Approved NSW and National Recovery Plan

Recovery Plan for

Boronia granitica (Granite Boronia)

July 2002

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

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Executive Summary

Introduction

Boronia granitica (Granite Boronia) is a medium-sized, open shrub with pinnate foliage and pink flowers. It grows in heathy vegetation amongst granite boulders of the New England Batholith, where it is restricted to a limited number of mostly small populations.

This recovery plan describes our current understanding of *B. granitica*, documents the research undertaken to date and identifies management actions required and parties responsible in addressing the conservation of *B. granitica*.

Legislative context

The *Threatened Species Conservation Act* 1995 (TSC Act) is NSW's most comprehensive legislative framework to protect and encourage the recovery of threatened species, populations and communities. Under the TSC Act, the Director-General of National Parks and Wildlife has certain responsibilities including the preparation of recovery plans for threatened species, populations and ecological communities. This recovery plan has been prepared to satisfy the requirements of both the TSC Act and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

Current species status

B. granitica is known in NSW from only five disjunct areas on the north-western side of the New England Tablelands from near Armidale north to the Torrington district. The species also occurs in the Stanthorpe district of southern Queensland.

Viable populations of *B. granitica* are known from Kings Plains National Park, Torrington State Recreation Area and Severn River Nature Reserve in NSW (and Girraween National Park in Queensland). However, populations outside conservation reserves are either critically small or vulnerable to decline.

The major threats to *B. granitica* are the impacts of inappropriate fire regimes and browsing by stock and feral goats. Such processes pose a serious threat to unreserved populations of *B. granitica* and a potential threat to reserved populations. Disturbances such as mining activities and clearing are additional potential threats.

B. granitica is listed as endangered under the NSW TSC Act. However, a review process by the NSW Scientific Committee has resulted in a recommendation in May 2002 that *B. granitica* be downlisted to vulnerable (NSW Scientific Committee 2002). The species is also listed as endangered under the EPBC Act and is included on the Australian and New Zealand Environment and Conservation Council (ANZECC) Threatened Australian Flora list (1993). On the Rare or Threatened Australian Plant (ROTAP) list, the species is considered vulnerable and is assigned a code of 3VC- (Briggs and Leigh 1996).

Recovery objectives

The overall objective of this recovery plan is to protect populations of *B. granitica* from decline induced by non-natural agents and to ensure that these populations remain viable in the wild in the long term.

Specific objectives of this recovery plan are to:

- improve the long-term viability of reserved populations;
- improve the viability of known non-reserved populations;

- determine if further populations exist on granite outcrops elsewhere on the New England Tablelands;
- increase our understanding of the ecology of *B. granitica*; and
- identify and ameliorate threatening processes.

Recovery criteria

Recovery criteria are that:

- cessation of feral goat browsing at the Parlour Mountain location and reduction of goat (and stock) interference at Howell;
- reduction in feral goat populations in NPWS estate to a minimum;
- an improved understanding of the biology and ecology of *B. granitica* is sufficient to enable management for long-term viability of the species in NSW;
- reserved populations do not suffer any reduction due to human induced causes;
- populations that are not reserved are protected by appropriate measures;
- evidence of seedling establishment and recruitment at all or most population areas; and
- site monitoring to indicate population stability.

Recovery actions

Recovery actions will be directed toward:

- implementation of the most appropriate and effective fire management options for the stability or enhancement of *B. granitica in situ*;
- research into aspects of the ecology of *B. granitica*, especially reproductive biology, seed-bank dynamics and fire response, necessary to develop the above management strategies; and
- protection of populations from the adverse impacts associated with feral goat and stock grazing.

Biodiversity benefits

The occurrence of *B. granitica* contributes to the high biodiversity of the flora of the northern tablelands and slopes of NSW. Other threatened species and communities that occupy similar granite outcrop habitats are likely to benefit from conservation of *B. granitica*.

Through awareness of the fate of *B. granitica*, the profile of all threatened plant species is raised in the general community. This in turn leads to greater opportunities for the conservation of threatened species and increased protection of biodiversity.

MICHAEL WRIGHT
A/Director-General

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Minister for Environment

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1 Current conservation status

Boronia granitica Maiden & Betche (Granite Boronia) is known from less than ten disjunct areas of granitic outcrop vegetation on the north-western side of the New England Tablelands from near Armidale in New South Wales (NSW) to the Stanthorpe district in southern Queensland.

The species is currently listed as endangered (Schedule 1 Part 1) on the NSW *Threatened Species Conservation Act* 1995 (TSC Act). The 'endangered' code is reserved for species considered 'likely to become extinct in NSW unless circumstances and factors that threaten its survival or evolutionary development cease to operate', or 'numbers are reduced to such a critical level, or its habitats have been so drastically reduced that it is in immediate danger of extinction'.

A review process by the NSW Scientific Committee has resulted in a recommendation in May 2002 that *B. granitica* be downlisted to vulnerable on the basis that the total population size of the species is much larger than previously believed (NSW Scientific Committee 2002).

A summary of the conservation status of *B. granitica* is given in Table 1.

Table 1: Conservation status of *Boronia granitica*

Legislative or scientific list	Code	Status
NSW *Threatened Species Conservation Act* 1995	E	endangered
Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999	E	endangered
ANZECC Threatened Australian Flora (ANZECC 1993)	E	endangered
Rare or Threatened Australia Plants (ROTAP) (Briggs and Leigh 1996)	3VC-	vulnerable
Vascular Plants of Conservation Significance in North-Eastern NSW (Richards *et al.* 1998)	C-1	critically threatened

Note:
E = endangered;
3 = a geographic range in Australia greater than 100 kilometres;
V = vulnerable, not presently endangered but at risk over a longer period (20-50 years) of disappearing from the wild through continued depletion, or occurs on land whose future use is likely to change and threaten its survival;
C- = at least one population within a proclaimed conservation reserve but population size not accurately known; and
C-1 = critically threatened.

2 Description

2.1 Taxonomic description

Boronia granitica is a medium-sized shrub with divided leaves and bright pink flowers. It was first described by Maiden and Betche in the *Proceedings of the Linnean Society of New South Wales* (1905) from Maiden and Boorman's 1905 type collection from Howell, south-east of Inverell in NSW. Detailed taxonomic descriptions are provided in Weston and Porteners (1991), Quinn *et al.* (1995) and Duretto (in press). Williams (1979) also provided an illustration of the species.

2.2 Taxonomic significance

The genus *Boronia* belongs to the Rutaceae, a plant family with a wide distribution throughout the warmer parts of the world. Rutaceae is predominantly a 'southern' family

with a high degree of endemism (greater than 95 percent of species and greater than 50 percent of genera) in Australia (Morley and Toelken 1983). The tribe *Boroniaea* is the largest of the six Australian Rutaceae tribes, has the greatest number of endemic species and is particularly common and conspicuous among sclerophyll heathlands.

The genus *Boronia* is confined to Australia and New Caledonia with approximately 100 of the total 104 species endemic to Australia (Weston and Porteners 1991). Of this, approximately 35 species occur in NSW (Weston 1990).

B. granitica belongs to the section *Valvatae*, with the two closest congeners, *B. repanda* and *B. boliviensis* m.s. (formerly *Boronia* sp. J.), being the most threatened members of the section (Duretto in press) and possibly the rarest boronias in eastern Australia.

Although *B. repanda* is listed under the TSC Act, its natural occurrence in NSW requires confirmation. It may be present in Boonoo Boonoo National Park (NP) (G. Robinson pers. comm.) but the nearest confirmed records are confined to a small area of the granite belt in south-eastern Queensland (refer Appendix 3). If the existence of *B. repanda* cannot be confirmed in NSW then the species should be removed from the schedules of the TSC Act.

3 Distribution

3.1 Current and historical distribution

Boronia granitica occurs in the northern part of the New England Tableland and Nandewar biogeographic regions of NSW and southern Queensland as described in Thackway and Cresswell (1995). The species has been known for several decades from the type locality at Howell, north to the Stanthorpe district in southern Queensland. More recently the species has been collected approximately 50 kilometres south of Howell at Parlour Mountain near Armidale (Hunter and Bruhl 1997).

In NSW, *B. granitica* is currently known from several isolated populations (see Figure 1 and details in Table 2), one of which is critically small and possibly non-viable.

A 1933 specimen of *B. granitica* lodged in the NSW herbarium is labelled 'The Gorge', Kangaroo Creek near Elsmore, *c.* 16 kilometres east of Inverell. Information on the current status of *B. granitica* near Elsmore is lacking. Although small areas of suitable habitat may occur in the Elsmore district, it has not been botanically surveyed. Given no subsequent records (for more than 50 years) and the possibility of error in locality labelling of the original voucher, the presence of *B. granitica* near Elsmore seems dubious and requires confirmation.

The local government areas in which populations of *B. granitica* occur in NSW are Tenterfield, Inverell, Severn, Guyra and possibly Armidale Dumaresq Councils.

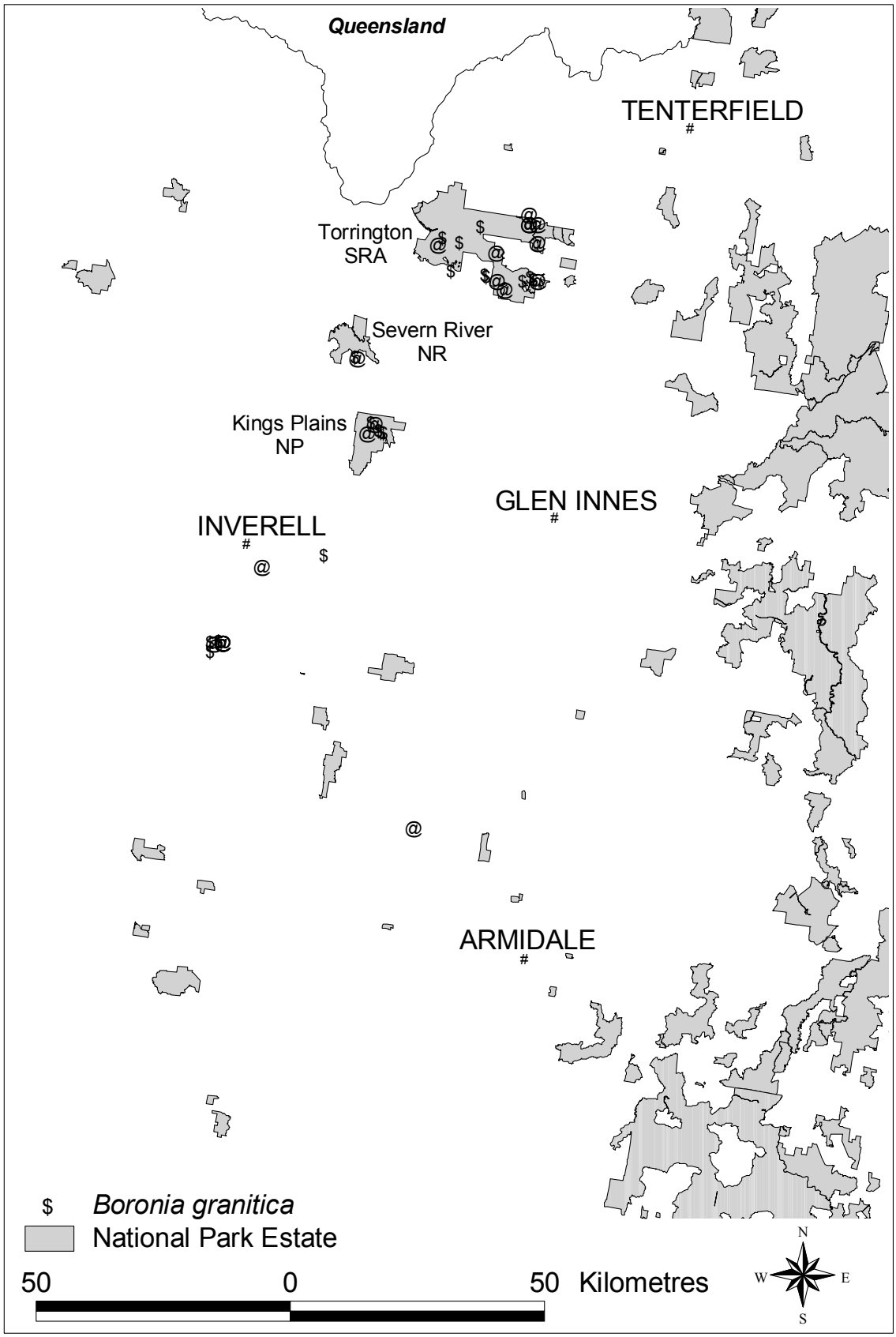

Figure 1: Location of known occurrences of *Boronia granitica* in New South Wales

Table 2: Tenure of known population areas of *Boronia granitica* in New South Wales

Population area	Land tenure	Local Government Area	No. of populations	Estimated population size
Parlour Mountain (*c.* 35 km NW of Armidale)	Private Freehold	Guyra / Armidale Dumaresq	one	three plants
Howell (*c.* 20 km SW of Inverell)	Leasehold & Permissive Occupancy	Guyra / Inverell	multiple	Possibly hundreds
Kings Plains	National Park	Inverell	one	thousands
Severn River and 'The Barbs' near Pindari Dam	Nature Reserve and Water Reserve	Inverell	multiple	thousands
Torrington area	State Recreation Area	Tenterfield / Severn	multiple	thousands

Note:
The Severn River and Kings Plains populations may not be totally isolated as there are scattered occurrences of *B. granitica* along the extent of the discontinuous band of granite and acid volcanic outcrops that broadly link the two areas (J. Hunter pers. comm.). Other populations can be considered isolated in a pragmatic management sense even though limited genetic exchange may still occur across intervening unsuitable habitat by vector transportation of pollen.

The Torrington area may represent a stronghold for *B. granitica* in NSW as several relatively large populations occur in suitable habitat over a range of approximately 40 kilometres from near Emmaville to Silent Grove. In a recent intensive survey of the vegetation of the Torrington SRA, Clarke *et al.* (1998) classified the distribution of *B. granitica* within the Torrington area as 'widespread' (as populations occur beyond a 10 kilometre radius), and 'frequent' (as the species was recorded in 14.5 percent of 246 sites surveyed). Additional herbarium records of *B. granitica* from the Torrington area are given in Table 3.

Table 3: *Boronia granitica* populations recorded from the Torrington area

Population location	Estimated population size	Year	Collector / surveyor
The Gulf, near Emmaville	Not given	1905	Andrews
Bismuth	Not given	1970	J. Williams
Silent Grove	Not given	1971	G. Althofer
Butler Road	15	1990	White & Williams
Bismuth Falls	10-20	1990	White & Williams
Blatherarm Creek	*c.* 40		Williams *et al.*
Breakfast Creek track (off Gulf Rd)	Not given	1990	Quirico *et al.*
Flagstone Creek track (off Gulf Rd)	Not given	1990	Quirico *et al.*
Highland Home Creek Crown Lease	50	1996	Croft & Sheringham
Carpet Snake Gap	200	1997	L. Copeland
'Mystery Face'	*c.* 50	1998	J. Westaway

Note:
Some of the above populations may have also been surveyed by Clarke *et al.* (1998).

In the Stanthorpe area of southern Queensland approximately ten small populations of *B. granitica* occur on private, or otherwise unreserved, lands scattered over 30 kilometres extending from near The Summit, Thulimbah and Amiens villages south to Girraween NP (Queensland Herbarium records, Quinn *et al.* 1995).

4 Habitat

4.1 Physical environment

Geology

Boronia granitica is restricted to a limited number of areas on the large plutonic masses collectively known as the New England Batholith. The exposed domes of the Batholith are comprised of various intrusive rocks and *B. granitica* has been found on granite, leucoadamellite and adamellite, but not granodiorite (Hunter and Clarke 1998). Additionally, Quinn *et al.* (1995) noted that a few plants occur on porphyrite at Severn River.

Topography and soils

The extensive rock sheets and massive outcrops resulting from erosion of the elevated domes of the Batholith form the conspicuous land form element that provides habitat for *B. granitica* on the northern tablelands and slopes of NSW. The outcropping areas where the species has been recorded lie in the mid elevation range of 700 metres AHD at Severn River to 1200 metres at Parlour Mountain.

B. granitica grows either amongst boulders in the skeletal soils found within narrow rock crevices and fissures, or in adjacent areas on granite scree and shallow soils (Quinn *et al.* 1995, Clarke *et al.* 1998). Detailed data are not available concerning the soil types that *B. granitica* occurs in, although Clarke *et al.* (1998) noted lithosols and podzolics for the Torrington area and Quinn *et al.* (1995) noted deep red soils at Severn River.

Climate

The granitic tablelands and slopes of NSW experience both tropical and temperate climatic influences, with predominantly summer rainfall and cool winters with associated frosts. Average temperatures range from summer maxima of 26-31° C to winter minima of -2°-0° C. *B. granitica* occurs within the relatively low rainfall regions of the tablelands and slopes with average annual precipitation varying with altitude from 700 millimetres at Severn River to 850 millimetres at Parlour Mountain.

4.2 Vegetation

B. granitica occurs in heathland, shrubland and adjacent heathy woodland / open forest associated with granite outcrops (Ross 1983, Weston and Porteners 1991, Quinn *et al.* 1995, Clarke *et al.* 1998, Hunter and Clarke 1998, Duretto in press).

In their detailed survey of the vegetation of the New England Batholith, Hunter and Clarke (1998) described the following five vegetation communities that contain *B. granitica*:

- *Prostanthera staurophylla - Kunzea bracteolata* low shrubland (Community 4b, Torrington shrublands) of the central New England shrublands vegetation element;
- *Babingtonia odontocalyx - Brachyloma saxicola* shrubland (Community 4c, Torrington woodlands), of the central New England shrublands vegetation element;
- *Calytrix tetragona - Leptospermum novae-angliae* shrubland (Community 5a, Kings Plains shrubland) of the Severn shrublands element;
- *Calytrix tetragona - Kunzea obovata* shrubland (Community 7e, Parlour Mountain shrublands) of the western New England shrublands and herbfields element; and

- *Babingtonia densifolia - Homoranthus prolixus* shrubland (Community 9a) of the Howell shrubland vegetation element.

In a further survey of the Torrington SRA, Clarke *et al.* (1998) identified and described the following four vegetation types that *B. granitica* was recorded in. The first two are analogous to the Torrington woodlands and Torrington shrublands communities respectively, as described above:

- western rocky outcrops (vegetation type 7a), *Eucalyptus prava - Callitris endlicheri* outcrop woodlands;
- Mole Tableland rocky outcrops (vegetation type 6), *Eucalyptus prava - Callitris endlicheri - Eucalyptus andrewsii,* Torrington outcrop heaths;
- vegetation type 3a, *Eucalyptus andrewsii - E. brunnea - E. williamsiana* shrubby forest; and
- vegetation type 3b, *Eucalyptus andrewsii* - mixed stringybark, Torrington shrubby stringybark forest.

Hunter and Clarke (1998) and Clarke *et al.* (1998) also detailed other vascular plants frequently occurring in each vegetation stratum within the above listed communities. Further plant species found in association with *B. granitica* are listed in Table 4 (Quinn *et al.* 1995, J. Westaway pers. obs.).

Table 4: Plant species associated with *Boronia granitica*

Kings Plains	'Mystery Face'-Torrington	Various other NSW sites
Eucalyptus prava	*Eucalyptus andrewsii*	*Acacia fimbriata*
Eucalyptus crebra	*Acacia betchei*	*Acacia neriifolia*
Leptospermum novae-angliae	*Bossiaea rhombifolia*	*Acacia triptera*
Allocasuarina brachystachya	*Bossiaea obcordata*	*Angophora floribunda*
Calytrix tetragona	*Brachyloma saxicola*	*Callitris endlicheri*
Melichrus urceolatus	*Gompholobium hueglii*	*Correa reflexa*
Homoranthus biflorus	*Dampiera stricta*	*Eucalyptus prava*
Grevillea triternata	*Patersonia sericea*	*Hibbertia obtusifolia*
Hakea dactyloides	*Hibbertia* sp. B	*Jacksonia scoparia*
Persoonia cornifolia	*Hibbertia* spp.	*Leucopogon melaleucoides*
Cryptandra amara	*Prostanthera staurophylla*	*Leucopogon muticus*
Leucopogon neo-anglicus	*Aotus subglauca*	*Leucopogon neo-anglicus*
Xanthorrhoea johnsonii	*Persoonia cornifolia*	*Melichrus urceolatus*
Astrotricha roddii	*Entolasia stricta*	*Olax stricta*
Phebalium rotundifolium	*Rhytidosporum procumbens*	*Phebalium rotundifolium*
Zieria laevigata	*Xanthorrhoea johnsonii*	*Prostanthera* sp.
		Xanthorrhoea sp.

5 Ecology

5.1 Life form and longevity

Boronia granitica is a perennial evergreen woody shrub with an open branched growth habit. The species appears to have a slow growth rate. Although longevity data are lacking, the CRA Threatened Flora Expert Workshops for the Upper North-East Region of NSW estimated B. *granitica* to have a longevity of about 15 years. This equates to that suggested for the closely related *B. boliviensis* m.s. (Morsley and Falconer in prep.).

Few data on *Boronia* exist concerning the time required for seedlings to mature and produce their first flowers (the primary juvenile period). *B. ledifolia* (closely related to *B. granitica*) and *B. serrulata* are fire sensitive species that were found to flower four or five years after fire in the Hawkesbury Sandstone vegetation (Benson 1985). *B. parviflora*, a resprouter of swampy heaths, is estimated to have a primary juvenile period of more than five years, although this period is thought to generally be longer in resprouters than seeders (Keith 1991). Preliminary observations suggest that *B. granitica* may flower in its third or fourth year (J. Westaway pers. obs.), which is consistent with the estimated primary juvenile period of 4-8 years for other restricted outcrop shrubs with similar regenerative strategies (Clarke and Fulloon 1999).

5.2 Reproductive biology

B. granitica is a dicotyledonous angiosperm that, once mature, flowers and sets seed annually. The species appears to have an extended flowering season from July to December, concentrated over spring. Fewer individuals flower in other months, although this may vary annually with local climatic conditions.

Little is known of the breeding system of *B. granitica*. All *Boronia* section *Valvatae* are described as self-incompatible (Weston *et al.* 1984). Thus, pollen transfer is required for successful fertilisation. Self-incompatibility implies an outcrossing breeding system with isolated pollen centres (populations) diverging genetically over time according to conventional speciation theory. However, the reduction in size of pollen centres, for instance due to clearing, could potentially force inbreeding. The ramifications of such changes are unknown but may speculatively include declines in genetic integrity and population viability. A detailed investigation of pollination mechanisms in *B. granitica* would improve understanding of the species' breeding system.

The flowers from plants in the *Boronia* genus emit volatile oils. The location and timing of these emissions suggest a role in attracting pollination vectors (Weston *et al.* 1984). There are no known limits to pollination in *B. granitica*, although little information is available because pollination vectors and mechanisms have not been studied. Unidentified beetles were attending flowers at one location during spring 1998 (J. Westaway pers. obs.) and beetles are thought to be involved in pollination of other *Boronia* species (M. Duretto pers. comm.). The role of introduced honeybees in pollination of *B. granitica* at sites in the Torrington SRA may also be significant given the proximity of at least 40 apiary leases to the area. More research is needed into the pollination ecology and population genetics of *B. granitica*.

Little is known of the fate of seed released from *B. granitica* but seeds of more than 30 percent of the sclerophyll shrub flora of low nutrient soils in Australia are ant dispersed (myrmecochory) (Beattie 1991). Seed of many *Boronia* species is likely to be ant dispersed (Berg 1975) and this is the case for the closely related *B. boliviensis* m.s. where seed has been found in excavated ant nests (Morsley and Falconer in prep.).

Seeds buried by ants are safe from fire and predation and are removed from competition with sympatric species for establishment microsites (Beattie 1991). The depth of burial affects dormancy breaking, germination and seedling emergence. In a study of ant-seed interaction in sclerophyll forest in Queensland, Drake (1981) found that the removal of seeds by ants could potentially deplete the available seed supply for regeneration, especially

if taken to unsuitable germination sites such as wood ant nests. In most cases, however, sufficient seed for regeneration remains after predator satiation has been reached (Drake 1981).

Beattie (1991) suggested that ants transport seeds mostly within 10-20 metres of the parent plant. Seed dispersal by rainfall runoff may exceed such distances where microtopographic variation is minimal allowing unhindered flow of high rainfall events down slope. Nonetheless, seed dispersal ability in *B. granitica* seems to be relatively poor when compared with other vascular plants.

The small hard seeds of *B. granitica* accumulate in the soil until dormancy is broken by germination cues. The related *B. keysii*, of more mesic environments in southern Queensland accumulated a large viable seed bank in the soil over an inter-fire period extending two decades (Leigh and Briggs 1992). The soil-stored seed bank of *B. granitica* is thought to be relatively small and suspected to be moderately long-lived (Clarke and Fulloon 1999). More research is needed into the role of ants in dispersing the seed of *B. granitica* and into long term viability of seed banks in soil.

6 Disturbance, threats and reasons for decline

Due to its intrinsic habitat specificity, *Boronia granitica* may have always had a restricted distribution, confined to heathy vegetation associated with large expanses of granite outcropping on the mid-elevation, dry western side of the New England Batholith. However, populations of *B. granitica* may have declined since European settlement of the area as a result of grazing by stock and feral goats, inappropriate fire regimes, mineral exploration, mining, quarrying and bushrock collection. Widespread land clearance and disturbance may have also impacted on the distribution of the species although this assumption is based principally on circumstantial evidence. A summary of impacts on *B. granitica* populations in various areas is given in Table 5.

Table 5: Relative impact of major current or potential threats to main population areas of *Boronia granitica*

Threat	Parlour Mountain	Howell area	Kings Plains	Severn River / The Barbs & adj. private land	Torrington area
Browsing of plants, especially by feral goats	high	high	moderate	moderate	moderate*
Inappropriate fire regimes	moderate	high	moderate	**moderate**	moderate*
Soil disturbance from mining and exploration activities	low	moderate	low	low	moderate
Loss of habitat to agricultural activities or access tracks	moderate	moderate	low	moderate	low

Note:
* down from 'high' as a result of active NPWS management.

6.1 Grazing

It was noted as early as 1932 that plants in the Elsmore area identified as *B. granitica* (but now requiring confirmation) were 'eaten by stock in the drought' (McKie herbarium label) and that this may have contributed to the disappearance of the species from this area. At Torrington SRA, stock grazing is permitted under licence but it is unclear whether any populations of *B. granitica* have been adversely affected. The draft Plan of Management for the SRA recommends elimination of grazing from the reserve by 2005.

The rocky habitat of *B. granitica* possibly confers a degree of protection from disturbance by domestic stock, but not from goats which can gain access to the entire landscape (Quinn

et al. 1995). Feral goats are now abundant in the Howell area and pose an increasing threat to the vegetation community (Hunter and Clarke 1998). A drastic reduction of the *B. granitica* population to critically low numbers has occurred at Parlour Mountain where two of the three plants that persist at the site have been eaten by goats (Hunter and Bruhl 1997). Feral goats and cattle also threaten vegetation on other outcrops in this area (Hunter and Clarke 1998). Evidence of feral goat activity was frequently recorded on the rocky outcrop heaths and shrubby stringybark woodlands supporting *B. granitica* in the Torrington area (Hunter and Clarke 1998) and Clarke *et al.* (1998) has stated that this threatens populations of some plant species.

Populations of *B. granitica* in the Howell area have declined since the type specimen was collected there nearly a century ago. *B. granitica* plants were observed to be heavily browsed by macropods in this area in the 1960s (Quinn *et al.* 1995). Macropod grazing could be considered a natural occurrence, although the populations of certain larger macropods may be artificially high due to agriculture. These reports suggest *B. granitica* is palatable despite bearing small, hairy leaves with oil glands. However, macropod grazing may also be related to shifts in food preferences during times of low resource availability such as drought.

6.2 Fire

The heathy vegetation that forms the habitat of *B. granitica* is characterised by a dominance of scleromorphic shrubs in conditions of high light penetration, low soil moisture retention, and slow litter decomposition. These factors and the volatile oils characteristic of the *Eucalyptus* overstorey and *Boronia* itself all contribute to a fire prone environment, as is typical for much of the Australian autochthonous vegetation (Specht 1981).

Many shrubs of heathy vegetation communities germinate prolifically after fire (Benson 1985, Keith 1996), including some *Boronia* species (M. Duretto pers. comm.). Others resprout from rootstock, such as the undescribed *Boronia* sp. aff. *microphylla* at Torrington and *B. parviflora* of upland swamps (Keith 1991), or are facultative resprouters such as *B. falcifolia* and *B. safrolifera* (Benwell 1998) of coastal heaths and the rare *B. galbraithiae* of dry sclerophyll forest in Victoria (Albrecht and Walsh 1993).

Post-fire vegetative resprouts of *B. granitica* have not been observed in the field. Thirty *B. granitica* individuals were burnt during fire research at Torrington and none resprouted (Clarke and Fulloon 1999). Lignotubers or similar root structures are absent and regeneration relies on the successful germination of seed and survival of seedlings, that is, the species is an obligate seeder.

Dormancy in soil stored seed of many obligate seeding plants is broken by heat (Keith 1996, Clarke and Fulloon 1999). Some Rutaceae have germination promoted by exposure to smoke from burnt native vegetation and an enhanced germination response to heat has been demonstrated for the persistent soil seed bank of some *Boronia* species (Keith 1996). A pH-sensitive enzyme is suspected of being the seed dormancy factor in *Boronia* and the enzyme is neutralised and denatured by basic post-fire leachates (Armstrong 1989). In recently conducted field experiments fire has been demonstrated to trigger or stimulate seed germination of *B. granitica* with a post-fire result of 1-10 seedlings present per square metre (Clarke and Fulloon 1999). The precise response to fire of the soil stored seed is likely to vary with components of the fire regime (intensity, season), fire residence time (duration) and local site conditions (eg. soil moisture availability).

It has been suggested that the low fire frequency at Howell may have adversely affected *B. granitica* populations in that area (Quinn *et al.* 1995) based on significant changes to the flora including the loss or reduction of several other species in the long fire-free period (Hunter 1998). Obligate seeders generally require periodic fire for substantial regeneration but some species, including the related *B. keysii* of southern Queensland (Leigh and Briggs 1992), achieve some regeneration in the absence of fire. Young plants of *B. granitica* have been observed in heathland that appeared not to have carried a fire for several years (J.

Westaway pers. obs.), suggesting that fire may not always be a prerequisite for germination. Recruitment cues other than fire (eg. soil disturbance) have been suggested in the establishment of young cohorts of the closely related *B. boliviensis* m.s. in long unburnt heath (Morsley and Falconer in prep.). Seasonal drought may also underlie the waxing and waning of *B. granitica* plants occurring in low moisture-retaining habitats but these effects have not been documented.

For species to persist in a fire prone environment new recruits must not only flower between successive fires, but also replenish propagule reserves. In a study of heathy woodland regeneration in Victoria, Wark *et al.* (1987) found that although most shrubs commenced flowering within two years of fire, few produced seed, suggesting that early post-fire flowering does not necessarily result in seedlings. Obligate seeding species are likely to be severely disadvantaged and possibly eliminated by a series of fires at intervals less than the time taken for the new cohort to produce sufficient seed (Benson 1985).

Conversely, if inter-fire periods extend beyond the longevity of plants and soil-stored seed bank, then adult plants will age and the accumulated seed become non-viable. During long fire-free periods local population extinctions may occur. Species most vulnerable to this are perennials which are killed by fire (Benson 1985, Gill and Bradstock 1995), irrespective of whether propagules for replenishment are canopy or soil stored.

Keith (1996) listed a number of fire-driven mechanisms of plant population decline and extinction that may be relevant to *B. granitica*:

1. depletion of standing plants and seeds through senescence and competition with community dominants;
2. high seedling mortality due to resource deprivation, competition, predation and disease;
3. low recruitment rate relative to mortality due to germination of few seeds caused by poor soil heating; and
4. low seed availability due to failure to satiate predators.

The majority of fires recorded in *B. granitica* habitat are large wildfires, control burns or arson events, not small-scale lightning events that rocky outcrops are prone to. The myriad of small-scale lightning induced fires that fail to spread due to low fuel loads are mostly unrecorded let alone mapped. The patchy (mosaic) distribution of fires from lightning strikes may be an important ecological process providing *B. granitica* with adequate regeneration opportunities.

Field observations suggest that when burnt by intense fires and even scorch burning, standing plants of *B. granitica* are usually killed outright (Gill and Bradstock 1992). In their study of fire and rare plants at Torrington SRA, Clarke and Fulloon (1999) classified *B. granitica* as 'highly sensitive' to inappropriate fire regimes because it is an obligate seeder with a soil-stored seed bank. They recommended that plant populations of 'high sensitivity' to fire frequency (such as *B. granitica*) not be burnt more frequently than 8-10 years, nor have fire excluded for more than 20 years. Alternatively, Hunter (1999) has recommended even longer (30-100 year) fire exclusion periods for certain vegetation communities (including communities containing *B. granitica*) within Kings Plains NP.

High frequency fire is currently listed as a key threatening process on Schedule 3 of the TSC Act (NSW Scientific Committee 2000a). In the determination for this key threatening process, *B. granitica* was identified as a species adversely affected by high frequency fire, which disrupts lifecycle processes.

In summary, the most current and thoroughly researched studies conclude that *B. granitica* is adversely affected by frequent fire and that much longer fire exclusion periods than those that occur at present should be part of future fire management strategies. More research is needed into the response of *B. granitica* to fire, especially in relation to lightning strikes, and optimal fire frequency.

6.3 Mining, quarrying and bushrock collection

Activities associated with mineral exploration, mining, granite quarrying and bushrock collection can be highly localised, and represent significant threats to *B. granitica* populations. These activities often require removal or damage of native vegetation and, in the case of open-cut mining, massive soil disturbance.

It is unknown whether specific sites supporting *B. granitica* have been mined in the past and the species is not known to occur on specific lands subject to current mining leases. However, the Howell area has experienced considerable local soil disturbance from mining activities whilst mineral exploration and mining are permitted in Torrington SRA under various mining lease options. The species is also known to occur on lands subject to current exploration licences. The perpetuation of these lease and exploration options could present a threat to *B. granitica* populations in the Torrington area (Hunter and Clarke 1998) unless appropriate environmental mitigation amendments are included. The environmental assessment requirements for the Department of Mineral Resources (DMR) and the NSW National Parks and Wildlife Service (NPWS) are currently under review in relation to these leases and licences. It has been agreed that future activities will be undertaken in a manner that avoids or minimises adverse impacts on the species and that the known occurrence of the species will be supplied to future lease and licence applicants.

Bushrock removal is currently listed as a key threatening process on Schedule 3 of the TSC Act (NSW Scientific Committee 1999). In the determination for this key threatening process *B. granitica* was identified as a species adversely affected by bushrock removal, which destroys and disturbs habitat.

The effect of soil disturbance on the seed bank of *B. granitica* is unknown but the likelihood of germination seems low without heat stimulation. Young individuals of *B. boliviensis* m.s. occur under a powerline easement on Bolivia Hill suggesting that, for this sister species, a recruitment cue other than fire, such as scarification of the seeds, may also be involved in reproduction. The impact of limited soil disturbance on germination of *B. granitica* requires further research.

6.4 Land clearance

Clearing of native vegetation has been listed by the NSW Scientific Committee as a key threatening process on Schedule 3 of the *Threatened Species Conservation Act 1995*. Clearing of native vegetation for agriculture and other purposes has been widespread on the New England Tablelands and has often included the less productive areas surrounding granite outcrops. Although possibly affected less than plants in more fertile areas, *B. granitica* and the associated flora of granite outcrops are, nevertheless, restricted in distribution and vulnerable to further clearing.

Vegetation removal for activities adjacent to known populations may also pose a risk. An example is the clearing for tracks on private property adjacent to Severn River NR where an ecologically significant stand of *B. granitica* occurs on deep red soils (J. Hunter pers. comm.).

Herbicide application on farmlands adjacent to rocky outcrops in the Tenterfield area has encroached significantly on native vegetation communities and may also be adversely affecting *B. granitica* populations (P. Croft pers. comm.).

6.5 Low population numbers

Reduction in the population size and distribution of *B. granitica* due to the above threats can result in stochastic (chance) events becoming increasing significant in the local extinction of the species. For example, the role of prevailing winds can affect the likelihood of successful cross-pollination between plants.

7 Relevant legislation

7.1 Recovery plan preparation and implementation

Recovery plan preparation
The TSC Act requires that the Director-General of National Parks and Wildlife prepare recovery plans for all species, populations and ecological communities listed as endangered or vulnerable on the TSC Act schedules. Similarly, the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) requires the Commonwealth Minister for the Environment ensure the preparation of a recovery plan for nationally listed species and communities or adopt plans prepared by others including those developed by state agencies. Both Acts 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 to satisfy the requirements of both the TSC Act and the EPBC Act. It is the intention of the Director-General of National Parks and Wildlife to forward the final version of this recovery plan to the Commonwealth Minister for the Environment for adoption, once it has been approved by the NSW Minister for the Environment.

Recovery plan implementation
The TSC Act requires that a government agency must not undertake actions inconsistent with a recovery plan. The government agency responsible for actions in this plan is the NPWS. Consequently, the NPWS must manage *Boronia granitica* populations in accordance with this recovery plan. Where *B. granitica* occurs on private property (eg. Parlour Mountain) and on permissive occupancy or leasehold lands (eg. Howell), the implementation of the recovery plan will largely depend on cooperative management of the species between the relevant title holder and the NPWS.

In some cases, where further approvals may be needed under the *Native Vegetation Conservation Act* 1997 (NVC Act) or the *Environmental Planning and Assessment Act* 1979 (EP&A Act), other public authorities may be involved as part of their core legislative responsibilities. Public authorities, other than the NPWS, with core legislative responsibilities relevant to the protection of *B. granitica* and its habitat are listed in Table 6.

The EPBC Act specifies that a Commonwealth agency must not take any action that contravenes a recovery plan.

Table 6: Public Authority Responsibilities

Organisation	Relevant responsibilities
Relevant councils include Guyra, Tenterfield and Severn	• Preparation of Local Environmental Plans under Part 3 of EP&A Act.
	• Consent authorities for development proposals under Part 4 of EP&A Act.
	• Approval authorities for council works under Part 5 of EP&A Act.
	• Responsibilities under *Rural Fires Act* 1997.
Department of Land and Water Conservation	• Approval authority for native vegetation clearance applications under NVC Act.
	• Management of Crown Land with potential habitat.
	• Coordination of Regional Vegetation Management Committees, Total Catchment Management and Landcare programs.
	• Coordination of voluntary property agreements and Native Vegetation Incentive Fund.
Department of Urban Affairs and Planning	• Development of policy and strategies for land-use planning and environmental assessment.
	• Advice and assistance on environmental planning matters
	• Assessment of major development applications.
Department of Mineral Resources	• Approval authority for activity proposals under Part 5 of EP&A Act.

7.2 State legislation

National Parks and Wildlife Act 1974 and Threatened Species Conservation Act 1995
The TSC Act makes provision for identification and declaration of critical habitat for species, populations and ecological communities listed as endangered. Once declared, it becomes an offence to damage critical habitat and a species impact statement is mandatory for all developments and activities proposed within critical habitat. Nomination of critical habitat for *B. granitica* will only be considered as a management option where other, more cooperative, approaches are unavailable.

Environmental Planning and Assessment Act 1979
The TSC Act amendments to the environmental assessment provisions of the EP&A Act require that consent and determining authorities consider threatened species and their habitat when exercising a decision-making function under Parts 4 and 5 of the EP&A Act. Therefore, when considering any development or activity within known or potential habitat of *B. granitica*, the determining authorities should consider the conservation strategy set out in this plan.

Native Vegetation Conservation Act 1997
The purpose of the NVC Act is the conservation and sustainable management of native vegetation and in particular the protection of native vegetation of high conservation significance. Under this Act, approval from the Department of Land and Water Conservation (DLWC) is a prerequisite for clearing of native vegetation unless a Regional Vegetation Management Plan has been approved or unless the clearing is an exemption under the NVC Act. There remains potential for significant and cumulative clearing to occur under these exemptions. The Act requires that the Director-General of National Parks and

Wildlife be consulted in the matter of threatened species and their habitat. Landholders may enter into voluntary property agreements with DLWC whereby government assistance can be provided to protect native vegetation under the Native Vegetation Incentive Fund. No regional vegetation management plan or property agreements relating to the habitat of *B. granitica* have yet been prepared.

Rural Fires Act 1997
Bush Fire Risk Management Committees must prepare draft bush fire risk management plans for their respective rural fire districts and are obliged to consider threatened species conservation. These plans may restrict or prohibit the use of fire and other fire hazard reduction activities in all or specified circumstances or places to which the plan applies. In particular, an adopted bush fire risk management plan may modify or prohibit hazard reduction activities in threatened species habitat.

Forestry and National Park Estate Act 1998
The *Forestry and National Park Estate Act* 1998 puts into effect the outcomes of the Government's Regional Forest Agreement. The agreement outlines licence conditions for threatened species within State Forests of NSW estate. These include a general licence condition that a standard 20 metre exclusion zone is to be applied around all rocky outcrops and cliffs greater than 0.1 hectares in area and another condition that 20 metre exclusion zones be applied around all known *B. granitica* populations. It is recommended that these conditions also be included in Regional Vegetation Plans being prepared by DLWC under the NVC Act.

7.3 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999
The EPBC Act provides a legislative framework for the protection of endangered and vulnerable species across Australia. An important role of the EPBC Act is to facilitate the preparation and implementation of recovery plans for species listed under the Act in cooperation with the States in which populations of listed species occur. The Act also seeks to impose the obligation (arising from the listing) for responsible agencies (particularly Commonwealth) to adopt protective measures. This recovery plan will be submitted to the Commonwealth for approval under the EPBC Act.

Under the EPBC Act, critical habitat may be registered for any nationally listed threatened species or ecological community. When adopting a recovery plan the Commonwealth Minister for the Environment must consider whether to list habitat identified in the recovery plan as being critical to the survival of the species or ecological community. It is an offence under the EPBC Act for a person to knowingly take an action that will significantly damage critical habitat (unless the EPBC Act specifically exempts the action). This offence only applies to Commonwealth areas. However, an action which is likely to have a significant impact on a listed species is still subject to referral and approval under the EPBC Act.

As *B. granitica* is listed nationally under the EPBC Act, any person proposing to undertake actions likely to have a significant impact on this species should refer the action to the Commonwealth Minister for the Environment for consideration. The Minister will then decide whether the action requires EPBC Act approval. This is in addition to any State or Local Government approval requirement specified for the NSW EP&A Act.

Administrative guidelines are available from Environment Australia to assist proponents in determining whether their action is likely to have a significant impact. In cases where the action does not require EPBC Act approval, but will result in the death or injury of a member of the species and the member is in, or on a Commonwealth area, a permit issued by the Commonwealth Minister under the EPBC Act, will be required.

8 Social and economic consequences

8.1 Intrinsic ecological value

The ecological function of *Boronia granitica* is unknown but the species has intrinsic value as a species with a narrow ecological amplitude and as a component of specialised vegetation communities restricted to a resource-poor, fire-prone environment.

8.2 Scientific and taxonomic value

B. granitica has considerable scientific value as a geographically and ecologically restricted species, as an example of granite island biogeography, and as a fire-sensitive 'obligate seeder' of granite outcrops for fire ecology research. *B. granitica* also has considerable taxonomic interest as it and its two closest congeners represent a small clade in the *B. ledifolia* group of section *Valvatae* that are all rare and restricted species.

8.3 Biodiversity value

The occurrence of *B. granitica* contributes to the high biodiversity of the flora of the northern tablelands and slopes of NSW. Granite outcrop vegetation communities on the New England Batholith are significant in terms of the high number of ROTAP species recorded (Hunter and Clarke 1998). Many of these species (see Table 7) occur sympatrically with *B. granitica* and would benefit from conservation efforts directed towards *B. granitica*.

Table 7: Rare or threatened flora occurring with *Boronia granitica*

Species	Species
Acacia betchi	*Eriostemon myoporoides* ssp. *epilosus*
Acacia granitica	*Hibbertia* sp. B
Acacia williamsiana	*Homoranthus biflorus*
Acacia torringtonensis	*Homoranthus prolixus*
Allocasuarina brachystachya	*Persoonia terminalis* ssp. *terminalis*
Astrotricha roddii	*Phebalium rotundifolium*
Babingtonia odontocalyx	*Prostanthera staurophylla*
Brachyloma saxicola	*Pultenaea stuartiana*
Dodonaea hirsuta	

References:
Quinn *et al.* (1995), Briggs and Leigh (1996), Clarke *et al.* (1998), Hunter and Clarke (1998), Richards *et al.* (1998).

Boronia granitica has been identified as a member of an assemblage of species characterising the Howell Shrublands ecological community, which occurs in the Inverell and Manilla local government areas within the New England and Nandewar bioregions (see Hunter and Clarke 1998). In 2000, this community was listed as an endangered ecological community on Part 3 of Schedule 1 of the TSC Act (NSW Scientific Committee 2000b). Therefore, actions directed toward conservation of *B. granitica* may also benefit this endangered ecological community.

Rare and threatened plants represent those plant species at greatest risk of becoming extinct due to human-induced causes. As such, they are priority species to consider in conservation efforts aimed at arresting further loss of biodiversity from our natural ecosystems.

8.4 Pharmaceutical and commercial value

There are no known pharmaceutical or other commercial values of *B. granitica*. The species has an abundance of the aromatic oils in the foliage that are characteristic of the Rutaceae that may have some, as yet unknown, application. Although *B. granitica* has been cultivated in NSW in the National Endangered Flora Collection, the species is not generally known to be under horticulture. However, it has potential as a garden plant because it exhibits masses of relatively large (for *Boronia*), bright pink flowers over several months.

8.5 Social benefits

The preparation of this recovery plan provides an information source for future research and management of *B. granitica* and may assist similar efforts directed at related species or plants occurring in the same habitat. Through awareness of the fate of *B. granitica* the profile of all threatened plant species is raised in the general community. This in turn leads to greater opportunities for the conservation of threatened species, an appreciation of the need for sustainable development, and increased protection of biodiversity.

9 Previous actions undertaken

No practical management efforts aimed directly at recovery or protection of *Boronia granitica* have been instigated on private lands. The establishment of Kings Plains NP and Severn River NR and their additions, as examples of intact land systems on the predominantly agricultural north-western slopes, have made a significant contribution to the conservation of the species on public land.

After surveying the vegetation of the Torrington SRA the Division of Botany, University of New England, has been further contracted by the NPWS to carry out initial research into components of the fire ecology of Torrington's threatened flora. Preliminary results are reported in this plan.

As part of the Comprehensive Regional Assessment of forests, the NPWS modelled a select group of 'critically threatened' species, including *B. granitica*, and convened an expert workshop to derive provisional population viability analyses (PVAs). The preliminary 'biophysical envelope' model developed for *B. granitica* appeared too broad for an effective distribution predictive tool (Summary outcomes of the CRA Threatened Flora Expert Workshops, July 1998).

10 Species' ability to recover

The underlying reasons for the natural rarity of *Boronia granitica* are poorly understood but may include poor dispersal ability, fire sensitivity and competitive exclusion from more favourable habitats. The fire-shadow and 'refuges' model discussed by Gill and Bradstock (1995) predicts that areas such as boulder outcrops would support more 'seeder' species than the surrounds. This fire refugial aspect of outcrops is likely to be just one of several factors confining many shrubs to rocky outcrops. Other interacting factors may include physiological tolerance of shallow soils and the absence of trees (Clarke *et al.* 1998).

Given the estimated size of *B. granitica* populations in the Severn River, Kings Plains, Torrington and Howell areas and the reservation status of the first two areas there appears no absolute constraints to the long term viability of the species. Options to reduce the likelihood of population decline include feral animal control and careful fire management. The success of the latter is likely to be assisted by an improved understanding of the species' fire ecology gained from research initiatives.

11 Recovery objectives and performance criteria

11.1 Objectives of the recovery plan

The overall objective of this recovery plan is to protect known populations of *Boronia granitica* from decline induced by non-natural agents and to ensure that these populations remain viable in the wild in the long term.

Specific objectives of this recovery plan are to:

- improve the long-term viability of reserved populations;
- improve the viability of known non-reserved populations;
- determine if further populations exist on granite outcrops elsewhere on the New England Tablelands;
- increase our understanding of the ecology of *B. granitica*; and
- identify and ameliorate threatening processes.

11.2 Recovery performance criteria

Recovery criteria are:

- cessation of feral goat browsing at the Parlour Mountain location and reduction of goat (and stock) interference at Howell;
- reduction in feral goat populations in NPWS estate to a minimum;
- an improved understanding of the biology and ecology of *B. granitica* is sufficient to enable management for long-term viability of the species in NSW;
- reserved populations do not suffer any reduction due to human induced causes;
- populations that are not reserved are protected by appropriate measures;
- evidence of seedling establishment and recruitment at all or most population areas; and
- site monitoring to indicate population stability (given natural fluctuations).

12 Recovery actions

12.1 Implement research and monitoring programs

12.1.1 Efforts directed to the recovery of *B. granitica* will continue to be hampered by the current inadequate understanding of the life history of the species. Research into aspects of the species ecology such as floral phenology, pollination biology, life stage longevity, seed dispersal, seed viability and seed bank dynamics will assist recovery through improved knowledge.

12.1.2 Population monitoring provides a mechanism to measure the outcomes of management actions and can, therefore, be used to help assess the degree to which factors such as fire and feral animals are implicated in the decline of *B. granitica*. Quantitative results from research and population monitoring can be incorporated into an adaptive management approach and help reduce uncertainty in biodiversity conservation.

12.1.3 Effective fire management strategies for *B. granitica* include the determination of an appropriate fire frequency. This is best developed in cognisance of the species' primary juvenile period, time required to establish a viable soil seed reservoir, recruitment rate and longevity. The following recommended research action can

provide this information and should be undertaken by a university or competent botanist. For cost effectiveness, such work could ideally be integrated into wider ecological research covering sympatric rocky outcrop species, especially the higher priority taxa, ie. those most threatened or restricted. It is recommended that a research program be designed and conducted focussing on experimental burns of tagged individuals at multiple sites. This should be followed by monitoring of germination, seedling establishment and survivorship, age at which recruits flower and set seed, the period required for replenishment of seed bank, seed longevity and mortality rates and causes.

The Division of Botany, University of New England, and the NPWS Northern Tablelands Region have recently established a detailed program studying fire and rare plants, including *B. granitica*, at Torrington SRA and initial post-fire results are presented in Clarke and Fulloon (1999). It would be logical and prudent for these authorities to continue this program through the plant's life stages to attain the other important life history information. Results of these programs should be correlated with the variables of temperature of burn (fire intensity) and post-fire climatic conditions.

As the impacts of herbivores can increase after fire, feral animal control may be required before experimental burns and post-fire browsing can be managed and monitored.

12.1.4 Concurrent with fire response experiments, plant-insect observational study, seed storage tests and seed burial and retrieval experiments should be conducted to reveal pollination vectors and mechanisms, aspects of seed dispersal and predation and seed dormancy and viability periods. Experimental testing for additional cues to break seed dormancy and initiate recruitment such as smoke or scarification would also be valuable in order to help determine the likelihood of recruitment in the absence of fire.

12.1.5 Conduct further surveys of suitable habitat, including the area near Elsmore, to confirm the presence of new populations on granite outcrops elsewhere on the New England Tablelands.

Outcome: Collation of ecological and life history information that assists the conservation and management of *B. granitica*.

12.2 Manage current reserved areas

12.2.1 In the development of Fire Management Plans for Kings Plains NP and Severn River NR, the NPWS should recommend an interim fire management strategy that ensures that locations of *B. granitica* populations are not burnt more frequently than 8-10 years and preferably have fire excluded for at least 20-30 years. This strategy should be reviewed in the light of further results of fire ecological research (see Section 6.2).

12.2.2 The NPWS should ensure that park workers are aware of the significance and location of the species and that park works, infrastructure and maintenance do not encroach on the species.

12.2.3 Continue with feral goat control and monitoring programs.

12.2.4 Continue to monitor the *B. granitica* population demographics regularly every 2 or 3 years.

Outcome: The conservation of the species where it is known in reserved areas is ensured.

12.3 Manage the Torrington State Recreation Area population

12.3.1 The status of Torrington SRA should be reviewed on account of its high botanical significance with the aim of improving the security of tenure of either the entire SRA or, at least areas of highest conservation value under National Park or Nature

Reserve status. The effectiveness of the Memorandum of Understanding between the DMR and the NPWS in regard to the conservation of *B. granitica* in the SRA should also be assessed.

12.3.2 An assessment should be undertaken of the effectiveness of legislative planning controls that require consideration of *B. granitica* habitat on lands that have potential for exploration, mining and other extractive industries such as granite quarrying and bushrock collection. Mining leases and exploration licences over specific sites that support *B. granitica* populations should be amended to ensure that activities are undertaken in a manner that avoids or minimises adverse impacts.

12.3.3 The NPWS should implement control of feral goats.

12.3.4 An appropriate fire management strategy should be included in the Plan of Management for the SRA and a provisional strategy implemented that is in accordance with the ecological requirements of *B. granitica* and other sympatric threatened species. These should include those species of extreme fire sensitivity, and be in accordance with results of Clarke and Fulloon (1999) and the recommendations of Hunter (1999).

Outcome: The Torrington population is conserved.

12.4 Manage the Howell and Parlour Mountain populations

12.4.1 Control of feral goats is the priority recovery action for these populations. This can be accomplished by culling programs and the fencing of the three plants at Parlour Mountain.

12.4.2 Small scale trial controlled burning should be undertaken to try to stimulate seed bank germination (avoid burning remaining plants at Parlour Mountain by selecting equivalent adjacent habitat). The response to trial burns should be recorded and the fate of any subsequent seedlings monitored.

12.4.3 Where *B. granitica* occurs on private property, landholders should be approached with a view to entering Voluntary Conservation Agreements under the NPW Act, Property Agreements under the NVC Act and/or preparing Property Management Plans under the TSC Act. Financial incentives are available from DLWC under the Native Vegetation Incentive Fund to assist in the management of the species on private lands.

Outcome: Known populations on private lands are conserved in cooperation with landholders.

12.5 Publicity

12.5.1 The NPWS Northern Tablelands Region have produced a free poster on threatened plants, including *B. granitica*, and a landowners guide book that includes management guidelines for the species (NSW NPWS 1999). An information leaflet for *B. granitica* has also been prepared (refer Appendix 2). These documents should continue to be distributed and promoted among local councils, landholders and leaseholders of granite country in the Tenterfield, Inverell, Severn, Guyra and Armidale areas. This will help increase public awareness of the status of rare flora including *B. granitica* and the value of remnant vegetation. Such information can potentially generate new records of the species from private property.

Outcome: Public awareness of the species is increased and new populations are found and conserved.

12.6 Horticulture

12.6.1 *B. granitica*, in common with much of the genus, is likely to have considerable horticultural appeal and has been successfully propagated using cuttings of matured new growth tips (see Section 8.4). Specialist authorities (eg. University of New

England, Mt Annan Botanical Gardens and Royal Botanic Gardens) will be encouraged to propagate the species. Plants will then be distributed through local Landcare and Greening Australia groups or commercial nurseries. More information is also available from the 'Boronia and Allied Genera Study Group' of the Australian Plants Society.

Outcome: The genetic variability of the species is maintained and its susceptibility to stochastic events that hinder its conservation is reduced.

13 Implementation

The following table allocates responsibility for the implementation of recovery actions specified in this plan to relevant government agencies. Each action is costed in Appendix 1.

Table 8: Implementation schedule for recovery actions

Section	Description	Responsibility for implementation	Timeframe	Priority
12.1	**Research and monitoring**			
12.1.1	determine life history attributes and reproductive biology	NPWS	subject to funding	2
12.1.2	monitor seedling establishment and survivorship	NPWS	life of plan	1
12.1.3	experimental study of fire and disturbance ecology	NPWS/Research Institutions	begun	2
12.1.4	investigate additional recruitment cues	NPWS/Research Institutions	subject to funding	3
12.1.5	conduct further surveys	NPWS	subject to funding	3
12.2	**Manage current reserved areas**			
12.2.1	implement provisional adaptive fire management strategy	NPWS	life of plan	1
12.2.2	staff education and work impacts	NPWS	ongoing	1
12.2.3	feral goat control	NPWS	ongoing	1
12.2.4	monitor population structure	NPWS	year 1,3,5	2
12.3	**Manage Torrington population**			
12.3.1	investigate partial SRA tenure status change	NPWS subject to community consultation	year 1	2
12.3.2	review planning instruments in mining process, amend mining and exploration leases where relevant	NPWS	year 1	1
12.3.3	feral goat control	NPWS	ongoing	2
12.3.4	prepare and implement provisional adaptive fire management strategy	NPWS	life of plan	2
12.4	**Manage the Howell and Parlour Mountain populations**			
12.4.1	feral goat control and fencing at Parlour Mountain	NPWS	ongoing	1
12.4.2	conduct fire regeneration trials and monitor recruits	NPWS subject to consultation with landholders	year 1 and ongoing	2
12.4.3	present conservation agreements to landholders	NPWS	year 2	3
12.5	**Publicity**			
12.5.1	disseminate information leaflet	NPWS	year 1	3
12.6	**Horticulture**			
12.6.1	Cultivate in nurseries etc.	specialist authorities	year 2,3	3

Note:
Recovery action implementation priority categorised as 1 (essential), 2 (highly desirable) and 3 (desirable).
Equivalent research identified in 12.1 has been instigated by Division of Botany, UNE as part of multi-species fire and rare plant study at Torrington SRA.

14 Preparation details

This recovery plan was prepared by John Westaway under contract to the Threatened Species Unit, NPWS Northern Directorate. Assistance was provided by John Martindale, Monica Collins and Shane Ruming, all of the Threatened Species Unit, NPWS Northern Directorate.

14.1 Date of last amendment

No amendments have been made to date.

14.2 Review date

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

15 Acknowledgments

Information was provided by John T. Hunter, Peter Clarke and John Williams of the Division of Botany, University of New England, Marco Duretto of the National Herbarium, Royal Botanic Gardens, Melbourne, and Alex Wyatt of NPWS Northern Tablelands Region. Michael Murphy, Threatened Species Unit, NPWS Northern Directorate reviewed the draft plan.

16 Acronyms used in this document

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
CRA	Comprehensive Regional Assessment
DLWC	Department of Land and Water Conservation
DMR	Department of Mineral Resources
DUAP	Department of Urban Affairs and Planning
EP&A Act	NSW *Environmental Planning and Assessment Act* 1979
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999
NP	National Park
NPW Act	NSW *National Parks and Wildlife Act* 1974
NPWS	NSW National Parks and Wildlife Service
NR	Nature Reserve
NSW	New South Wales
NVC Act	NSW *Native Vegetation Conservation Act* 1997
PA	Property Agreement
PMP	Property Management Plan
PVA	Population Viability Analysis
ROTAP	Rare Or Threatened Australian Plant (Briggs and Leigh 1996)
SRA	State Recreation Area
TSC Act	NSW *Threatened Species Conservation Act* 1995
UNE	University of New England
VCA	Voluntary Conservation Agreement

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Appendix 1: Implementation costs

Estimated costs of implementing the actions identified in the recovery plan are provided below. All costs are unsecured funds unless noted otherwise.

Section	Description	Priority	Year 1	Year 2	Year 3	Year 4	Year 5
12.1 Research and monitoring	12.1.1 determine life history attributes and reproductive biology	2	2000	1500	1000	500	500
	12.1.2 monitor seedling establishment and survivorship	1	2000	2000	1000	500	500
	12.1.3 experimental study of fire and disturbance ecology	2	3000	2000	2000	1000	500
	12.1.4 investigate additional recruitment cues	3	-	2000	1000	-	-
	12.1.5 conduct further surveys	3	4000				
12.2 Manage current reserved areas	12.2.1 implement provisional adaptive fire management strategy	1	✔	✔	✔	✔	✔
	12.2.2 staff education and work impacts	1	✔	✔	✔	✔	✔
	12.2.3 feral goat control	1	✔	✔	✔	✔	✔
	12.2.4 monitor population structure	2	1500	-	1000	-	500
12.3 Manage the Torrington population	12.3.1 investigate SRA tenure status change	2	✔	-	-	-	-
	12.3.2 review planning instruments in mining process, amend leases	1	●	-	-	-	-
	12.3.3 feral goat control	2	✔	✔	✔	✔	✔
	12.3.4 prepare and implement fire management strategy	2	✔	✔	✔	✔	✔
12.4 Manage the Howell and Parlour Mountain populations	12.4.1 feral goat control and fencing at Parlour Mountain	1	3500	2000	1000	500	500
	12.4.2 conduct fire regeneration trials and monitor recruits	2	1000	500	500	500	-
	12.4.3 present VCA, PMP or PA to landholders	3	● ✔	● ✔	● ✔	● ✔	● ✔
12.5 Publicity	12.5.1 disseminate information leaflet	3	1500	1500	-	-	-
12.6 Horticulture	12.6.1 cultivate in nurseries etc.	3	-	1000	1000	-	-
Annual cost of implementing plan			18500	12500	8500	3000	2500
Total cost of implementing plan							45,000

✔ cost covered by NPWS core duties.
● cost covered by DUAP, DMR or Council core duties as relevant.

Section 12.2 funded jointly by NPWS and UNE.

Appendix 2: Information leaflet, *Boronia granitica*

Boronia granitica

This medium-sized shrub with divided leaves and bright pink flowers is restricted to a limited number of locations on the north-western side of the New England Tablelands from near Armidale north to the Stanthorpe district in southern Queensland. *Boronia granitica*, as its name suggests, grows in heathy vegetation amongst granite boulders of the New England Batholith.

Boronia granitica is known from Kings Plain National Park, Torrington State Recreation Area and Severn River Nature Reserve in New South Wales, and also Girraween National Park in Queensland. These populations in conservation reserves support hundreds of individual plants and require careful fire management.

Populations of *Boronia granitica* on freehold and leasehold lands are either critically small and threatened by the impacts of browsing feral goats and stock, or susceptible to decline through inappropriate fire regimes.

Activities associated with mineral exploration, mining and bushrock collection may pose a potential risk to *Boronia granitica* populations in the Howell and Torrington districts.

The recovery plan

A recovery plan has been prepared for *Boronia granitica* by the NSW National Parks and Wildlife Service under the *Threatened Species Conservation Act* 1995. The plan aims to protect known populations of *Boronia granitica* from decline and to ensure that these populations are secure in the long term.

A detailed study of the vegetation of the New England Batholith has been undertaken, highlighting the occurrences of *Boronia granitica* and other rare flora.

The University of New England has commenced studies into the fire ecology of many rare plants occurring in the Torrington district. This will provide important information for management of *Boronia granitica* and other restricted flora.

Implementation of the recovery plan involves research into the life history and ecology of *Boronia granitica* and management actions aimed at minimising identified threats to the species. Recovery actions will be directed towards:

- research into aspects of the ecology of *Boronia granitica*, especially reproductive biology, seed-bank characteristics and fire response, necessary to develop the above management strategies;
- protection of populations from the adverse impacts associated with feral goat and stock grazing; and
- involving the community in cooperative management through property and conservation agreements that offer various incentives to land owners.

The occurrence of *Boronia granitica* contributes to the high biodiversity of the flora of the northern tablelands and slopes of New South Wales. Several other rare or threatened species that occupy similar granite outcrop habitats are likely to benefit

from conservation of *Boronia granitica*.

How you can help

If you are a landholder or leaseholder and your property supports native vegetation on outcropping granite that may provide habitat for *Boronia granitica* and other threatened flora, you are in a position to assist in the conservation of these species. This may involve helping ensure that granitic outcrop shrubland vegetation is not subjected to frequent fires. It might also involve fencing vegetation remnants to exclude stray stock and feral goat control to protect rare flora from the detrimental impact of browsing.

If you are visiting Kings Plain National Park, Severn River Nature Reserve or Torrington State Recreation Area please observe the National Parks and Wildlife Service standard code of behaviour at all times:

- camp only at established camp sites;
- do not light fires except in designated fireplaces;
- stay on the established walking tracks;
- leave pets and firearms at home;
- leave rocks, native plants and animals as you find them;
- do not pick native plants; and
- take your rubbish home with you.

If you or your organisation would like to discuss ways in which you can be involved in the conservation of these granitic areas and their significant flora, then please contact either the Glen Innes West Area of the National Parks and Wildlife Service on telephone 02 6732 5133 or the Threatened Species Unit at the National Parks and Wildlife Service Northern Directorate office on 02 6651 5946.

For further information about conserving threatened species in NSW and cooperative management of habitat please contact:

The Manager
Threatened Species Unit
NSW NPWS Northern Directorate
Telephone: 02 6651 5946

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Information

Boronia granitica
Granite Boronia

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Appendix 3: *Boronia repanda* in NSW

Introduction

Boronia repanda (Border Boronia) is a distinctive small shrub with simple foliage and pink flowers that grows in heathy woodland vegetation on granitic soils. The species is confined to a very limited area near Stanthorpe within the 'granite belt' of south-east Queensland. The occurrence of *B. repanda* in New South Wales (NSW) is equivocal and requires confirmation.

Legislative status

Boronia repanda is listed as endangered on both the NSW *Threatened Species Conservation Act* 1995 (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999. The species is considered endangered and assigned a Rare or Threatened Australian Plant (ROTAP) code of 2E by Briggs and Leigh (1996).

Taxonomic description

Boronia repanda (F. Muell. ex Maiden & Betche) Maiden & Betche (Rutaceae) is a small shrub to 1 metre tall with simple oblong or elliptic leaves (to 18 millimetres long) that are thick, glandular and stellate hairy and have revolute glandular margins. Inflorescences are axillary, single-flowered and pedicellate, and the tomentose flowers have pale to bright pink (occasionally white) valvate petals that enlarge to 10 millimetres long and persist in fruit (Weston and Porteners 1991, Quinn *et al.* 1995). For a full taxonomic description see Duretto (in press). The species is illustrated in Williams (1979) and Weston and Porteners (1991).

Taxonomic significance

From a 1904 collection from Stanthorpe, Maiden and Betche first described *Boronia repanda* as *B. ledifolia* var. *repanda* noting that the specimen was most closely related to *B. ledifolia*. *B. repanda* remains within the *B. ledifolia* group (Weston *et al.* 1984) and is the sister species of *B. granitica* (Duretto in press). *B. repanda* differs from other members of *Boronia* section *Valvatae* of the 'granite belt' by having simple leaves.

Habitat

Boronia repanda grows in heath and woodland on sandy granitic soils often in association with granite boulders (Weston and Porteners 1991, Quinn *et al.* 1995, Duretto in press). Quinn *et al.* (1995) lists the following as associated species: *Allocasuarina* sp., *Boronia anemonifolia*, *Cryptandra* sp., *Daviesia* sp., *Eriostemon myoporoides* subsp. *epilosus*, *Eucalyptus andrewsii* and *Exocarpos* sp.

At Jolly's Falls, north of Stanthorpe, *B. repanda* occurs at low frequency in low open forest dominated by *Eucalyptus andrewsii* and *E. banksii* on a steep southern slope with few scattered granite boulders. A sparse secondary tree layer of *Callitris endlicheri* and *Leptospermum trinervium* occurs above a moderately dense shrub stratum dominated by *Acacia betchei, Hovea purpurea, Notelaea linearis, Mirbelia confertiflora* and *Dodonaea hirsuta*.

B. repanda has been collected flowering between July and November and with fruit in October and November. Very little is known of its life history, ecology or response to disturbance, though it is apparently fire-sensitive (Quinn *et al.* 1995).

Distribution

Boronia repanda is confined to a small portion of the 'granite belt' and appears to have an extremely narrow distributional range of less than 20 kilometres. Quinn *et al.* (1995) list

nine population localities in the Stanthorpe district of Queensland, all of which are pre-1975 collections.

Approximately 20 specimens lodged in herbaria (Duretto in press) are presumably collections from the same nine localities, with more recent collections from Cottonvale (Duretto 1992 voucher in Melbourne herbarium) and Jolly's Falls (Westaway 1998 voucher in Coffs Harbour regional herbarium).

B. repanda is listed as occurring in NSW (Weston and Porteners 1991, Briggs and Leigh 1996). The only collections from NSW are those made by Hickey from the Maryland area, approximately 10 kilometres north-east of Stanthorpe on the Queensland/NSW border. There is a possibility that these historic 19th century specimens may actually have been collected in Queensland as Maryland Station apparently extended at that time across the border into Queensland (W. McDonald pers. comm.). *B. repanda* has not subsequently been recorded from the Maryland area and a recent search along roadsides in the Maryland-Stanthorpe area failed to reveal suitable habitat on the New South Wales side of the border (Quinn *et al.* 1995).

Other records of *B. repanda* in NSW such as those provided from the National Parks and Wildlife Service Wildlife Atlas cannot be substantiated and therefore are regarded as invalid. The species presence in NSW therefore remains equivocal.

Threats and current conservation status

Boronia repanda has not been collected from a national park and no populations are known to occur in any conservation reserve (Quinn *et al.* 1995, Duretto in press). Clearing has occurred around the known locations and most populations appear to be in small patches of remnant vegetation or in heavily disturbed areas. Populations have almost certainly been eliminated by clearing for pine plantations, which occur up to hill tops and ridges (Quinn *et al.* 1995).

Agricultural expansion and clearing of remnant vegetation continue to be threatening processes (Duretto in press). A high fire frequency would also pose a serious threat to *B. repanda* populations as the species is apparently fire-sensitive and its dry sclerophyll forest and heath habitat is prone to frequent fires (Quinn *et al.* 1995).

B. repanda is probably the most threatened member of *Boronia* section *Valvatae* (Duretto in press) and possibly the most threatened *Boronia* in eastern Australia. However, its occurrence in NSW requires confirmation (Quinn *et al.* 1995, Richards *et al.* 1998) and further surveys are needed to ascertain the exact distribution and status of the species in both NSW and Queensland (Duretto in press).

Recommendations

- contract a botanist, familiar with *Boronia repanda* and the granite flora of the New England Tablelands, to collate all existing information pertaining to the species, its distribution and habitat;
- utilise computer predictive models to derive the distribution of mapped environmental attributes common among known sites to predict further occurrences. This will only be possible if sufficient environmental data exist and are accessible from Queensland authorities;
- utilise aerial photograph interpretation to examine remnant vegetation stands on granite in proximity to the NSW border for the same vegetation 'phototype' as that of known Queensland localities which may indicate the occurrence of similar habitat in NSW;
- locate potential habitat on topographic and cadastral maps;
- liaise with relevant landholders to acquire property access; and
- undertake detailed targeted field searches for *B. repanda*.

Should the existence of the species in NSW be confirmed, specimens supported by accurate and detailed locality data should be collected and lodged with the appropriate herbaria. Upon validation of any such records of the species in NSW, the current listing as endangered under the TSC Act and the ROTAP conservation code of 2E would be maintained. Obligations under the TSC Act would then require the preparation of a recovery plan for *B. repanda* as a priority.

Alternatively, should a reasonable level of habitat survey and targeted species search effort fail to locate *B. repanda* in NSW, the species should be recommended for downlisting or deletion from the schedules of the TSC Act.

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