Phebalium daviesii

Flora Recovery Plan

Australian Government

Tasmania
Explore the possibilities

ACKNOWLEDGMENTS

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Abbreviations

DPIPWE	Department of Primary Industries, Parks, Water and Environment (Tasmania)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Australian Government)
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
NC Act	Tasmanian *Nature Conservation Act 2002*
NRM	Natural Resource Management
PWS	Parks and Wildlife Service (DPIPWE)
RTBG	Royal Tasmanian Botanical Gardens (DPIPWE)
TSP Act	Tasmanian *Threatened Species Protection Act 1995*
TSS	Threatened Species Section, Biodiversity Conservation Branch (DPIPWE)

Taxonomy follows Buchanan (2009); common names are consistent with Wapstra *et al.* (2005).

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SPECIES INFORMATION

Scientific name:	***Phebalium daviesii*** Hook.f., *Fl. Tasm.* 2: 358 (1859)
Common Name:	davies waxflower (Wapstra *et al.* 2005)
Group:	vascular plant, dicotyledon, family **Rutaceae**
Status:	*Threatened Species Protection Act 1995* (TSP Act): **endangered** *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act): **Critically Endangered**
Distribution:	Endemic status: **Endemic to Tasmania** Tasmanian Natural Resource Management (NRM) Region: **North**

Description and taxonomy

Phebalium daviesii is a medium sized shrub to about 3 metres tall. It has cuneate-shaped leaves, 2 to 3 centimetres long, with a distinctive bi-lobed apex. The lower leaf surface is silvery, while the upper surface is dark green with a row of glands along each side. The pale yellow flowers occur in groups of 5 to 8 at the ends of the branchlets. The flowers are five-lobed, symmetrical and hermaphrodite. The stamens protrude from the flowers to about twice the length of the petals (Curtis & Morris 1975).

Phebalium daviesii is a member of the Rutaceae, a family that is common in sclerophyll and heath vegetation in Australia. *Phebalium* is a genus in the Boronieae tribe, which is the largest of the six Australian Rutaceae tribes and the one with the highest level of diversity and species' endemism (Armstrong 1983). The 33 taxa in the Rutaceae family in Tasmania are all in the Boronieae tribe, with 18 of these being endemics (Buchanan 2009). *Phebalium daviesii* is now the only member of the genus *Phebalium* in Tasmania, others having been assigned to *Leionema* or *Nematolepis* (Wilson 1998, Buchanan 2009).

Life history and ecology

Recruitment: Recruitment is from seed. While a small number of seedlings and juvenile plants have been recorded in the wild, recruitment is not keeping pace with mortality as evidenced by the decline in the number of mature plants since the 'rediscovery' of the species in the late 1900s (Table 1). *Phebalium daviesii* flowers between late September and mid January, with fruit developing from January to February (Lynch 1994). *Phebalium* flowers appear to be adapted to pollination by non-specialised insects and birds (Armstrong 1983). An ejectile mechanism assists dispersal of the seed, with water and ants the most likely transport vectors (Lynch 1994). Although large amounts of seed are produced, few seeds have been found in the soil seed-bank after 4 to 5 months, with predation by ants and redistribution by washing downslope probably accounting for much of this loss (Lynch 1994). The long term presence of *Phebalium daviesii* seed in the soil seed-bank and their long term viability are not known. Other studies on Rutaceae seed have shown that the family typically has a low to moderate level of viability (McIntyre & Veitch 1972, Paynter & Dixon 1990), and may also suffer a natural attrition with storage by ants (Paynter & Dixon 1990). Age estimates of mature plants are suggestive of major regeneration events after fire, and as the habitat is subject to flooding, this process may stimulate germination as well as dispersal of seed. The area supporting *Phebalium daviesii* was burnt in about 1969 and again in 1983 (Lynch 1994). Regeneration of *Phebalium daviesii* by the 1983 fire is supported by a comparison of the growth rate of cuttings to the stem diameters of *in situ* plants (Lynch 1994). The presence of seedlings, albeit in low numbers, suggests that at least a fraction of the seed germinates without the stimulus of fire.

Genetic variation: An analysis of genetic variation in *Phebalium daviesii* found that all plants tested (30) were genetically distinct individuals (Lynch & Vaillancourt 1995). There is no genetic differentiation between plants on the eastern and western banks of the George River (about 400 metres apart), and all plants are therefore considered a single subpopulation. Lynch and Vaillancourt (1995) demonstrated that the level of

inbreeding in *Phebalium daviesii* was similar to that in some of its widespread relatives, indicating that *Phebalium daviesii* does not yet suffer from inbreeding due to rarity. The collection at the Royal Tasmanian Botanical Gardens (RTBG) now holds more genotypes than are represented by surviving wild plants.

Propagation: Because of their ejectile seed dispersal mechanism, plants need to be bagged to enable the collection of seed. Seed germination trials of *Phebalium daviesii* have indicated physical and chemical seed dormancy (Lynch 1994). In the laboratory, seed required scarification combined with leaching, cold stratification and the addition of gibberellic acids to stimulate germination. The germination rate was very low, and seedlings displayed poor vigour (Lynch 1994). In contrast, healthy seedlings have been observed growing under benches holding potted plants of mixed genotype, indicating that germination requirements are not yet well understood. Propagation from cuttings has been successful, with cuttings used for conservation plantings and commercial sale by nurseries to home gardeners.

Distribution and habitat

Phebalium daviesii is endemic to Tasmania, being known from one extant location consisting of two sites on the banks of the lower reaches of the George River near St. Helens in northeastern Tasmania (Table 1, Figure 1). Two groups of plants exist in the main occurrence, one spread over about 350 m on the river's eastern bank and the other on the western bank a further 450 m downstream. The linear range of extant wild plants is 0.7 km, the extent of occurrence 0.07 km^2, and area of occupancy approximately 0.03 ha.

The first collection of *Phebalium daviesii* in Tasmania was by R.H. Davies from 'near St. Helen's Bay' sometime prior to 1860 (Lynch 1994), with later collections at 'Georges Bay' by Augustus Simson (1876) and 'Constable Creek' by Leonard Rodway (1892). The original collection may have been from the George River itself, since Davies is known to have farmed the lower reaches of the river below the currently known site (Lynch 1994). No new collections were made until 1990 when the species was found along the lower reaches of the George River. The Constable Creek site has not been relocated since 1892, despite a number of targeted surveys (Lynch 1994, Barker 1996). A single plant was located a few kilometres upstream of the main George River occurrence in 2001, though this plant has since died.

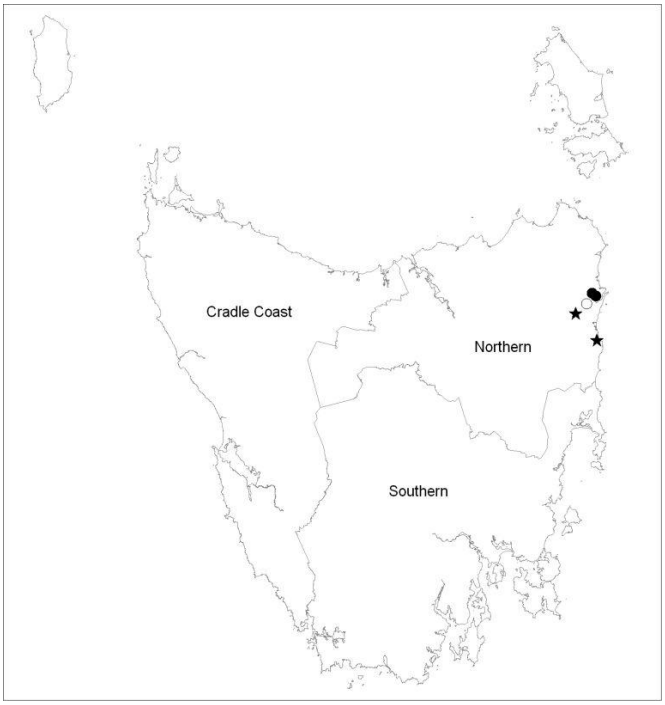

Figure 1. Distribution of *Phebalium daviesii*

(● = extant, ○ = presumed extinct, ★ = *ex situ* conservation plantings; NRM regions labelled)

Table 1. Wild population summary for *Phebalium daviesii*

Site	Tenure	NRM region	1:25 000 mapsheet	Year first (last) seen	Most mature plants ever recorded	Latest number of mature plants	Year of last census
1.1 George River -Eastern bank	Private (with Conservation Covenant *)	North	St Helens	1990? (2010)	42	10	2010
1.2 George River -Western bank	Private (with Conservation Covenant *)	North	St Helens	1990? (2010)	5	1	2010
1.3 George River -Upstream	*Mt Pearson State Reserve#*	*North*	*St Helens*	*2001 (2004)*	*1*	*0*	*2010*
***2** Constable Creek*	*Unknown*	*North*	*St Helens*	*1892 (1892)*	*Presumed extinct*		

* = Under the Tasmanian *Nature Conservation Act 2002*.
# = Managed by the Tasmanian Parks and Wildlife Service.

Table 2. Conservation plantings of *Phebalium daviesii*

Location *Tenure*	Initial no. planted	Number of surviving plants				Factors limiting establishment
	1997–1998	**2000**	**2002**	**2004**	**2010**	
***Ex situ* site 1** Scamander River *State Forest (Special Management Zone)**	262	166	140	49	47	Heavy browsing, flood damage & associated debris.
***Ex situ* site 2** Banticks Creek *State Reserve#*	108	64	56	38	0	Wildfire in December 2006. No recruitment as at 2008 (heavy browsing prior to fire).
***In situ* (site 1.2)** George River *Private (with conservation covenant)*	169	103	89	42	21	Large-scale flood damage & associated debris, light browsing.

* = Managed by Forestry Tasmania.
# = Managed by the Tasmanian Parks and Wildlife Service.

Ex situ conservation plantings have been made at two separate sites and supplementary plantings were made within the portion of the wild subpopulation on the western bank (Table 2, Figure 1). Some of the plants have flowered and it is assumed that seed set is taking place. However, these plantings will only be regarded as being established subpopulations when recruitment is apparent. Site 2 may have been lost as all plants were burnt in late 2006 with no survivors and no seedling recruitment noted in the following two years. However, this site should still be monitored for any future germination.

Phebalium daviesii grows along the lower reaches of the George River. This site has a mild maritime climate. Mean rainfall at nearby St Helens is around 800 mm/year (Pinkard 1980). Small depressions off Tasmania's east coast may lead to heavy downpours in summer, with consequent localised flooding. The elevation of the George River site is about 20 metres above sea level within a narrow river valley. Plants are situated within 15 metres of the riverbank and less than 3 metres vertically above the water line, well within the flood-zone of the river. Soils are coarse, well-drained granitic sands, with exposed granite boulders. The area supports riparian *Eucalyptus viminalis* woodland, with a shrubby understorey characterised by a mix of dry and wet sclerophyll species dominated by species such as *Allocasuarina littoralis*, *Pomaderris apetala*, *Zieria*

arborescens, *Micrantheum hexandrum* and *Leptospermum lanigerum* (Lynch 1994).

The precise location and environmental conditions of the historic Constable Creek site are not known. However, the probable location of this site may be inferred from the presence of the rare *Hovea corrickiae* on Constable Creek, as this species is known to co-occur with *Phebalium daviesii* along the George River. The section of Constable Creek that supports *Hovea corrickiae* is underlain by granite, and has a similar climate to the George River site (Pinkard 1980, Davies & Nielson 1987). It is considered likely that past tin-mining activities have led to the demise of *Phebalium daviesii* along Constable Creek (Lynch 1994).

Population estimate

A census of the George River wild population undertaken in July 1996 revealed 42 mature plants and 7 seedlings on the eastern bank and 2 mature plants on the western bank (Lynch & Appleby 1996). In 2010 only 10 mature plants were recorded on the eastern bank and 1 on the western bank, with about 50 seedlings and juveniles on the eastern bank in an area of 20 by 5 m. In 2001 a single mature plant was also recorded about 3.5 kilometres upstream from the known eastern bank stand (Table 1). Searches did not locate additional plants in the vicinity of this plant, and the plant is believed to have died in the interim. The three sites are considered to belong to a single subpopulation. Given the considerable targeted survey effort that occurred following the rediscovery of the species, there is a low chance of finding further subpopulations. However, the occurrence of the single individual upstream of the main subpopulation suggests that more plants may be found on the George River in suitable habitat. Details of the number of plants planted *in situ* and at two *ex situ* sites and survivorship are shown in Table 2.

Reservation status

The extant plants along the George River occur on private land covenanted under the Tasmanian *Nature Conservation Act 2002* (NC Act). The upstream George River site is within Mt Pearson State Reserve, though as noted earlier, the solitary plant at this site is presumed dead.

Threats, limiting factors and management issues

The main threats to *Phebalium daviesii* are small population size, vegetation clearance, damage by floods, storms and associated debris, inappropriate fire regimes, exotic plant invasion, disease (*Phytophthora cinnamomi*), browsing, trampling by stock and climate change. Collection of specimens is no longer considered a threat given the wide availability of nursery grown plants.

Small population size and limited recruitment: The extreme rarity of *Phebalium daviesii* makes the species highly susceptible to the stochastic risk of extinction. It is likely that numbers in the wild have been reduced since European settlement through clearance of its riparian habitat, mining activity, and an increased frequency of fire. The low number of seedlings may be due to low fecundity, seed loss, and lack of suitable conditions to allow major regeneration events or limited establishment because of browsing. Because of the small size of the population, the amount of seed being produced may also limit regeneration in the event of suitable conditions.

Vegetation clearance: Vegetation clearance and consequent fragmentation of habitat since European settlement are thought to have contributed to the decline of *Phebalium daviesii*. Clearance of vegetation within the George River subpopulation is precluded under Conservation Covenants. Land clearance and the destruction of riparian vegetation is a continuing threat to potential plants upstream and to potential recruitment niches along the river, while the clearance of riverside vegetation upstream will, in all likelihood, increase sedimentation rates and impact negatively on species and communities downstream of the disturbance itself. The clearing of 'riparian scrub' with which *Phebalium daviesii* is associated is now regulated as it is a vegetation community listed as threatened under the NC Act.

Flood and storm damage: *Phebalium daviesii* grows within the flood zone of the George River, and in consequence the risk of destruction or damage to either the plants or their substrate is great. Floodwaters may erode the riverbanks, while flood-borne debris is capable of wreaking significant damage to plants.

Damage may also occur to *Phebalium daviesii* plants through the collapse of adjacent vegetation as a result of storms. There has been a significant reduction in the numbers of mature wild plants since monitoring began in the mid 1990s, the decline largely a consequence of damage associated with floods and storms.

Inappropriate fire: Although it is speculated that fire may play a part in the ecology of *Phebalium daviesii*, more research is required to determine the optimum fire frequency for the species' survival and recruitment. Even if fire stimulates recruitment, too frequent fire will eventually eliminate the species by destroying new plants before they become reproductive, while too long an interval between fires is likely to be detrimental to the species' long term survival. Frequent fire may also encourage weeds and ultimately change the structure of the site's vegetation, with undesirable effects on the species.

Exotic plant invasion: Gorse (*Ulex europaeus*), blackberry (*Rubus fruticosus* aggregate), hawthorn (*Crataegus monogyna*) and willow (*Salix* spp.) are major woody weeds present in the area of the George River location and constitute a threat to *Phebalium daviesii* if allowed to increase in numbers. Weeds such as gorse have the ability to invade the species' habitat to the exclusion of other plants. Willow infestation also excludes native plant species and can alter river hydrology, causing waterlogging and sediment build up, and consequent problems for the dispersal of native species.

Disease: The exotic soil-borne plant pathogen *Phytophthora cinnamomi* is considered a threat to *Phebalium daviesii*. Barker (1994) found the plant to be highly susceptible to infection in laboratory trials. *Phytophthora cinnamomi* is not evident in the subpopulation at present. The pathogen is transported in soil and there is a risk that it may be brought into the plant's habitat on the footwear of visitors who have recently been to infected areas. Risk also exists where infected machinery or soil/gravel is worked upslope from plants.

Stock grazing and trampling: The threat of direct damage to the George River subpopulation has been reduced through the placement of Conservation Covenants on the private properties that encompass the subpopulation, with the stipulation that stock be excluded. However, stock have access to the river only a short distance upstream, and damage to the riverbank in those areas has the potential to impact indirectly on the subpopulation.

Browsing by native animals: Native herbivore browsing has significantly impacted conservation plantings at Banticks Creek and Scamander River and is likely to be limiting the establishment of seedlings in the wild stands. As it has not been practical to erect fences in the flood zones, it has been necessary to cage individual plants that were planted though this will not protect seedlings that may germinate outside the cages. While newly planted clones appear to be particularly palatable, browsing levels were notably higher in the two *ex situ* sites than the wild subpopulation. The level of browsing at sites may ultimately determine the success of *ex situ* conservation plantings.

Climate Change: The trend towards a warmer drier climate may also threaten the species, either through the loss of climatic habitat producing less favourable conditions for recruitment, by increasing the risk of stochastic events such as flood or fire or by increased risk from weeds and disease.

Conservation status

Phebalium daviesii was adjudged by the Threatened Species Scientific Committee to qualify for listing as Critically Endangered on the EPBC Act under criteria 2, 3 and 4 (on 16 October 2001). The Committee concluded that: '*The geographic distribution of the species is precarious for the survival of the species and is very restricted. The species is known from a single population. The area of occupancy is 0.03ha and the extent of occurrence is 0.0003km². The total number of mature individuals is extremely low, 29 plants having been recorded in dedicated surveys. Population decline has been observed and is projected to continue due to the ongoing threats of trampling or grazing by livestock, clearing, flooding and limited recruitment.*'

The species meets the following criteria for the endangered category under the Tasmanian TSP Act:

D1. There are fewer than 250 mature individuals.

D2. The area of occupancy is less than 1 ha and typically occurs in 5 or fewer locations that provide an uncertain future.

B1&2. The species extends less than 500 km², it occupies less than 10 ha, it occurs in no more than 5 locations and there is a continuing decline in the number of mature individuals.

C2a i & ii. There is a continuing decline in the number of mature individuals, no subpopulation is estimated to contain more than 250 individuals and 90% of all mature individuals occur in a single subpopulation.

Habitat critical to the survival of the species

Habitat considered critical to the survival of *Phebalium daviesii* includes:

- the area of occupancy of the only known wild site, and the single plant on the banks of the George River is considered to be critical for the survival of the species and the maintenance of its genetic diversity;
- areas of similar habitat surrounding and between those areas which may support further plants;
- additional occurrences of similar habitat which may contain undiscovered subpopulations or may be suitable for translocations; and
- the area of occupancy of *ex situ* conservation plantings along the upper Scamander River and Banticks Creek are considered essential in order to ensure the survival of the species in the event of the loss of the George River wild subpopulation;
- the local catchment for the surface and/or groundwater that maintains the habitat of the species.

The area of occupancy of the existing subpopulation (total 0.03 ha) is known and has been mapped. The locations of similar habitat surrounding the subpopulation, and additional occurrences of similar habitat have not been determined or mapped. The location of existing planted sites is known and has been mapped though the area of occupancy has not been measured. The location of the local catchment area which maintains the species' habitat is known, but has not been mapped.

RECOVERY

Existing conservation measures

A number of the recovery actions outlined in the *Phebalium daviesii Recovery Plan 1996–2004* (Lynch & Appleby 1996) were implemented during the period 1996–2004 through Australian Government funding, including the following

- A Recovery Team was convened (no longer active).
- Perpetual conservation covenants under the NC Act were negotiated for the two private properties that encompass the two known wild sites in 1999 and 2004. The covenants are designed to ensure that *Phebalium daviesii* is not adversely impacted, and include provisions to exclude disease, stock, the application of fertilisers, cultivation, the removal of native vegetation, or any other activity that may be considered detrimental to the species. The covenants stipulate activities to be excluded from the area, and oblige landowners and the Minister to manage each covenanted area according to a Plan of Management. The level of compliance between both parties is to be assessed every five years by the Minister in conjunction with a review of the Plan of Management, although the Plan may be amended at any time if deemed necessary to protect the natural values of the covenanted area. The covenants on the two property titles will alert new landowners to the issues to help prevent the inadvertent destruction of the known wild subpopulation.
- A 1200 m long cattle-proof fence was erected in October 1996 on the upslope boundary of the area covenanted on the western bank of the George River. The fence was erected with the assistance of the land manager and Australian Trust for Conservation Volunteers.
- Invasive weeds (gorse, blackberry) have been treated within the stand on the western bank over the period 1996 to 2004. On-ground weed works have been undertaken by Threatened Species Section (TSS) personnel, the St Helens Landcare Group and Green Corps volunteers.
- *Ex situ* plantings were undertaken in 1997 at three sites within 30 km of the George River

subpopulation: Banticks Creek, Scamander River and Golden Fleece Rivulet. The Golden Fleece site (close to Constable Creek) was undertaken to raise the species' profile in the local community, with the plantings carried out by local girl guides, cubs and scouts, and was not intended as a long term proposition. A supplementary planting also took place within the wild stand on the western bank of the George River. Plants for the *ex situ* sites were propagated by Tasmanian Electro Metallurgical Company Pty Ltd (TEMCO) (initially) and RTBG, and assistance with the plantings was provided by Green Corps volunteers. Stock plants were propagated from most of the wild plants. Plantings used a representative mixture of genotypes propagated from the stock plants. Plans of the plantings (including genotype) are held by TSS.

- A collection of *Phebalium daviesii* genotypes has been maintained at the RTBG since the mid 1990s, and the species has been available to the public from commercial nurseries. The RTBG collection maintains genotypes of mature individuals that have now been lost in the wild.
- Publicity has been generated in the local area, including a public awareness program through local organisations. The Break O'Day Council has adopted the species as their floral emblem. Propagated plants were made available to members of the public and distributed for planting in private gardens around the state, including in the grounds of the local Council chambers.
- A Listing Statement has been prepared under provisions of the TSP Act (Threatened Species Unit 2001).
- The two wild sites have been included within a *Phytophthora cinnamomi* management zone (Schahinger *et al.* 2003). It includes the site with the majority of wild plants and the site in which supplemental planting has occurred. Any activity proposed for a *Phytophthora* management area is evaluated against the risk of introducing or spreading the pathogen and, where necessary, prescriptions implemented to mitigate that risk.

The wild subpopulation and *ex situ* conservation plantings have been monitored in subsequent years by TSS personnel (Table 2). Additional activities instigated in recent years have included:

- a weeding program in the George River catchment by NRM North;
- maintenance of stock plants and propagation at the RTBG;
- collection of seed from the stock plants held at RTBG for long term conservation storage at the Tasmanian Seed Conservation Centre (also involving germination testing);
- inclusion of the Scamander River site on State Forest in a threatened flora Special Management Zone in 2007 (Orr & Gerrand 1998), with the exclusion of fire a specified prescription.

Strategy for recovery and progress evaluation

The *Phebalium daviesii* Recovery Plan will run for five years and is based on strategies to prevent the loss or degradation of habitat, to encourage an increase in seedling recruitment, to preserve genetic variation within the species through supplementation of the wild subpopulation and maintenance of conservation plantings, to develop mechanisms to manage and better protect the species in the long term and to search for new plants.

This Plan has been prepared in consultation with representatives of the Resource Management and Conservation Division (DPIPWE), and various experts. It incorporates management issues and strategies outlined in the earlier Recovery Plan (Lynch & Appleby 1996) and Listing Statement (Threatened Species Unit 2001) and takes existing conservation measures into account.

A Recovery Team is not required as TSS will guide implementation, monitoring and review of this Plan or parts thereof if funding is secured, in partnership with experts and organisation as detailed in Action 7. Evaluation of the success or failure of the Recovery Plan will be measured against the performance criteria. A formal review within 5 years of adoption is required under the EPBC Act. Significant developments will be communicated to the general public through Listing Statement updates, websites, newsletters and reports.

This Plan is consistent with the aims of the *Threatened Species Strategy for Tasmania* (Parks & Wildlife Service

2000) and *Tasmania's Nature Conservation Strategy* (Nature Conservation Branch 2002).

Recovery objectives, performance criteria and actions needed

The **overall objective** of the Recovery Plan is to prevent *Phebalium daviesii* from declining further. This will require protection and maintenance of the wild subpopulation, existing *ex situ* plantings and habitat, supplemental plantings, the establishment of new *ex situ* subpopulations, and searches for new plants.

Specific objectives are to:

1. maintain and enhance habitat critical to the survival of the species;
2. increase the size of the population, range and number of subpopulations.

The **criteria** for achieving the objectives constitute a quantifiable decrease in the risk of extinction over the five years of Recovery Plan implementation. They include:

1. the area of habitat critical to survival (as measured by Action 4 in year 1) is maintained over 5 years;
2. the quality of critical habitat is enhanced (as measured by Action 5);
3. no decline in the number of plants or area occupied by the wild *Phebalium daviesii* subpopulation over 3 years;
4. no decline in the number of plants or area occupied by the existing *ex situ* conservation plantings over 3 years;
5. 3 new *ex situ* conservation plantings established by year 5;
6. management agreements in place and implemented for any new *ex situ* conservation plantings, new subpopulations and important areas;
7. an increase in the total population size of 20% within 5 years
8. an increase in the total area occupied by the species of 20% within 5 years;

The **actions** required for achieving the objectives are:

1. protect and manage wild plants;
2. protect and manage *ex situ* conservation plantings;
3. establish new *ex situ* conservation plantings with management agreements;
4. survey habitat;
5. monitor species and habitat;
6. investigate recruitment and response to fire;
7. manage the species for the long term.

Recovery actions

1. Protect and manage wild plants

This action is ongoing for the life of the Recovery Plan and involves:

- management of the known wild subpopulation;
- regular review of appropriate management;
- pursuing protection of any new plants or subpopulations found;
- advising developers upstream of restrictions.

Ongoing management is required to stem the population decline. Appropriate on-ground actions will be indicated by monitoring (Action 5), and may include:

- weed control;

- stock management;
- fire regime management;
- prevention or management of disease;
- clearing debris accumulated after major flood events;
- caging plants to control browsing;
- repairing or removing cages;
- supplementing wild subpopulation by planting, using genetically representative plants grown from stock plants held at RTBG;
- regulation of activities upstream or upslope to prevent damage to subpopulations.

Management will be re-assessed as new situations arise or the environment changes. Officers with the Private Land Conservation Program (DPIPWE) will conduct reviews and updates of the Covenant Management Plans between landowners and the Tasmanian Government, with recourse to TSS expertise and advice.

Should further wild plants be found on unprotected private land, protection should be pursued, preferably through perpetual conservation covenants or, if not, via fixed-term covenants or Part 5 agreements on title and management agreements with landowners.

Land managers and potential developers of properties upstream or upslope of the wild subpopulation on the George River will be advised that restrictions might apply if proposed developments are deemed likely to have a detrimental effect on the species, especially if activities are likely to promote the introduction of *Phytophthora cinnamomi* or weeds into the habitat of the species.

2. Protect and manage *ex situ* conservation plantings

This action involves:

- replanting the Banticks Creek site in year 3;
- on-ground management of planted sites (year 1 to 5);
- informing land managers of the management requirements of sites, and providing assistance where appropriate (year 1).

Appropriate on-ground actions will be indicated by monitoring (Action 5), and may include any of those listed under Action 1.

3. Establish new *ex situ* conservation plantings with management agreements

The wild *Phebalium daviesii* subpopulation and existing *ex situ* conservation plantings are all within a linear range of 30 kilometres. Increasing the number of plants and subpopulations within this range, via re-introduction at selected locations, will help to minimise stochastic risk including impact of localised events such as fire and flood. Three new *ex situ* conservation plantings will be located within the species' putative geographic area and habitat. This action involves:

- assessment of potential sites in year 1;
- negotiating management agreements prior to planting, in year 1 and 2;
- propagation of plants, in year 1 and 2;
- site preparation, including weeding, in years 2 to 4;
- planting sites, in years 2 to 4;
- management of plants until established (possibly including caging, watering), in years 3 to 5.

Factors such as site suitability and ecological and logistical assessments must be taken into account (Vallee *et al.* 2004). Potential sites need habitat, geology and river flow (flooding characteristics) similar to that of the

wild subpopulation. The Constable Creek area will be surveyed for an appropriate site as the species was previously recorded here, and areas upstream and downstream of the George River subpopulation will also be assessed.

Successful techniques for growing *Phebalium daviesii* plants from seed have not been developed to date, but it is relatively easy to propagate the plant from cuttings. The risk in the latter case is that there may be inadvertent selection of the most successful clones, limiting the genetic diversity of the survivors. However, this can be managed if losses are replaced with genotypes to maximise genetic diversity. RTBG currently hold stock plants of at least 26 genotypes. The number of plants needed for successful establishment of a genetically diverse *ex situ* subpopulation can be guided by past experience (see Table 2), suggesting 200 to 300 plants per site (less if a replacement planting program is adopted). The mortality rate will be largely dependent on local browsing pressure and it may be possible to screen potential sites to improve establishment rates. The *ex situ* conservation plantings should each attempt to represent the full range of the collection of stock plants held at RTBG, with an equal number of cloned individuals from each stock plant planted in a randomly spaced arrangement within plantings. Propagation in the nursery should involve rigorous methods to maintain diversity and to avoid infection. The introduction of *Phytophthora cinnamomi* and weeds to the wild must be avoided.

The plants will be managed under this action until they are established and growing. After this, site management will occur as per Action 2. Each conservation planting will be considered a subpopulation of the species if natural recruitment occurs.

4. Survey habitat

While the likelihood of finding new locations is low given past survey efforts, the discovery in 2001 of a single individual a few kilometres upstream from previously known plants suggests that renewed searches on the George River and in nearby areas, could result in further plants being located.

This action includes:

- assessing potential habitat (including the identification and mapping of areas of similar habitat around existing plants and additional occurrences of similar habitat) in year 1;
- identifying, ground-truthing and mapping other areas considered critical to the survival of the species in year 1;
- surveying sites in subsequent years (depending on time since last fire), focussing on areas that have not been previously searched for the species or in areas on other rivers that have been burnt in the last 15 years (in case of a regeneration event since previous searches). Searches will be conducted during the species flowering period (September to January).

5. Monitor species and habitat

This action includes:

- annual monitoring of the wild subpopulation (including any newly discovered plants from Action 4) and conservation plantings (including new plantings from Action 3, and the Banticks Creek site given some plants had flowered and presumably set seed prior to the wildfire which killed the plants) during the species flowering period (September to January) to determine population status, mortality, recruitment, health, management requirements and possible causes of any decline/damage so that they can be addressed under Action 1 or 2;
- monitoring areas critical to the survival of the species and in the immediate vicinity of plants, to ensure compliance with management agreements or other regulatory requirements, and to detect any changes in the area or quality of habitat critical to survival. Habitat quality measures will include evidence of browsing, fire, rubbish dumping, disease and weeds, vegetation clearing, stock, or timber harvesting. This will be conducted every second year, with additional surveys if required.

6. Investigate recruitment and response to fire

This action involves research on:

- reproductive output, seed viability and longevity, germination requirements and incidence of seed predation;
- germination response to fire stimulus (e.g., smoke and heat);
- priming methods to promote germination.

While germination in other members of the Rutaceae family can be promoted by factors such as smoke and heat (Dixon *et al.* 1995), germination of *Phebalium daviesii* has been observed in the absence of fire. Trials will be conducted to investigate the recruitment strategies and germination triggers of *Phebalium daviesii* to inform management action. By understanding these processes the potential exists to stimulate germination thereby promoting recruitment in the wild.

Germination testing of banked seed at the Tasmanian Seed Conservation Centre will help to understand seed viability and longevity, dormancy mechanisms and germination requirements. The RTBG collection of stock plants is a continuing source of seed if further research is required and to determine whether translocation of primed seed to the wild is a feasible way of promoting recruitment in the wild. This research may be suitable for a post-graduate student project at the University of Tasmania.

7. Manage the species for the long term

This action involves:

- the collation and interpretation of data on *Phebalium daviesii*;
- the dissemination of this information to stakeholders and other interest groups;
- implementing mechanisms to facilitate community participation in, and ownership of, the recovery program.

The availability of up-to-date information is a necessary base for formulating management advice, as well as informing the allocation of resources and the assessment of the impact of development proposals.

Ongoing data and interpretation requirements as new information becomes available are:

- entry of spatial, population (including conservation plantings), disturbance and threat information into the Natural Values Atlas (DPIPWE);
- regular reassessment and documentation of the species' extinction risk, and preparation of nominations for a change in the conservation status for State and Commonwealth legislation as required;
- regular interpretation of data, including research data, to inform, adapt and prioritise on-ground management;
- lodgement of specimens of any new subpopulation with the Tasmanian Herbarium in case of future taxonomic treatments.

Requirements for the dissemination of information are to:

- update the *Phebalium daviesii* listing statement (Threatened Species Unit 2001) as new information becomes available, and include on the DPIPWE website to allow access to the wider botanical community and the general public;
- review the Recovery Plan every five years and update if required, circulate to libraries and the wider botanical community, and include on the DPIPWE and DSEWPaC websites to allow access to the general public;
- prepare written management advice for any new subpopulations or update existing advice for known sites as necessary and provide to landowners/managers;
- circulate spatial information to relevant users including NRM North, and regulators including Break O'Day Council, the Forest Practices Authority, the Development and Conservation Assessment Branch and Water Resources Division of DPIPWE, the Environment Division (DPIPWE), the Tasmanian Planning Commission and DSEWPaC;
- investigate additional processes to alert potential landowners as to possible occurrences of threatened

flora species and associated responsibilities.

Mechanisms to facilitate community participation and ownership are:

- assist landowners/managers to implement on ground recovery actions;
- involve NRM North in the recovery process
- make requests to volunteer networks to participate in specific recovery actions (groups might include Wildcare's Threatened Plants Tasmania, Green Corps, Conservation Volunteers Australia and the Australian Plant Society);
- request participation in recovery actions by the wider botanical community through the Tasmanian Flora Network;
- provide advice to community groups on possible funding and assist with funding applications;
- promote threatened flora, threatened vegetation community and river condition issues in the community;
- when necessary, organise (1) permission from landowners/managers to access sites, and (2) permits from TSS for the collection of propagation material and/or herbarium specimens.

Table 3. Estimated cost of recovery

Recovery Action	Cost	Duration	NRM Region
1. Protect and manage wild plants	$41 000	Years 1–5	North
2. Protect and manage *ex situ* conservation plantings	$41 000	Years 1–5	North
3. Establish new *ex situ* conservation plantings	$40 000	Years 1–5	North
4. Survey habitat	$16 000	Years 1–2	North
5. Monitor species and habitat	$39 000	Years 1–5	North
6. Investigate recruitment and response to fire	$45 000	Years 1–5	North
7. Manage the species for the long term	$50 000	Years 1–5	State
Total	**$272 000**		

Duration and cost

The Plan will run for five years with the estimated cost being $272,000 (Table 3).

The *Phebalium daviesii* Recovery Plan may be supported, and may benefit from other projects supported, by DPIPWE, NRM North, RTBG, Tasmanian Seed Conservation Centre, Tasmanian Parks and Wildlife Service, Forestry Tasmania, Break O'Day Council, Wildcare's Threatened Plants Tasmania, Private Land Conservation Program (DPIPWE), National Reserve System Land Acquisition Program, voluntary reserve programs, Tasmanian Farmers and Graziers Association and the Tasmanian Land Conservancy.

Management practices

This Plan identifies the following management practices necessary to avoid a significant adverse impact on *Phebalium daviesii*:

- ensuring that relevant landowners, land managers and planning authorities are aware of their responsibilities under the TSP Act, EPBC Act and NC Act to prevent the inadvertent destruction or decline of subpopulations and potential habitat;
- maintenance of *Phebalium daviesii* sites, including physical protection of new and established plants, e.g. by caging;
- prevention of invasion by weeds;

- exclusion of stock, and erection and maintenance of fences;
- restriction of use of chemicals (except where herbicides are used for weed management);
- no cultivation;
- no damage or removal of native vegetation;
- no fire (except for management purposes);
- no changes to hydrology in the habitat or irrigating or allowing effluent runoff;
- no introduction of foreign material, particularly soil or plant material;
- prevention of the introduction and/or spread of disease;
- maintenance of propagation and conservation seed storage facilities at RTBG;
- maintenance of the Natural Values Atlas (DPIPWE);
- maintenance of relevant information by TSS;
- continuation of private land conservation schemes;
- compliance with existing clearing, damming and water use restrictions and regulations;
- conservation management of Mt Pearson State Reserve, Scamander River SMZ, Banticks Creek State Reserve and covenanted private land reserves.

International obligations

Phebalium daviesii is not listed under any international agreement and the Plan does not affect Australia's international responsibilities.

Affected interests and social and economic impacts

Phebalium daviesii has legal protection as a listed threatened species. This places an obligation on landowners and reserve managers for its protection. Conservation Covenants are in place for the two private properties that encompass the wild subpopulation along the George River (excluding the site with 1 plant several km upstream), while a threatened flora Special Management Zone covers the *ex situ* site on State Forest along the upper Scamander River. If amendments are required to these agreements in the future, negotiations will be undertaken with the appropriate landowner/land manager.

Affected interests include: NRM North, PWS, Forestry Tasmania, RTBG, Australian Trust for Conservation Volunteers, Wildcare's Threatened Plants Tasmania, Threatened Flora Network, private landholders (including those upslope of sites), St Helens Landcare Group, Green Corps, Break O'Day Council, Conservation Volunteers Australia, Australian Plant Society and the University of Tasmania.

Recovery actions for *Phebalium daviesii* are unlikely to have any adverse social and economic impacts beyond the aforementioned landowners. However, the protection of the species' habitat should be factored into any new development applications in adjoining areas, particularly upstream. The protection of natural riparian ecosystems in farming areas has a high priority and is increasingly seen to be beneficial to agriculture, water supply and public amenity.

Roles and interests of indigenous people

In the preparation of this Plan the important role Tasmanian Aboriginal people have played in land management was recognised, and the impact of European settlement on this role acknowledged.

The following Aboriginal organisations have been consulted on the significance of *Phebalium daviesii* in Aboriginal cultural tradition, and on their knowledge, role and interest in its management: Aboriginal Land Council of Tasmania, Tasmanian Aboriginal Centre, and Tasmanian Aboriginal Land and Sea Council.

Implementation of this Plan will involve:

- knowledge sharing;
- participation in education and training relevant to threatened species management; and
- engagement in recovery actions where relevant to Aboriginal land management and communities.

If, during any recovery activity, suspected evidence of Aboriginal heritage significance is found, this will be reported to Aboriginal Heritage Tasmania, and, if the evidence is to be disturbed, the activity will be suspended pending appropriate follow-up.

Biodiversity benefits

Measures undertaken to protect *Phebalium daviesii* will enhance the status of the co-occurring rare shrub *Hovea corrickiae*, as well as the riparian *Eucalyptus viminalis* woodland community. Fauna species that are likely to benefit from recovery actions for *Phebalium daviesii* include the wedge-tailed eagle (*Aquila audax fleayi*) and the swift parrot (*Lathamus discolor*). Both species are listed as Endangered under the EPBC Act and the TSP Act. *Phebalium daviesii* is associated with 'riparian scrub', a vegetation community listed as threatened under the NC Act.

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