Image by B. Potts

Eucalyptus gunnii subsp. *divaricata*

miena cider gum

TASMANIAN THREATENED SPECIES LISTING STATEMENT

Scientific name: ***Eucalyptus gunnii*** **subsp.** ***divaricata*** (McAulay & Brett) B.M. Potts, *Pap. Proc. R. Soc. Tasm.* 135: 57 (2001)

Common name: miena cider gum (Wapstra *et al.* 2005)

Group: vascular plant, dicotyledon, family **Myrtaceae**

Status: *Threatened Species Protection Act 1995*: **endangered**

Environment Protection and Biodiversity Conservation Act 1999: **Endangered**

Distribution Endemic status: **Endemic to Tasmania**

Tasmanian NRM Region: **South**

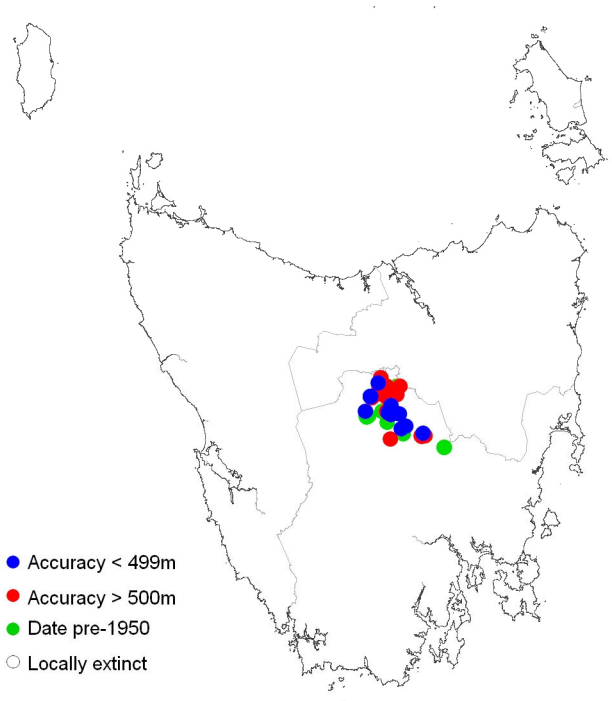

Figure 1. Distribution of specimens attributed to *Eucalyptus gunnii* subsp. *divaricata*. The northern and western most records require verification.

Plate 1. *Eucalyptus gunnii* subsp. *divaricata* (Image by J. Calder)

IDENTIFICATION AND ECOLOGY

Eucalyptus gunnii subsp. *divaricata* is a small to medium sized tree in the Myrtaceae family (Plate 1). It is endemic to Tasmania's Central Plateau where it mostly grows on the edges of frost hollows (Potts *et al.* 2001). *Eucalyptus gunnii* subsp. *divaricata* is one of the most frost resistant of Tasmania's eucalypts. Being part of a continuum involving *Eucalyptus gunnii* subsp. *gunnii* and *Eucalyptus archeri*, the taxon is morphologically variable, with the most differentiated forms found at the edges of frost hollows where environmental conditions are harshest. The morphological differences have been shown to have a genetic basis (Potts 1985, Potts & Reid 1985a,b). However, molecular studies have failed to find significant neutral DNA differentiation between the afore-mentioned members of the *Eucalyptus gunnii*/*Eucalyptus archeri* complex and the closely related *Eucalyptus urnigera* on the Central Plateau, suggesting relatively recent differentiation between white gums on the Plateau, with selection playing an important role in maintaining differences (Hudson 2007).

The taxon's peak flowering period is from December to January, though it may be identified at any time of year using a combination of distinguishing features. Recruitment is from seed stored in woody capsules in its canopy. Capsules generally take one to two years to mature following flowering. As capsules dry out following damage or fire, seed is released through valves, though valves of capsules that have been mature for longer than two years tend to fail to open. As such there is generally only two years worth of releasable seed held in the canopy at any one time. *Eucalyptus gunnii* displays inbreeding depression, reducing the quality of seed produced in declining stands as fewer trees flower. Seedlings grown from self-pollinated seed have stunted growth and high mortality (Potts *et al.* 1987).

Eucalyptus gunnii subsp. *divaricata* can resprout from lignotubers following fire or damage. However, regrowth is highly palatable to insect and animal browsers, with herbivory often leading to the death of individuals, particularly in drought conditions or in stands disturbed by stock grazing. While *Eucalyptus gunnii* subsp. *divaricata* is highly frost resistant, it is the first eucalypt in the area to display symptoms following drought, leading to the death of mature trees in relatively large patches since the mid 1990s (Plate 2) (Potts *et al.* 2001, Calder & Kirkpatrick 2008). Often seedlings, repressed through continual browsing, persist amongst the dead trees. Pertinent to recovery, the taxon strikes relatively easily from cuttings taken from seedlings or ground-level coppice regrowth (Potts & Potts 1986).

Eucalyptus gunnii subsp. *divaricata* is of iconic significance due to its extreme frost resistance, popularity with florists, tapping of sap by Aborigines and early European settlers (stands at Cider Marsh and Jacks Marsh were sap producers) and as a subject of ongoing study of evolutionary processes in Tasmania (Potts *et al.* 2001). It has also been used in breeding programs because of its frost resistance (Potts & Potts 1986).

Plate 2. Dead *Eucalyptus gunnii* subsp. *divaricata* at Cider Marsh (Image by J. Shaw).

Description

Eucalyptus gunnii subsp. *divaricata* is a small to medium-sized umbrageous tree 12 to 15 m high, with distinct forked branches (Plates 1 & 2). The branchlets are covered with a heavy whitish waxy bloom (glaucousness) that often extends onto the flower buds and young capsules (Plate 3). Stems of seedlings and

coppice regrowth are heavily glaucous. Juvenile leaves are stalkless and arranged in opposite pairs along the stem, and are about 2.5 cm by 2 cm, and generally rounded. Being glaucous, they are a matt bluish-green colour. Adult leaves are stalked, green or subglaucous and arranged alternately along the stem. They are lance-shaped and 4 to 8 cm long and 1.5 to 3 cm wide. The flowers are stalkless or shortly stalked and arranged in clusters of three on a common stalk (peduncle) 5 to 10 mm long. Buds are glaucous, obovate to cylindrical in shape, 6 to 8 mm long by 5 mm wide. The fruit is an often glaucous capsule 7 to 9 mm long by 6 mm wide (description from Potts *et al.* 2001).

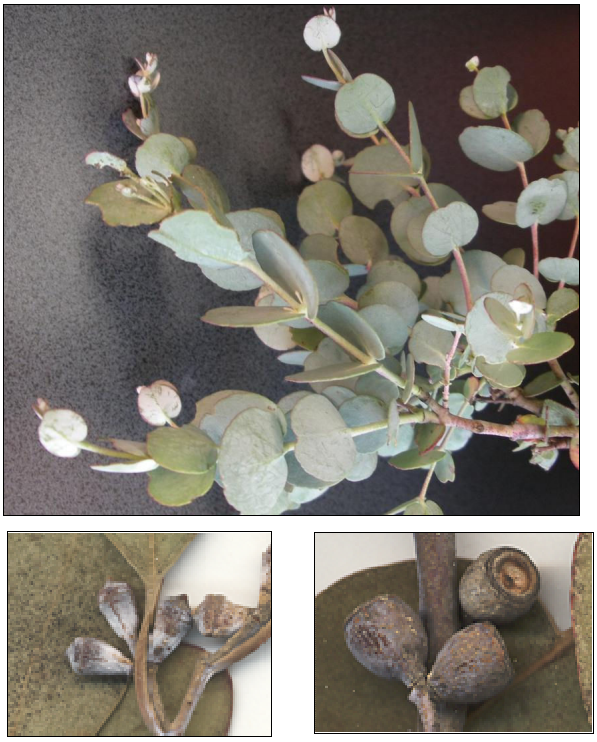

Plate 3. Juvenile foliage, buds and capsules of *Eucalyptus gunnii* subsp. *divaricata* (Images by B. & W. Potts)

Confusing Species

Being part of a cline, it can be difficult to attribute intermediate trees to either *Eucalyptus gunnii* subsp. *divaricata* or *Eucalyptus gunnii* subsp. *gunnii*, generally requiring use of a combination of distinguishing features. *Eucalyptus gunnii* subsp. *divaricata* can be distinguished from *Eucalyptus gunnii* subsp. *gunnii* by its more branched and rounder crown, smaller and broader juvenile and adult leaves, greater degree of glaucousness clearly extending to stems of seedlings in particular as well as coppice regrowth and branchlets, a more cylindrical to sub-urceolate capsule, greater retention of juvenile foliage, greater lignotuber development, the absence of marked oil glands in its juvenile leaves, and its earlier (up to 6 weeks) flowering period (Potts *et al.* 2001). In recent years, higher mortality has almost become a diagnostic feature of the taxon.

DISTRIBUTION AND HABITAT

Eucalyptus gunnii subsp. *divaricata* is endemic to Tasmania occurring as grassy open woodland at the exposed edges of treeless flats or hollows (frost hollows) around the Great Lake region on the Central Plateau (Figure 1). Sites tend to be poorly drained and prone to frost on Jurassic dolerite. The recorded altitude range is 865–1150 m above sea level.

Eucalyptus gunnii subsp. *divaricata* occurs in seven major locations (Table 1), with most occurrences within a 40 by 40 km area from west of Miena to Interlaken (Potts *et al.* 2001). The species has a linear range of about 60 km, and an area of occupancy roughly estimated to be to be in the low hundreds of hectares (Table 1).

The most extreme morphological form of the species occurs in the type locality at Shannon Lagoon (sometimes called Barren Tier) near Miena. From this core area, the taxon intergrades to *Eucalyptus gunnii* subsp. *gunnii* at lower altitudes to the south-east, to the small tree or mallee form of *Eucalyptus gunnii* subsp. *divaricata* at higher altitudes and to *Eucalyptus archeri* at the northern end of Great Lake where the rainfall is higher (Potts & Reid 1985a,b).

Associated species include the shrubs *Richea acerosa*, *Hakea microcarpa* and *Melicytus dentatus,* the herb *Viola cunninghamii*, the grasses *Poa clivicola* and *Poa fawcettiae,* and the threatened orchids *Prasophyllum crebriflorum* and *Pterostylis pratensis*. Associated grassland is habitat for the vulnerable ptunarra brown butterfly (*Oreixenica ptunnara*).

Table 1. Locations for *Eucalyptus gunnii* subsp. *divaricata*. Details of specific sites within locations are italicised.

	Location	Tenure	NRM *	1:25000 mapsheet	Approx. area occupied (ha)	Approx. live mature trees 1985 **	Approx. live mature trees 2008 **	Approx. number of trees setting seed in 1999 ***	Comment
1	**Great Lake (southern shore)** *including sites at:*		South	Arthurs Lake, Miena				**1,000 for locations 1 & 2**	Some clearing to expand lake.
	-Shannon Lagoon	Private			*50*	*200*	*0*	*20*	*Most extreme form. Type population. All mature trees dead. About 100 repressed seedlings remain. History of sheep grazing. Frequently burnt. Roadworks.*
	-Barren Plains Road	Private				*80*	*30*		*History of sheep grazing. Part impacted by subdivision.*
	-Todds Corner	Great Lake Conservation Area, Private				*70*	*30*		*Subdivision pressures, road and pipeline works.*
2	**Liawenee Plains to South Brandum** *including site near Skittleball Hill* **(western shore, Great Lake)**	Private	South	Miena, Split Rock				See entry for location 1	Some clearing to expand lake. Part impacted by subdivision. *The extensive Skittleball Hill stand was discovered in the early 2000s, though all mature trees were already dead or dying. High wallaby browsing pressure in this stand.*
3	**Arthurs Lake**	Private, HEC, CHC	South	Arthurs Lake, Wihareja	10–15			**500** (likely over-estimate)	Numbers requiring verification. In decline.
4	**St Patricks Plain**	Private	South	Wihareja	10	100	100		Isolated stand in reasonable condition. ~150 repressed seedlings in understorey. History of sheep grazing. Contains shooters' camp.
5	**Cider Marsh**	Private	South	Wihareja, Steppes	10	150	0	**50**	Isolated stand. All mature trees dead. 2 repressed seedlings remain. Sheep grazing.
6	**Jacks Marsh**	Private	South	Wihareja	15	100	90 (in 2003)	**50**	Isolated stand. All mature trees dead or dying in 2008. Marsh drained in past. Sheep grazing.
7	**Jemmys Marsh (Alma Tier)**	Private	South	Interlaken	15			**50**	Isolated stand in reasonable condition (last seen ~5 years ago). No sheep grazing.

* NRM region = Natural Resource Management region; **Estimates from Calder & Kirkpatrick (2008); *** Based on 1999 estimates by Brad Potts (Potts 2001);
HEC = Hydro-Electric Commission; CHC = Central Highlands Council.

POPULATION ESTIMATE

Intergradation with other members of the *Eucalyptus gunnii*/ *Eucalyptus archeri* complex have made estimates of the size of the total population difficult, with work on the species generally focussing on core occurrences (Table 1). There is an urgent need to map all extant occurrences to use as a baseline in view of the alarming decline in the taxon in recent years. As a result of its formal description in 2001, a number of herbarium specimens have been recently redetermined to be *Eucalyptus gunnii* subsp. *divaricata* (Figure 1). However, ground truthing is required to confirm the identity of stands taking account of characteristics not evident from herbarium specimens.

There were estimated to be greater than 10,000 seedlings and trees in 1999, clearly in decline, and with only about 2,000 thought to be setting seed, half of these on the shores of the southern third of Great Lake (Potts 2001). The core stand of the most morphologically extreme form at Shannon Lagoon supported about 20 trees that were still setting seed in 1999 (of approximately 70 mature trees at the time, Calder & Kirkpatrick 2008) though all had died by 2008. Only 2 repressed seedlings remain in the Cider Marsh stand (all trees dead) (Plate 2), whereas the number of repressed seedlings in the core stand at Shannon Lagoon was estimated to be in the order of 100 in early 2009. All mature trees in the Jacks Marsh stand are now dead or dying. Widescale death has occurred in the recently identified stand near Skittleball Hill leaving only groups of saplings, struggling, though still alive, when last seen several years ago. Estimates from Calder & Kirkpatrick (2008) demonstrating declines at some sites and locations are shown in Table 1.

RESERVATION STATUS

While stands of the most extreme forms of *Eucalyptus gunnii* subsp. *divaricata* remain unreserved, forms attributable to the taxon are known from the Great Lake Conservation Area.

CONSERVATION ASSESSMENT

Eucalyptus gunnii subsp. *divaricata* was listed as endangered on the Tasmanian *Threatened Species Protection Act 1995* in 2002 under criterion C1:

- population estimated to number less than 2,500 mature individuals and an estimated continuing decline of at least 20% within 5 years.

The taxon was listed as Endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* in May 2003, satisfying criteria 2 and 3:

- its geographic distribution is precarious for the survival of the species; and
- the estimated total number of mature individuals is low and the number is likely to decline.

THREATS, LIMITING FACTORS & MANAGEMENT ISSUE

The main threats to *Eucalyptus gunnii* subsp. *divaricata* are drought, browsing, inappropriate fire regimes, fragmentation, climate change, clearing and stochastic events. These are detailed below and interactions between the perceived stressors and characteristics of the taxon that result in spiralling declines, and management implementations are also discussed.

Drought: Although *Eucalyptus gunnii* subsp. *divaricata* has developed a high level of frost tolerance, it has poor drought tolerance (Potts *et al.* 2001). Drought has caused a severe decline across the species' geographic range (Plate 2), especially in the southern and western edges of its distribution, possibly due to rain shadow effects (Calder & Kirkpatrick 2008). While *Eucalyptus gunnii* subsp. *divaricata* is the first of the eucalypts to show drought symptoms at a given site, it is not known whether the response is genetically based or whether it is a consequence of the taxon occupying the most exposed of habitats.

Drainage works to improve pasture at Jacks Marsh may have made this stand more susceptible to drought. Higher evaporation

rates as a result of sealing the Lake Highway through the Shannon Lagoon stand in the early 2000s may have contributed to drought stress, though road runoff was diverted into the stand to attempt to redress the problem.

Browsing: Lacking marked oil glands in the juvenile leaves in particular, *Eucalyptus gunnii* subsp. *divaricata* is highly palatable, with selective browsing by sheep, brushtail possums, wallabies, deer and rabbits, as well as leaf eating and sap sucking insects (including the introduced European wasp). Possums in particular appear to have a preference for browsing this species, with congregation in cider gums stands well recognised by farmers and shooters. Browsing pressure is thought to have increased following the cessation of the possum fur trade (Potts *et al.* 2001). The relatively good condition of the St Patrick Plains stand is thought to be a partial consequence of the recreational shooters' camp located within the stand (Calder & Kirkpatrick 2008).

Stands have been demonstrated to be well adapted to local insect herbivores (Potts 1985) though it is thought that milder winters have allowed insect populations to proliferate, thereby increasing browsing pressure in recent decades. Insect browsing pressure may also have increased as an indirect result of loss of trees in the vicinity through timber harvesting activities or dieback (Peter McQuillan, pers. comm.).

As a consequence of low recruitment through browsing by rabbits, sheep and deer as well as wallabies and possums, most live stands consist mainly of over-mature trees which are more susceptible to stressors and as a result are often in poor condition (Potts *et al.* 2001). Such trees attempt to regenerate through epicormic shoots, though these are more palatable than mature adult foliage. Continual browsing of the regrowth by possums and insect attack has been implicated in hastening tree death. It has been hypothesised that stock grazing and pasture improvement can lead to nutrient enrichment, further increasing the palatability of any regrowth (Davidson *et al.* 2007). Dead trees or branches also offer increased opportunity for nesting sites for possums and insect browsers leading to increases in browsing pressure. It is not known whether trunk boring insects (ghost moths) in the declining stand at Arthurs Lake are causal or are a result of increased amounts of dying trees and dead wood in stands.

Fragmentation: There is increasing isolation of mature *Eucalyptus gunnii* subsp. *divaricata* trees as plants die and are not replaced. This reduces the likelihood that bird and insect pollinators will travel between distant individuals leading to an increased rate of self-pollination and inbreeding. Inbreeding reduces the viability of seedlings of *Eucalyptus gunnii*, as they have been found to have a much lower survival rate than seedlings derived from unrelated trees (Potts *et al.* 2001).

Inappropriate fire regime: Since European settlement the vegetation on the Central Plateau has been burnt at frequencies designed to create pasture for grazing (Jackson 1973). This has probably led to a decline in the species, as fewer individuals were able to attain maturity or recover sufficiently to set sufficient seed before the next fire. With coppice and lignotuber regrowth being more palatable to browsers than adult foliage, post fire mortality of stressed *Eucalyptus gunnii* subsp. *divaricata* is thought to be relatively high, particularly as browsers are attracted to recently burnt areas by increased food supplies. As well as killing seedlings and young saplings, frequent firing can also deplete the understorey, removing shrubby protection of survivors from grazers. As exemplified in the Cider Marsh stand, it can also encourage a thick grassy understorey with fewer, drier recruitment niches.

Climate change: Climate change is implicated in the decline of *Eucalyptus gunnii* subsp. *divaricata* through increased severity and frequency of drought over recent decades and interaction with browsers leading to imbalances in the ecosystem (Potts *et al.* 2001, Calder & Kirkpatrick 2008). Stressed trees are more palatable, can house more browsers and warmer, drier conditions can increase browser populations (particularly insects).

Clearing and stochastic events: The small size of stands means that the loss of a single mature tree may be significant. Prior to listing, many large trees were felled prior to the level of Great Lake being raised, while other trees were lost during roadside maintenance, works associated with generation of hydroelectricity and subdivision. Over-mature trees are also prone to loss through wind throw. Illegal collection of seed has been an issue with a number trees felled in the past to facilitate collection of seed. Confusion as to the identity of stands in the *Eucalyptus gunnii*/*Eucalyptus archeri* complex can also hinder protection of *Eucalyptus gunnii* subsp. *divaricata*.

Spiralling declines and management issues: Davidson *et al.* (2007) for eucalypts in the Midlands and Calder & Kirkpatrick (2008) for *Eucalyptus gunnii,* set the scene to explain how drought stress coupled with disturbance in the form of grazing and frequent fire may lead some eucalypts into a decline that is difficult to stem or reverse. Key contributing factors to dieback include a short-lived canopy-held seedbank limiting recruitment to a short period following release after disturbance or decline, over-mature stands with few seedlings or saplings in grazed or frequently burnt stands and increased palatability of regrowth, particularly if nutrient enriched through pasture improvement activities for domestic stock.

Eucalyptus gunnii subsp. *divaricata* fits this model and represents an extreme example given that it is possibly Tasmania's most palatable eucalypt, it mainly occurs on private land in a sheep grazing area, it appears extremely susceptible to drought events and suffers from inbreeding depression. As such, the extensive and rapid decline in many stands, triggered by changing climatic conditions in its range in recent decades (Calder & Kirkpatrick 2008) is perhaps not surprising. It is also possible that changes in soil temperature and the composition of soil micro-organisms as a result of thinning canopies, dying roots of dieback affected stands or changed soil chemistry also contribute to the decline.

In view of the alarming decline in *Eucalyptus gunnii* subsp. *divaricata* in recent years there is an urgent need to identify and map all occurrences and quantify capsule yield and presence of seedlings to use as a baseline and to prioritise recovery activities. With the advanced decline in many stands prioritisation of recovery activities needs to consider feasibility of recovery and recovery of the most morphologically extreme forms as well as forms representative of variation within the taxon. Tree banding, caging of wild seedlings and reintroductions at Shannon Lagoon and Cider Marsh need to be monitored to prioritise *in situ* conservation efforts, bearing in mind that even well established saplings have died (e.g. at Shannon Lagoon).

Seed collection from healthy stands is a high priority, though as a result of recent drought, the canopy held seedbank appears to be low and probably of poor quality given the likelihood of inbreeding with the low number of trees bearing capsules. The University of Tasmania's School of Plant Science holds a collection of seed from a number of stands. However, the viability of the seed is dropping rapidly given that the seed was collected in the 1980s through to the mid 1990s and kept under short-term storage conditions. Seed from two stands (Shannon Lagoon and Cider Marsh) has been used for *ex situ* plantings and supplementation *in situ*. The primary purpose of the *ex situ* plantings is to enable fresh seed to be collected for long-term conservation storage in case of extinction in the wild. It may be necessary to consider controlled pollination in these plantings when they reach maturity in order to obtain seed uncontaminated by pollen of other eucalypts, though hybrids can be culled at the seedling stage as they are generally easily distinguished.

For stands where there is no seed available, protection of repressed seedlings may be necessary to encourage growth to enable them to be propagated from cuttings.

MANAGEMENT STRATEGY

What has been done?

Research into speciation, biology and ecology of *Eucalyptus gunnii* subsp. *divaricata* has occurred

since the 1970s (e.g., Potts & Reid 1985a & b, Potts & Potts 1986).

Banding and fencing of mature trees at the St Patricks Plains site began in 2005 through a Threatened Species Network project, with the cooperation of local landholders. Part of the moribund Shannon Lagoon site was also fenced, while cages were erected around wild seedlings at both sites. In 2007 and 2008 additional plants were caged at St Patricks Plains through NRM-funded threatened flora recovery projects, while plants were re-introduced to fenced areas at Cider Marsh and Shannon Lagoon, the latter on land managed by the Department of Infrastructure, Energy and Roads (the plants had been propagated from seed collected from the two wild subpopulations in the 1980s and 1990s).

Ex situ plantings were established at four sites in 2007 and 2008, also from seed collected from the Cider Marsh and Shannon Lagoon subpopulations. Sites included Green Valley near Bothwell, Kellevie, Granton and Anglesea Barracks in Hobart. Plantings were also undertaken in the Forestry Tasmania seed production area at Geeveston in 2005, though these have suffered from possum browsing.

Volunteers have played a significant role in the aforementioned activities, including building and erecting protective wire cages. Activities were facilitated through the Threatened Species Network, Wildcare's Threatened Plant Action Group (now Threatened Plants Tasmania) and the Threatened Species Section, with assistance from land owners, Green Corps and Conservation Volunteers Australia. The University of Tasmania and Forestry Tasmania have supported this work.

Management objectives

The main objectives for the recovery of *Eucalyptus gunnii* subsp. *divaricata* are to prevent the inadvertent destruction of known subpopulations, maintain the viability of standing subpopulations, to promote conditions for the taxon's successful recruitment, and conservation storage to preserve genetic diversity and prevent extinction in case declines in the wild cannot be stemmed.

What is needed?

- survey and map all wild subpopulations to determine their extent, status, threats and management issues, and identify key sites;
- field truth locations of herbarium specimens attributed to the taxon;
- monitor *in situ* seedlings (caged and uncaged) to determine feasibility of future *in situ* planting and caging efforts;
- prepare and implement management plans for key sites, addressing issues such as site security and the management of fire and herbivores (stock, deer, possums);
- provide information and extension support to relevant Natural Resource Management committees, local councils, government agencies and the local community on the location, significance and management of known subpopulations, *ex situ* plantings and areas of potential habitat;
- fence additional key sites, band additional mature trees, cage additional wild seedlings and young juveniles (particularly in the core stand at Shannon Lagoon), extend cages if necessary;
- *ex situ* conservation, including maintenance of existing plantings, seed collection from plantings for long term storage (possibly requiring manipulated cross pollination to exclude pollen contamination from other eucalypts), propagation from cuttings from wild seedlings if seed is not available for re-establishment of plants in suitable habitat;
- collect seed that represents the diversity within the taxon for long-term conservation storage at the Tasmanian Seed Conservation Centre.

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Permit: It is an offence to collect, disturb, damage or destroy this species unless under permit.