



Conservation Advice for *Darwinia carnea* (Mogumber and Narrogin Bell)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 23 November 2021.

This document provides a foundation for conservation action and further planning.



Darwinia carnea (Mogumber and Narrogin Bell) © Copyright, M. Fagg ([Australian National Botanic Gardens 1980](#)).

Conservation status

Darwinia carnea (Mogumber and Narrogin Bell) is listed in the Endangered category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) effective from 16 July 2000. The species is eligible for listing because prior to the EPBC Act, it was listed as Endangered under the *Endangered Species Protection Act 1992* (Cwlth).

The main factors that make the species eligible for listing in the Endangered category are restricted and fragmented distribution, small population size, and continuing decline due to climate change, invasive species, habitat loss, disturbance and modifications.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the [Species Profile and Threat Database](#).

Species information

Taxonomy

Conventionally accepted as *Darwinia carnea* Gardner (1928).

The plants near Mogumber (Mogumber form) and Narrogin (Narrogin form) are considered to potentially be two different taxonomic forms and possibly separate subspecies (DEC 2009). This needs to be confirmed via genetic studies.

Description

The Mogumber and Narrogin Bell is a small shrub, which grows up to 20 to 40 cm tall. The leaves are narrow, keeled, 6 to 10 mm long and arranged in opposite pairs along the stem. The flower head is surrounded by broad, yellowish-green to pinkish-red bracts, up to 3 cm long. Bracts conceal eight tubular flowers with short, blunt lobes, approximately 1.5 mm long, and five white petals, which are approximately 4 mm long. This description is drawn from Leigh et al. (1984), Hopper et al. (1990) and Brown et al. (1998).

The Mogumber form is the type form (Gardner 1928). The Mogumber form is taller with larger inflorescences and different coloured bracts to the Narrogin form (Brown et al. 1998).

Distribution

The Mogumber and Narrogin Bell is endemic to south-western Western Australia (WA) and is the only member of the Mountain Bell subgroup to occur outside the Stirling Range (DEC 2009, Keighery 2016). Historically, the species occurred near Cranbrook (Keighery 2016), however, the Mogumber form is now confined to the Mogumber area, while the Narrogin form is confined to the Narrogin area (DEC 2009). The forms are geographically isolated by approximately 250 km (DEC 2009). The Mogumber and Narrogin Bell was first collected from an area near Mogumber in 1922 (Mogumber form; subpopulation 2; Gardner 1928). In 2009, the Mogumber and Narrogin Bell was known from four wild subpopulations and three translocated subpopulations, totalling approximately 515 mature individuals (85 percent in translocated populations; Table 1; DEC 2009). Targeted surveys have been completed in areas of suitable habitat, including south-east and south-west of Narrogin, east of Cuballing, north-west and south-west of Highbury, south and east of Gillingarra and north of North Road on the eastern side of the Great Northern Highway. However, no additional subpopulations have been located (DEC 2009).

The WA Threatened Seed Centre holds fruit and seed collected from subpopulations 1, 3, 5 and 6 between 1990 and 2006 (DBCA 2021). The collections include approximately 2890 fruits collected from the Narrogin form and approximately 3660 from the Mogumber form (DBCA 2021).

Mogumber form

In 2009, the Mogumber form was known from three wild subpopulations on private property (subpopulations 3a, b, c, covering three distinct areas approximately one ha in size and two km apart) and a translocated subpopulation at Udamung Nature Reserve (subpopulation 7; Table 1; Stack et al. 2006; DEC 2009). The translocated subpopulation was established in 2006, from plants propagated from cuttings sourced from subpopulation 3a and 3b (Table 1; Stack et al. 2006; DEC 2009). The type subpopulation (subpopulation 2) is now presumed extinct, as it has not been sighted since 1970, despite an unsuccessful translocation attempt in 1985 (Table 1; Holland et al. 1997; DEC 2009).

Narrogin form

In 2009, the Narrogin form was known from one wild subpopulation on private property (subpopulation 1, covering an area of approximated 0.5 ha) and two translocated subpopulations in a Shire Reserve and Dryandra Woodlands (subpopulations 5 and 6), which have produced viable offspring (Table 1; Monks 2004; DEC 2009). Translocated subpopulations were established in 1999, with follow-up planting in 2001 and 2002, from plants propagated from cuttings (20 clonal types) sourced from subpopulation 1 in 1997 and 1998 (Monks 2004; DEC 2009). The death of several clonal lines and the disproportionate survival of other lines, resulted in inbreeding depression and the potential for a few clonal lines to dominate the gene pool of the second generation (Monks 2004). Additionally, the number of plants established in each subpopulation was deemed too small for long-term population viability (Monks 2004). To prevent inbreeding depression and increase the long-term viability of populations, cuttings were taken from subpopulation 1 in 2005 and 2006, and propagated to replace the clonal lines lost from subpopulations 5 and 6 (DEC 2009). In 2021, infill planting of seedlings occurred at subpopulation 5 (DBCA 2021).

In 1992, an unconfirmed sighting of a single plant (subpopulation 4) was made in Highbury State Forest, south-west of Narrogin. However, surveys in 1993, 1994 and 1995 did not find any plants (DEC 2009).



Table 1 Summary of Mogumber and Narrogin Bell subpopulation information and threats

Subpopulation	Status	Form	Survey Year	Number of mature individuals	Habitat condition	Main threats	Vesting	Manager	Translocation
1. Narrogin (private property)	Extant	Narrogin form	1978	6	Moderate	Weeds, grazing (rabbits, birds), drought/exposure, insect damage to reproductive shoots, competition with native plants	Freehold	Landholder	NA - wild subpopulation
			1983	67					
			1984	85					
			1989	30					
			1990	36 (41) [2]					
			1995	26 (43) [4]					
			1996	20 (5)					
			2006	20 (52) [5]					
			2007	16 (37) [12]					
			2009	18 (29) [10]					
			2010	28 (8) [1]					
2020	13								
2. Mogumber † (private property)	Presumed extinct	Mogumber form	1985	44 [6]	-	Grazing (parrots), drought/exposure, trampling	Freehold	Landholder	Type locality with unsuccessful translocation in 1985
			1990	0 [50+]					
3(a). Mogumber (private property)	Extant	Mogumber form	1990	200	Moderate	Grazing (rabbits, kangaroos, birds), trampling, insect damage to reproductive shoots, drought/exposure, fire	Freehold	Landholder	NA – wild subpopulation
			1995	80 (30)					
			1997	120					
			1999	127 (31)					
			2005	34 [3]					
			2007	22 (1) [5]					
			2011	24 (2) [16]					
			2012	30 (31) [11]					
2019	17								

Darwinia carnea (Mogumber and Narrogin Bell) Conservation Advice

Subpopulation	Status	Form	Survey Year	Number of mature individuals	Habitat condition	Main threats	Vesting	Manager	Translocation
3(b). Norcia (private property)	Extant	Mogumber form	1990	50	Poor	Weeds, fire, drought/exposure, grazing, habitat deterioration	Freehold	Landholder	NA – wild subpopulation
			1994	25 (45)					
			1995	10 (30)					
			2007	1**					
			2011	6					
			2012	8					
3(c). Mogumber (private property)	Extant	Mogumber form	1995	100	Moderate	Weeds, grazing (kangaroos), inappropriate fire regimes, land clearing	Freehold	Landholder	NA – wild subpopulation
			1996	70					
			1997	70					
			1998	65 (31)					
			2007	39 (6)					
			2011	31 (2) [1]					
			2012	24 (8) [1]					
			2018	23 (16)					
4. <i>Highbury State Forest*</i>	<i>Unconfirmed sighting</i>	-	1992 1995	1 0	-	-	<i>Lands and Forests Commission</i>	<i>DBCA</i>	<i>NA</i>
5. Narrogin (Shire Reserve/Gravel Pit)	Extant	Narrogin form	2001	48 [36]	Moderate	Drought, grazing (loopers caterpillar), poor recruitment, competition with native plants	Shire of Narrogin	Shire of Narrogin	Translocation: 224 individuals planted in 1999 – propagated from cuttings from subpopulation 1.
			2002	124 <89> [9]					
			2006	66 <22> [1]					
			2007	54 <16> [17]					
			2007	51 (25)					
			2009	59 (20)					
			2010	53 (9) [11]					
			2013	21 (7)					
2019	21								

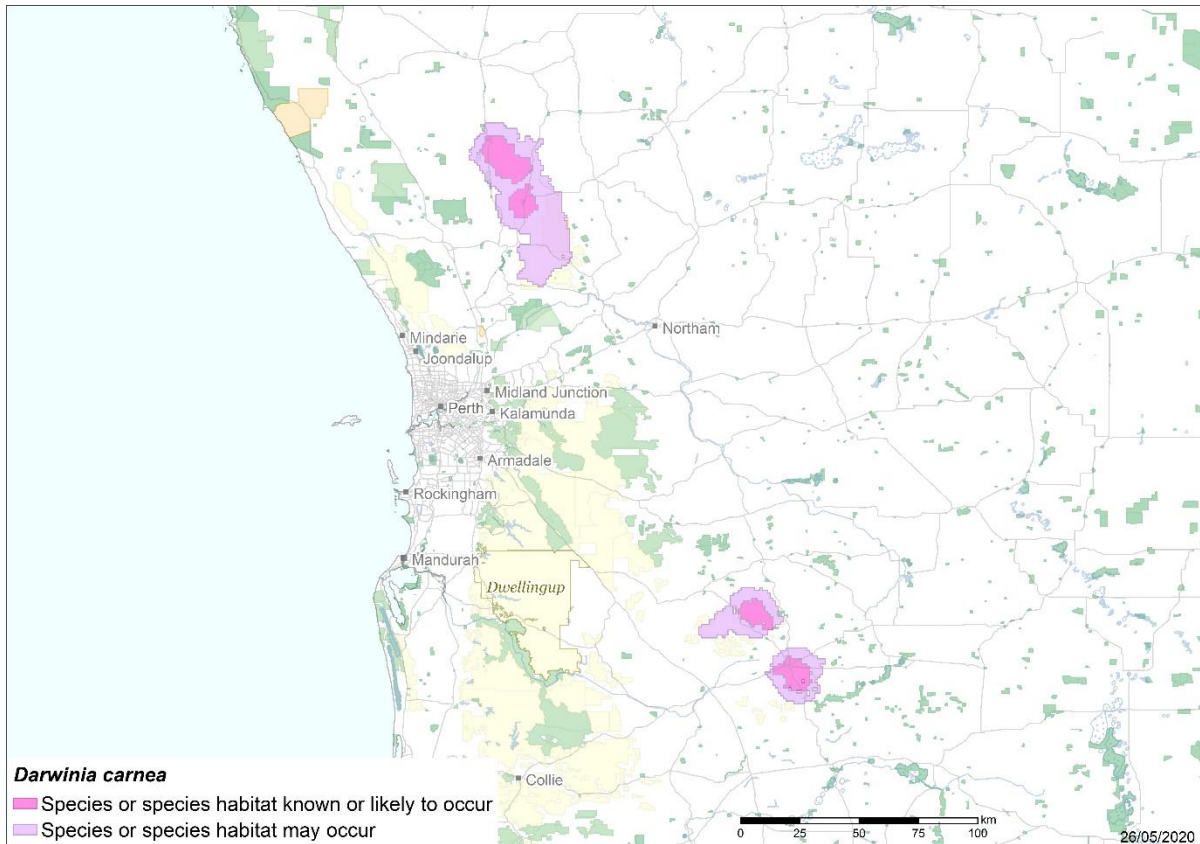
Darwinia carnea (Mogumber and Narrogin Bell) Conservation Advice

Subpopulation	Status	Form	Survey Year	Number of mature individuals	Habitat condition	Main threats	Vesting	Manager	Translocation
6. Dryandra Woodland (previously State Forest)	Extant	Narrogin form	2001	127 [30]	Healthy	Drought, grazing (looper caterpillar), poor recruitment, competition with native plants	Lands and Forests Commission	DBCA	Translocation: 282 individuals planted in 1999 – propagated from cuttings from subpopulation 1.
			2001	113 [14]					
			2002	189 <98> [12]					
			2006	103 <1> [3]					
			2007	90 <10> [13]					
			2007	88 (1)					
			2009	92					
			2010	84 (7) [4]					
			2013	51 (18) [9]					
			2016	76					
7. Udumung Nature Reserve	Extant	Mogumber form	2006	<400>	Healthy	Fire, senescence due to lack of disturbance	Park and Conservation Commission	DBCA	Translocation: 400 individuals planted in 2006 – propagated from cuttings from subpopulation 3a and 3.
			2007	396					
			2009	323					
			2011	212					
			2015	158					
			2019	127					

Note: Subpopulation information is taken from DEC (2009) and DBCA (2021), presumed extinct and unconfirmed subpopulations are italicised, [] = dead, () = natural recruit seedlings, <> = planted seedlings, *Unconfirmed sighting 19/9/92 by Mrs Barratt-Lennard and Mrs Scott; further surveys have failed to locate this single plant, **incomplete survey.



Map 1 Modelled distribution of Mogumber and Narrogin Bell



Source: Species distribution data [Species of National Environmental Significance](#) database, Base map Geoscience Australia.

Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.

Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the specific habitat type or geographic feature that represents to recent observed locations of the species (known to occur) or preferred habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Cultural and community significance

The significance of the Mogumber and Narrogin Bell is unknown. However, the Mogumber form occurs in the Yued region of Noongar Nation. The Narrogin form occurs in the Gnaala Karla Booja region of Noongar Nation. Noongar People have lived on boodjah (Country) since the beginning of the Dreaming. Many significant sites occur in the Yued and Gnaala Karla Booja regions, including caves, ceremonial sites, rock art, paintings and artefacts (South West Aboriginal Land & Sea Council 2020a, b). Aboriginal Heritage Places (20008, 20749, 21620, 38005, 5626, 5888, 15139, 3275 and 3276) have been registered with the WA Department of Planning, Lands and Heritage in or adjacent to lands where the Mogumber and Narrogin Bell occurs (DPLH 2020). Moore River Native Settlement, later re-named Mogumber Native Mission, was an Aboriginal settlement and internment camp located at Mogumber from 1918 to 1974 (Haebich 1988; South West Aboriginal Land & Sea Council 2020a). Many Indigenous children were sent to the camp as part of the Stolen Generations (Haebich 1999; South West Aboriginal Land & Sea Council 2020a).

Noongar People have identified Dryandra Woodlands, a translocation site for the Narrogin form (subpopulation 6), as a favoured location for future cultural activities, including hunting, camping, and passing on cultural knowledge to younger generations (DEC 2011). Additionally, the Yued and Gnaala Karla Booja Indigenous Land Use Agreements (2018), executed by the WA Government and the Noongar Nation as part of the South West Australian Native Title Settlement, includes lands in or adjacent to lands where the Mogumber and Narrogin Bell occur.

Relevant biology and ecology

Habitat ecology

The Mogumber form grows in association with low open woodland of *Eucalyptus wandoo* (Wandoo) over heath or sparse shrub of *Adenanthos cygnorum* (Woollybush), *Banksia polycephala* (Many-headed Dryandra), *Banksia sphaerocarpa* (Fox Banksia), *Banksia nobilis* (Golden Dryandra), *Corymbia calophylla* (Marri), *Eucalyptus accedens* (Smoothbark Wandoo), *Petrophile heterophylla* (Variable-leaved Conebush), *Xanthorrhoea preissii* (Balga) and *Dodonaea*, *Calothamnus*, *Banksia* and *Hibbertia* species (Stack et al. 2006; DEC 2009). The wild subpopulation (Mogumber form; subpopulation 3) is situated on lateritic breakaways, growing in gravelly, brown, loamy soil (DEC 2009). The translocated subpopulation (Mogumber form; subpopulation 7) is situated near a laterite hill with boulders, growing in gravelly, orange-brown, loamy clay, with some coarse white sand (Stack et al. 2006; DEC 2009).

The Narrogin form grows in association with low open woodland of *Allocasuarina huegeliana* (Rock Sheoak), Wandoo and Fox Banksia over heath of Golden Dryandra, Woollybush, *Beaufortia incana* (Grey-leaved Beaufortia), *Hibbertia rupicola* (no common name) and *Grevillea leptobotrys* (Tangled Grevillea; DEC 2009). The wild subpopulation (Narrogin form; subpopulation 1) grows on an exposed lateritic gravel hilltop in dark yellow brown sandy loam soil with gravel over the lateritic duri-crust (DEC 2009).

Reproductive ecology

The Mogumber and Narrogin Bell flowers from October to November, but flower buds have been recorded as early as July (DEC 2009). The collections held by the WA Threatened Seed Centre contained low estimated numbers of germinable seed that ranged from approximately 3 to 36 seeds per 100 fruit (DBCAs 2021). In general, Mountain Bells start flowering two to five years after germination, however, do not reach reproductive maturity until seven to ten years after germination (DEC 2009). Population health and numbers are thought to decline twenty years after germination, as the surrounding vegetation becomes too dense for Mountain Bell individuals to survive (Keighery & Marchant 1993). This crowding by associated vegetation has been noted at subpopulation 1, where several associated species, including Golden Dryandra and Woollybush compete with the Mogumber and Narrogin Bell (Holland et al. 1997). Without intervention, these larger plants could displace the Mogumber and Narrogin Bell (Holland et al. 1997).

Mountain Bells are likely pollinated by nectar-feeding birds (Keighery & Marchant 1993). Flowers are brightly coloured and positioned so that birds can probe for nectar from the ground or when perched on the plant (Keighery & Marchant 1993).

In many Myrtaceae species, including Mountain Bells, germination of dormant seeds is triggered by fire-related cues, including heat, smoke and scarification (Keighery 1985; Dixon et al. 1995; Auld & Ooi 2008). As the mature plants of such species are usually killed by fire, there must be sufficient intervals between fires, for new seedlings to reach maturity and replenish the seedbank (Keighery 1985; Brown et al. 1998). The Mogumber and Narrogin Bell is thought to regenerate from seed following fires (Keighery 1985). Mountain Bell seeds have no specialised means of dispersal and remain stored in the soil below adult plants until the next fire (Keighery & Marchant 1993). A minimum fire interval of at least 10 years is likely required for Mountain Bells to mature and reproduce successfully following fires (Brown et al. 1998). Additionally, the Mogumber and Narrogin Bell also appears to respond to disturbance as 72 seedlings germinated in disturbed rabbit warrens (DEC 2009).

Habitat critical to the survival

Due to the species eligibility for listing (highly restricted range, severe fragmentation and small population size), all habitat is considered critical to the survival of the species.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat.

Important populations

In this section, the word population is used to refer to subpopulation, in keeping with the terminology used in the EPBC Act and state/territory environmental legislation.

There is sufficient evidence through the species eligibility for listing, to declare all populations/the national population of this species under particular pressure of survival and which therefore require protection to support the recovery of the species.

Threats

The Mogumber and Narrogin Bell is threatened by climate change, invasive species, habitat loss, disturbance and modifications (Table 2). The species is threatened by several fire-related threats, including high frequency fire, fire-drought interactions, and fire promoted weed invasion. The Mogumber and Narrogin Bell is highly susceptible to extinction via stochastic processes, due to its small population size and restricted distribution (DEC 2009). Illegal collection is a known threat to rare flora (Banks & Rice 2008), however, the Mogumber and Narrogin Bell is protected under the WA Biodiversity Conservation Act (2016) and illegal collection could result in a penalty of \$500 000. Consequently, illegal collection is likely a negligible threat to the Mogumber and Narrogin Bell and has not been considered in Table 2.

Table 2 Threats impacting Mogumber and Narrogin Bell

Threat	Status and severity ^a	Evidence
Climate change		
Increased severity/frequency of bushfire	<ul style="list-style-type: none"> • Timing: current • Confidence: inferred • Consequence: catastrophic • Trend: increasing • Extent: across the entire range 	<p>The Mogumber and Narrogin Bell is thought to be killed by fire and regenerate from soil-stored seeds (Keighery 1985). A high frequency fire regime (<10 years) is likely to kill adult plants before soil-stored seed banks can be replenished (Brown et al. 1998). Furthermore, a drying climate will lengthen the minimum fire interval required for self-replacement of obligate seed regenerators, due to higher seedling mortality and slower growth (Enright et al. 2014). Analysis and modelling predict that a 20 percent reduction in post-fire winter rainfall would increase the minimum fire interval for this species to 15 years (Enright et al. 2014), further imperilling the Mogumber and Narrogin Bell.</p> <p>The small population size and restricted distribution of the species may also increase population extinction risk, following stochastic events, such as fire (DEC 2009). Fires can also alter habitat structure, by favouring the invasion and establishment of weeds (D'Antonio & Vitousek 1992; Grigulis et al. 2005).</p> <p>In 2019-20, following years of drought (Bureau of Meteorology 2020), catastrophic bushfire conditions resulted in unprecedented, extensive bushfires across southern Australia. Fire intensity and severity varied across the bushfire extent, with many patches burning at extreme intensity and severity while others remained unburnt (DPIE 2020). This type of event is increasingly likely to reoccur due to climate change. Initial estimates suggest the 2019-20 bushfires overlapped with 0.5 to 17 percent of the Mogumber and Narrogin Bell's modelled distribution (Gallagher 2020). However, the species has not been identified as a high priority species for recovery actions as known populations were not impacted (Gallagher 2020).</p>

Threat	Status and severity ^a	Evidence
<p>Increased temperatures and change to precipitation patterns</p>	<ul style="list-style-type: none"> • Timing: current • Confidence: inferred • Consequence: catastrophic • Trend: increasing • Extent: across the entire range 	<p>In the twentieth century, south-western WA has experienced a significant decrease in autumn and early winter rainfall and an increase in mean ambient temperatures (Bates et al. 2008; CSIRO & Bureau of Meteorology 2015). CSIRO & Bureau of Meteorology (2015) predict south-western WA will continue to experience decreased rainfall, increased average temperatures and frequency of droughts.</p> <p>Drought threatens all Mogumber and Narrogin Bell subpopulations and contributed to the presumed extinction of subpopulation 2 (Table 1; DEC 2009). Drought conditions may have serious effects on the fecundity and survival of Mogumber and Narrogin Bell individuals (DEC 2009) in particular seedlings. Fire-drought interactions are particularly an issue for obligate seeders, as they rely on fire for recruitment, yet seedlings have rudimentary root systems vulnerable to desiccation if post- fire drought occurs (Burgman and Lamont 1992).</p> <p>Drought may also alter the habitat structure, by killing associated species and opening up the canopy and ground cover layers (DEC 2009). This could cause mortality in Mogumber and Narrogin Bell individuals, due to increased intense direct sunlight and decreased soil moisture (DEC 2009).</p> <p>Additionally, a drying climate will increase the extent of the fire season and lengthen the minimum fire interval required for self-replacement of obligate seed regenerators, like the Mogumber and Narrogin Bell, to 15 years, due to higher seedling mortality and slower growth (Enright et al. 2014). Under the current high frequency fire regime, the Mogumber and Narrogin Bell may not be able to replenish soil-stored seed banks before the next fire, putting this species at serious risk of extinction. The small population size and restricted distribution of the species may also increase population extinction, following stochastic events, such as drought (DEC 2009).</p>

Threat	Status and severity ^a	Evidence
Invasive species		
Grazing and habitat damage by Rabbits (<i>Oryctolagus cuniculus</i>) and domestic stock	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: major • Trend: static • Extent: across the entire range 	<p>Rabbits (<i>Oryctolagus cuniculus</i>) are found in all states and territories of Australia and have been listed as a Key Threatening Process (KTP) under the EPBC Act (DOEE 2016). Grazing by rabbits can prevent plant regeneration, reverse the normal processes of plant succession, alter ecological communities and promote weed invasion (DOEE 2016). Rabbits may also damage the habitat by digging, warren construction and increased nutrient levels from faeces (DEC 2009). Similarly, domestic livestock can destroy and degrade native vegetation, by trampling and grazing plants, preventing plant regeneration, altering ecological communities, promoting weed invasion and spreading <i>Phytophthora cinnamomi</i> (DEC 2009).</p> <p>All subpopulations of the Mogumber and Narrogin Bell are protected by rabbit proof fencing and fences are maintained annually (DBCA 2021). Rabbit control is implemented within fenced areas if a breach occurs (DBCA 2021).</p>
Weed invasion	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: major • Trend: static • Extent: across part of its range 	<p>Weeds can invade, establish in and outcompete native vegetation, particularly following disturbance events, such as bushfires (Hobbs 1991; Hobbs 2002; Brown et al. 2016). In particular, grassy weeds can increase fuel load and alter fire regimes (Milberg & Lamont 1995; Setterfield et al. 2013). These altered fire regimes can create conditions that are detrimental to the maintenance of native species and favourable to the establishment and spread of weeds (D'Antonio & Vitousek 1992; Grigulis et al. 2005). Weeds also compete with the Mogumber and Narrogin Bell for space, nutrients, water, light and pollinators, which likely reduces the survival and recruitment success of the species (DEC 2009).</p> <p>In 2009, weeds were considered a threat to subpopulations 1, 3b and c, but not to translocated subpopulations 5, 6 and 7 (Table 1; DEC 2009). By 2021, weeds were no longer considered a threat to any subpopulations (except following fire) (DBCA 2021). Weed management practices must be continued to control this threat (DEC 2009).</p>
Habitat loss, disturbance or modification		
Grazing by native species	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: moderate • Trend: static • Extent: across the entire range 	<p>In 2009, all subpopulations of the Mogumber and Narrogin Bell were threatened by grazing by native insects, parrots and macropods., despite all subpopulations (except 3b) being fenced (DEC 2009). Fences require regular monitoring and maintenance to control this threat (DEC 2009).</p> <p>Native grazers can prevent plant regeneration and reduce plant recruitment (DEC 2009). <i>Steriphus diversipes</i> (Spotted Vegetable Weevil) has been observed in plants in subpopulation 1 (DEC 2009). The Spotted Vegetable Weevil bores through the bracts and consumes the seeds, reducing recruitment success (DEC 2009). <i>Trichoplusia ni</i> (Looper Caterpillar) has also been observed eating flowers and immature fruit at subpopulation 5 (DEC 2009).</p>

Threat	Status and severity ^a	Evidence
Trampling by Macropods (Kangaroos)	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: moderate • Trend: decreasing • Extent: across the entire range 	<p>Mogumber and Narrogin Bell plants occur under large native species, such as Woollybush or Dryandra, which Kangaroos use for shelter and rest (DEC 2009). Accordingly, plants are prone to being smothered and trampled by Kangaroos (DEC 2009). Fencing has abated this threat for all subpopulations (DBCA 2021). Fences require regular monitoring and maintenance to control this threat (DEC 2009).</p>
Habitat fragmentation	<ul style="list-style-type: none"> • Timing: historical • Confidence: inferred • Consequence: major • Trend: static • Extent: across the entire range 	<p>Broad-scale land clearing for agriculture has removed large areas of suitable habitat and lead to the fragmentation of Mogumber and Narrogin subpopulations (DEC 2009). Although broad-scale clearing has ceased since the introduction of the <i>Environmental Protection Act 1986</i> (EP Act), remnant populations likely have reduced genetic diversity and reduced opportunities for recolonisation in nearby areas (DEC 2009). In particular, subpopulation 1 is restricted to a small area of remnant vegetation on private land and is vulnerable to severe edge effects (DEC 2009).</p> <p>Agriculture may also cause soil erosion, soil acidity, water logging, salinity and fertiliser spray drift, which may have secondary impacts on the resilience of remnant native vegetation (Dohle 2013).</p>
Competition with native vegetation	<ul style="list-style-type: none"> • Timing: current • Confidence: known • Consequence: moderate • Trend: static • Extent: across part of its range 	<p>Mountain Bells are thought to decline in population health and size, twenty years after germination, as the surrounding vegetation becomes too dense for individuals to survive (Keighery & Marchant 1993). This crowding by associated vegetation has been observed at subpopulation 1 (Narrogin form), where several associated species, including Golden Dryandra and Woollybush, compete with the Mogumber and Narrogin Bell (Holland et al. 1997). Without intervention, these larger plants could displace the Mogumber and Narrogin Bell (Holland et al. 1997). However, loss of associated vegetation, may also cause mortality of the Mogumber and Narrogin Bell, due to increased intense direct sublight and decreased soil moisture (DEC 2009). Regular monitoring and maintenance of associated vegetation may be required to control this threat.</p>

Threat	Status and severity ^a	Evidence
Disease		
Dieback caused by <i>P. cinnamomi</i>	<ul style="list-style-type: none"> • Timing: future • Confidence: inferred • Consequence: major • Trend: static • Extent: across the entire range 	<p><i>Phytophthora cinnamomi</i> is an introduced soil-borne pathogen, which infects a large range of plant species and may contribute to plant death, when other stresses are present, such as waterlogging, drought and bushfire (DOEE 2018). <i>Phytophthora cinnamomi</i> can disperse in water flowing from roots of infected plants to roots of healthy plants and mud clinging to vehicles, animals and walkers (DOEE 2018). Dieback caused by <i>P. cinnamomi</i> is listed as a KTP under the EPBC Act (DOEE 2018). The disease has been detected in the Narrogin area, including in Dryandra Woodland (Sage et al. 2004), as well as in the Cullalla area, approximately 25 km south of Mogumber (Boulden 2020).</p> <p>The susceptibility of the Mogumber and Narrogin Bell to <i>P. cinnamomi</i> is unknown. Testing of three seedlings suggested the species may be resistant to <i>P. cinnamomi</i> but this lacks statistical replication (DEC 2009). Other Mountain Bell species are susceptible to <i>P. cinnamomi</i>, with a very high risk of extinction resulting from infestation (Barrett et al. 2008). The Mogumber and Narrogin Bell may be severely impacted if <i>P. cinnamomi</i> spreads to known subpopulations. The small population size and restricted distribution of the Mogumber and Narrogin Bell may increase the likelihood of extinction, following stochastic events, such as disease (DEC 2009).</p>

Timing—identify the temporal nature of the threat;

Confidence—identify the extent to which we have confidence about the impact of the threat on the species;

Consequence—identify the severity of the threat;

Trend—identify the extent to which it will continue to operate on the species;

Extent—identify its spatial content in terms of the range of the species.

Each threat has been described in Table 2 in terms of the extent that it is operating on the species. The risk matrix (Table 3) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration, they are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Table 3 Mogumber and Narrogin Bell risk matrix

Likelihood	Consequences				
	Not significant	Minor	Moderate	Major	Catastrophic
Almost certain	Low risk	Moderate risk	Very high risk	Very high risk	Very high risk Increased severity/frequency of bushfire Increased temperatures and change to precipitation patterns
Likely	Low risk	Moderate risk	High risk	Very high risk Weed invasion	Very high risk
Possible	Low risk	Moderate risk	High risk Grazing by native species Trampling by kangaroos Competition with native vegetation	Very high risk Grazing and habitat damage by rabbits and domestic stock Dieback caused by <i>P. cinnamomi</i>	Very high risk
Unlikely	Low risk Illegal collection	Low risk	Moderate risk	High risk Habitat fragmentation	Very high risk
Unknown	Low risk	Low risk	Moderate risk	High risk	Very high risk

Priority actions have then been developed to manage the threat particularly where the risk was deemed to be ‘very high’ or ‘high’.

Conservation and recovery actions

Primary conservation objective

By 2030, the population of the Mogumber and Narrogin Bell will have increased in abundance and viable populations are sustained in disease-free habitats.

Conservation and management priorities

Habitat loss disturbance and modifications

- Prevent clearing or detrimental habitat modification in known subpopulations and surrounding native vegetation, for tracks, management infrastructure or fire suppression.
- Ensure local governments, relevant state agencies and land holders/owners have access to adequate distribution information and use best practice methods for land management to protect the species and its habitat.
- Investigate options to enhance the resilience of the species’ current habitat to climate change and options for providing new habitat that would be suitable for the species under climate change scenarios.

- Manage kangaroos and other native animals, where appropriate, to reduce their impact the Mogumber and Narrogin Bell. Remove kangaroos from within fenced areas and maintain such areas as kangaroo-free.
- Manage native vegetation, where appropriate, to reduce crowding and displacement of the Mogumber and Narrogin Bell by associated native vegetation.

Invasive species (including threats from grazing, trampling, predation)

- Implement weed management actions in consultation with land managers/owners and community groups, using hand weeding or localised application of selective herbicides during the appropriate season to minimise the effect of herbicides on native vegetation.
- Implement grazing management actions in consultation with land managers/owners and community groups; prevent further introduction of pest animals and control those that are already present. Maintain fenced populations as vertebrate herbivore free enclosures.

Fire

- Provide maps of known occurrences to local and state fire management services and seek inclusion of mitigation measures in bushfire risk management plan/s, risk register and/or operation maps.
- Develop and implement a fire management strategy that optimises the survival of the Mogumber and Narrogin Bell during planned burns and bushfires.

Disease

- Establish susceptibility of Mogumber and Narrogin Bell to *P. cinnamomi*.
- Implement a *P. cinnamomi* management plan to ensure the pathogen is not introduced unknowingly into known subpopulations of Mogumber and Narrogin Bell (DOEE 2018). Ensure appropriate hygiene protocols are in place and adhered to when entering or exiting known subpopulations, such as those outlined in Podger et al. (2001).

Impacts of domestic species

- Monitor and control damage caused by livestock. Maintain fencing around all known subpopulations.

Breeding, seed collection, propagation and other ex situ recovery action

- Continue maintenance of the translocated populations until they are viable and able to persist for long periods without intensive management. Investigate the possibility of establishing further translocated populations, according to Commander et al. (2018).

Stakeholder engagement/community engagement

- Engage and involve Traditional Owners in conservation actions, including the implementation of Indigenous fire management practices and other survey, monitoring and management actions. Liaise with Yued Noongars in regard to land acquisitions possibilities in the Mogumber area associated with the Moore River Native Settlement and establishment of the Noongar Land Estate.
- Liaise with the local community and government agencies to ensure that up-to-date population data and scientific knowledge inform the implementation of conservation actions for this species.
- Contribute to impact assessment and planning processes on measures to protect the Mogumber and Narrogin Bell and its habitat.

Survey and monitoring priorities

- Undertake annual monitoring of known subpopulations, potential habitat, habitat condition/degradation (including impacts from weed invasion, introduced species and diseases), population stability (expansion or decline), pollination activity, seed production, recruitment and longevity.
- Monitor the size, structure and reproductive status of populations at different stages in the fire cycle, taking opportunities to monitor after planned and unplanned fires (where they occur) and improve understanding of the fire response of the species.

Information and research priorities

- Resolve taxonomic uncertainties between the Mogumber and Narrogin forms.
- Investigate options for linking, enhancing or establishing additional populations.
- Survey suitable habitat and potential habitat to locate any additional populations/occurrences/remnants to assess population size and distribution more precisely. Investigate the ecological requirements of the Mogumber and Narrogin Bell, that are relevant to persistence:
 - Population genetic structure, levels of genetic diversity and minimum viable population size,
 - Soil seed bank dynamics and the role of various disturbances (including fire), competition, rainfall and grazing in respect to germination and recruitment,
 - Reproductive strategies, phenology and seasonal growth, and
 - Pollinator biology and requirements.

Links to relevant implementation documents

[Declared Rare and Poorly Known Flora in the Moora District, Western Australian Wildlife Management Program no. 28 \(2001\)](#)

[Declared Rare and Poorly Known Flora in the Narrogin District, Western Australian Wildlife Management Program no. 30 \(2001\)](#)

[Dryandra Woodland Management Plan no. 70 \(2011\)](#)

[Mogumber and Narrogin Bell \(Darwinia carnea\) Recovery Plan \(2009\)](#)

[Threat Abatement Plan for Competition and Land Degradation by Rabbits \(2016\)](#)

[Threat Abatement Plan for Disease in Natural Ecosystems caused by *Phytophthora cinnamomi* \(2018\)](#)

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Department of Agriculture, Water and the Environment

GPO Box 858, Canberra ACT 2601

Telephone 1800 900 090

Web awe.gov.au

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