazard reduction activities, track construction). The exclusion of fire from isolated occurrences of *P. junonis* may present a threat in the long term as many of the component species of *P. junonis* habitat require fire for regeneration. In addition, areas of *E. haemastoma/ B. ericifolia* woodland that have been left unburnt for several decades appear to support only small populations of *P. junonis,* which is likely to be shaded-out by the dense *Banksia* thickets.

Viable local population of the species

In the absence of more comprehensive studies on the species' breeding system, the minimum size of a viable local population of *P. junonis* is unknown. Tierney (1994) suggests that fruit set in *P. junonis* can result from both outcrossing and self-reproductive strategies, however these results need to be replicated and augmented in additional populations. *P. junonis* is also stoloniferous which means that individual plants in a population may be clonal, effectively reducing the apparent size of any given population (Tierney 1994, Conn 1997).

It should be assumed that a particular population is viable regardless of its size, until further assessment indicates otherwise.

On the basis of current information, it is anticipated that any development which results in the complete destruction of a viable 'local population', or causes a viable 'local population' to become non-viable, will have a significant impact on the species.

Significant area of habitat

The current distribution shows that *P. junonis* has an extremely narrow extent of occurrence (c.4700ha) and a total area of occupancy of just c. 41.75ha. Given this narrow distribution, all currently known areas of habitat for the plant are considered significant.

Isolation/fragmentation

Nine discrete populations of *P. junonis* have been identified and described in the Recovery Plan for *P. junonis* (NPWS 2000). Several populations are isolated from continuous areas of native vegetation as a consequence of vegetation clearance for agricultural or other landuses on the Somersby Plateau. Where continuity of habitat exists between populations, this should be maintained

and enhanced as far as possible to facilitate exchange of genetic material.

Within each 'local population', there may be several "sub-populations" (see NPWS 2000) between which there is suitable habitat to encourage expansion of and interchange between these components. Smaller, isolated sub-populations are likely to require intensive management as they are more vulnerable than sub-populations which occur in larger, continuous and connected vegetation remnants. Management of *P. junonis* should aim to maintain the continuity of habitat (ie. native vegetation) between sub-populations. In doing so, this will prevent the creation of new isolated populations and sub-populations which are at greater risk of local extinction.

Regional distribution of the habitat

P. junonis occurs on the Somersby Plateau, which in a broad sense consists of three elongated smaller plateaus divided by Mooney Mooney Creek, Popran Creek and their tributaries (Hawkins *et al* 1984). Significant areas of the Somersby Plateau have been cleared for agriculture and industry, however, there remains areas of native vegetation in NPWS protected areas, Crown Land, areas zoned for Scenic Protection/Water Supply, and remnant vegetation on private land. *P. junonis* is currently restricted to the eastern part of the Somersby Plateau, however there is suitable habitat in remaining areas of native vegetation across the whole of the plateau which have not been comprehensively surveyed. It should not be assumed that *P. junonis* is present in other areas of the Somersby Plateau until further survey has been completed.

Limit of known distribution

P. junonis occurs within a north-south range of approximately 19km on the Somersby Plateau, in the Gosford and Wyong Local Government Areas. Within this range, there are nine populations. The northern limit for the species is an outlier occurring at Barnes Road, Kulnura. The remaining eight populations occur over a greatly reduced range of c.10km, with the southern limit at Wiseman's Ferry Road, north-west of Kariong, western limit at Reservoir Road and eastern limit at Reeves Road, Somersby. It is likely that additional sub-populations will be identified within the current distributional limits on the Somersby plateau, however further survey is required to determine whether there are populations which occur outside of the current distribution.

Adequacy of representation in conservation reserves or other similar protected areas

There are two populations which occur in NPWS protected areas (Brisbane Water National Park), in the west of the species distribution. One population occurs in a Crown Reserve for Recreation and Preservation of Flora and Fauna in the south of the species distribution. Not strictly categorised as "conservation reserves", two populations in the south and west of the species distribution respectively are on land that is zoned either Scenic Protection or Special Purposes - Water Supply, offering some degree of security. The four other populations (northern, southern and eastern limits) occur on land that is zoned Industrial, Agricultural or Highway Protection.

While the largest population of the species occurs in Brisbane Water National Park, populations in conservation reserves or other similar protected areas are not representative of the species distribution as a whole. *P. junonis* is therefore not considered to be adequately represented in conservation reserves or other similar protected areas in the region.

Critical habitat

Critical habitat has not been declared for *P. junonis*

For further information contact:

Threatened Species Unit, Central Directorate, NSW NPWS, PO Box 1967, Hurstville NSW 2220. Phone: 9585 6678.

www. npws.nsw.gov.au

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Appendix 3
Fire Management Guidelines

The following recommendations are based on sandstone vegetation communities rather than specifically P. junonis. It is expected that the fire regime for P. junonis should fall within these recommendations, however, should be subject to change as new information becomes available.

Current guidelines for fire management of sandstone vegetation communities define fire regimes that are likely to lead to a decline in plant community diversity (Bradstock et al 1995). Four possible scenarios in which declines may occur have been described by Bradstock *et al.* (1995). Following these scenarios, recommendations regarding the fire regime for known sites of *P. junonis* and its habitat are listed below.

- Fire regime should **not** consist of two consecutive fires of less than 6-8 years apart as this leads to a decline in fire sensitive shrubs.
- Fire intervals should **not** exceed thirty years as this leads to seedbank decline in herbs and shrubs with short lived individuals.
- Fire regime must **not** consist of three or more consecutive fires at intervals of 15-30 years, this leads to the decline of sub-dominant herbs and shrub.
- Fire regime must **not** consist of more than two consecutive cool fires (i.e. fires which consume less than 8-10 tonnes ha^{-1} of surface fuel). This regime will lead to the decline of species with heat stimulated seedbanks in the soil.

Further investigation is required into seed bank characteristics of *P. junonis.* including seed longevity and accumulation rates and the fire response of adult plants. More specific guidelines will be formulated when this work has been completed.

Fire Management of isolated *P. junonis* habitat.

Fire management of isolated *P. junonis* habitat (such as at site 2) should follow the general guidelines for sandstone vegetation communities as described above. As more specific guidelines are formulated, this information should be incorporated into specific site plans of management.

Appendix 4
Implementation Costs

Action	Description	Year of Implementation					Total ($)	Source of Funding				
		1	2	3	4	5		NPWS		DLWC	Landholder*	Unsecured
								Recurrent Funds	Program Funds			
Conservation status of populations	Public authority liaison	3500	3500				**7000**	7000				
	Landholder liaison	3000	3000	3000			**9000**	6000				3000
	Preparation of EPIs	√	√	√	√	√	**-**					
	RVMP Liaison	√	√	√	√	√	**-**					
Habitat Management	Permanent record	√	√	√	√	√	**-**					
	s149 certificates	√	√	√	√	√	**-**					
	Reporting	√	√	√	√	√	**-**					
	Field staff notification	1000					**1000**	1000				
	DAs and rezonings	√	√	√	√	√	**-**					
	EIA guidelines	√					**-**					
	Monitoring conditions	√	√	√	√	√	**-**					
	Fire management	√	√	√	√	√	**-**					
	Site monitoring	3000		2000		2000	**7000**		5000			2000
	Site management	5000	5000	5000	5000	5000	**25000**		2000	3000	20000	
Survey	Targeted survey	4000	3000				**7000**	7000				
	Reporting	√	√	√	√	√	**-**					
Research	Research program	8250	8250				**16500**		16500			
Critical habitat	Critical habitat decision			3000			**3000**					3000
Ex situ	*Ex situ* investigations		3000	3000			**6000**					6000
	Ex situ collection	√	√	√	√	√	**-**					
Education	Species profile	√					**-**					
	Liaison with landholders	√	√	√	√	√	**-**					
	Survey involvement	√	√	√	√	√	**-**					
TOTAL		**27,750**	**25,750**	**16000**	**5000**	**7000**	**81,500**	**21,000**	**23,500**	**3000**	**20,000**	**14,000**

√ = No direct cost associated with action; * = Estimated costs provided by landholders to implement consent conditions to manage *Prostanthera junonis.*

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

43 Bridge Street
HURSTVILLE
NSW 2220

02 95856444