Conservation Assessment of *Bertya opponens* (F.Muell. ex Benth.) Guymer (Euphorbiaceae)

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***Bertya opponens* (F.Muell. ex Benth.) Guymer (Euphorbiaceae)**
Distribution: NSW and QLD.
Current EPBC Act Status: Vulnerable
Current NSW BC Act Status: Vulnerable
Current QLD NC Act Status: Least Concern

Proposed listing on NSW BC Act: Vulnerable

No change to listing.

Summary of Conservation Assessment

Bertya opponens was found to be eligible for listing as Vulnerable under IUCN Red List Criterion B2ab(ii,iii,iv,v).

The main reasons for the species being eligible are: (1) *Bertya opponens* has a moderately restricted geographic range, with an area of occupancy (AOO) of 322 km^2; (2) the species is known from seven threat-defined locations; (3) there is an estimated and inferred continuing decline in the area, extent and quality of habitat, and number of mature individuals occurring due to clearing and fragmentation of habitat, largely due to activities associated with coal mining and gas, as well as maintenance and establishment of tracks; and (4) it is inferred that continuing decline in the number of subpopulations and AOO will occur in the future, due to the existence of extremely small subpopulations comprised of one to two individuals.

Description and Taxonomy

Bertya opponens (family Euphorbiaceae) is described as a “slender shrub or small tree to 4 m high with a thick, whitish to brown tomentum. Leaves mostly opposite, oblong to oblanceolate or narrow-elliptic, 10–50 mm long, 5–25 mm wide, with an apical gland; margins recurved to revolute, upper surface hairy, becoming scabrous, lower surface densely white-tomentose with prominent midrib; petiole 3–5 mm long. Flowers ± sessile, 1–3 male and female flowers together; bracts 4, conspicuous, narrow, 2–5 mm long, thick, yellowish brown tomentose, 2 inner bracts ± obscure, heavily viscid. Perianth segments 4, broad-ovate, 5–6 mm long, mostly glabrous and viscid; female segments fused towards the base, lobes oblong-ovate. Ovary densely villous; styles 3 or 4, mostly deeply 4-lobed. Capsule ovoid to globose, 8–9 mm long, densely villous” (PlantNet 2023).

Bertya opponens foliage and fruits in Jacks Creek, south of Narrabri, NSW. Image: Gavin Phillips

In 1873, George Bentham described *Bertya opponens* (F.Muell. ex Benth.) Guymer under the name *Croton opponens* from material collected in Queensland (Guymer 1985). Synonyms for *B. opponens* include *B*. sp. A, *B*. sp. Cobar-Coolabah (Cunningham & Milthorpe s.n. 2/8/73), and *B. oppositifolia* F.Muell. & O'Shanesy (CHAH 2023). Halford and Henderson (2002) noted the variability in *B. opponens* including a variant later to be known as *B*. sp. Clouds Creek (M.Fatemi 4) (Fatemi *et al*. 2007). *Bertya opponens* can be distinguished from *B*. sp. Clouds Creek by sessile basal leaf glands, the presence of apical leaf glands, and white indumentum (Fatemi *et al*. 2007).

Distribution and Abundance

Bertya opponens has a widespread but sparse distribution, ranging from central Queensland (QLD) south into the northwest plains of New South Wales (NSW) (Fig. A1). The species has a total of 45 recognised subpopulations across its range, as per the IUCN (2022) definition.

In NSW, four subpopulations have been recorded: two on private properties near Coolabah and Cobar respectively, and two to the south of Narrabri, including the largest known subpopulation of the species, in Jacks Creek State Forest (NSW Scientific Committee 2010). The subpopulation near Cobar has not been seen since 1982 and may now be extinct (NSW Scientific Committee 2010).

In QLD, *Bertya opponens* is widely distributed. It is bounded roughly by White Mountains National Park in the northwest, Burton in the northeast, Chesterton Range National Park in the central west, St George in the southwest, and Toowoomba in the southeast (Fig. A1). For the purposes of this assessment, *B. opponens* is considered to occur within 41 subpopulations in QLD (Table A1).

Subpopulations were defined by distance of separation, the likelihood of suitable habitat between records based on topography and land use, and the potential for gene exchange via pollination. The 45 subpopulations comprise both clusters of records and isolated singular records, generally separated by more than four kilometres, with

areas in between of different habitat and topography, as well as suitable habitat being fragmented by non-remnant vegetation and infrastructure. Pollen dispersal in other *Bertya* species has been detected at distances of approximately 3 km (Fatemi and Gross 2009) and a distance of separation of four kilometres has been used to delineate subpopulations of *Bertya glandulosa* (T. Collingwood *in litt.* July 2023). Furthermore, *B. ingramii*, which occurs as three subpopulations separated by <2.5 km, has been shown to have restricted gene flow (Fatemi and Gross 2009). Therefore, sites of *B. opponens* separated by more than four kilometres are likely to have limited genetic exchange.

Population size and trends

The total known population of *Bertya opponens* is estimated to be greater than five million individuals (Austen 1999, cited in NSW Scientific Committee 2010), including an estimated 1,066,930 individuals on land owned by Whitehaven Coal in the Jacks Creek area (Eco Logical Australia 2019). It is not known what proportion of the population comprises mature individuals. Based on the limited estimates for subpopulation sizes available (Table A1), it is estimated that over 99% of the population occurs in the Jacks Creek subpopulation in NSW. This subpopulation has an age structure comprised of abundant adults, juveniles, and seedlings (NSW Scientific Committee 2010; M. Saunders pers. obs. March 2023). Conversely, the Coolabah subpopulation was observed to be comprised of predominantly mature and senescent individuals in 2002, supporting an estimated 500–600 individuals (J. Austen pers. comm., cited in NPWS 2002). The density of individuals in the Jacks Creek subpopulation varies but can be extremely high (M. Saunders pers. obs. September 2021, May 2022; G. Phillips pers. comm. September 2023). In QLD, the species is generally locally abundant where it occurs (J. Wang *in litt.* July 2023; P. Forster *in litt.* July 2023), with subpopulation sizes ranging from as little as a single individual (Craig Eddie pers. comm. July 2023) into the thousands (Queensland Herbarium 2023; P. Forster *in litt.* July 2023).

Extent of occurrence and area of occupancy

The extent of occurrence (EOO) is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022). The EOO was calculated at 606,408 km^2. The area of occupancy (AOO) was calculated using 2 x 2 km grid cells, the scale recommended by IUCN (2022), and was calculated to be 322 km^2. Both EOO and AOO were calculated using ArcGIS (Esri 2015), enclosing all confirmed survey records, and cleaned spatial datasets.

Number of Locations

The most serious plausible threat that results in the lowest number of locations for *Bertya opponens* is considered to be drought, which results in the species having seven threat-defined locations. These locations can be defined across the distribution of *B. opponens* using the Interim Biogeographic Regionalisation for Australia (IBRA; DCCEEW 2023), and Köppen climate classes (Bureau of Meteorology 2024). This is because the IBRA bioregions are defined by common climate, geology, landform, native vegetation and species information (DCCEEW 2023), and attributes that influence the effects of drought events such as productivity and natural drought frequency are known to differ across ecoregions (Pausas and Ribiero 2013). Additionally, significant differences in drought characteristics and propagation are found between the Köppen climate classes (Fuentes *et al.* 2022). This means that the

effects of drought are likely to differ across the different combinations of IBRA bioregions and Köppen climate class regions where *B. opponens* occurs.

Each location can therefore be defined using these regional combinations as the effects of a given drought event, and the chance of such an event occurring is likely to be similar within each unique region. These combinations and the threat-defined locations are:

1. Stands in the Desert Uplands Bioregion and Grassland climate class. This location incorporates subpopulations in the White Mountains area of northern Queensland.
2. Stands in the Brigalow Belt North Bioregion and Subtropical climate class. This location incorporates subpopulations in Queensland in the Bowen Basin and the area around Emerald.
3. Stands in the Brigalow Belt South Bioregion and Subtropical climate class. This is a large location encompassing subpopulations in Queensland from the Blackdown Tableland, Squire State Forest and the Biloela area south to St George and Inglewood, and subpopulations near Narrabri in NSW.
4. Stands in the Brigalow Belt South Bioregion and Temperate climate class. This location covers the southernmost portion of the Jacks Creek subpopulation south of Narrabri in NSW.
5. Stands in the South Eastern Queensland Bioregion and Subtropical climate class. This location incorporates subpopulations in Queensland south of Gladstone and around Wivenhoe Dam.
6. Stands in the South Eastern Queensland Bioregion and Temperate climate class. This location covers subpopulations around Kingaroy and the Lockyer Valley in Queensland.
7. Stands in the Cobar Peneplain Bioregion and Grassland climate class. This location includes subpopulations northeast of Cobar in NSW.

Cultural significance

Bertya opponens occurs on the traditional lands of the Kamilaroi and Wongaibon peoples in NSW and the Barunggam, Ngarabal, Bigambul, Mandanjani, Gungarri, Gungabula, Yiman, Waka Waka, Wuli Wuli, Gureng Gureng, Gangulu, Wadjigu, Gayiri, Biri, and Yirandali peoples in QLD (AIATSIS 2023). The cultural significance of *B. opponens* is currently undocumented; however, Aboriginal Peoples have cared for Country for tens of thousands of years (Bowler *et al*. 2003; Clarkson *et al*. 2017). Over 1,500 plant species have been documented as used by Aboriginal peoples in Australia for medicine, including a closely related member of the Euphorbiaceae family, *Croton arnhemicus*, which was used to treat sores, skin lesions, wounds, cuts, and stomach aches (Turpin *et al.* 2022). It is therefore likely that *B. opponens* holds cultural significance to Aboriginal people that is currently undocumented.

Ecology

Habitat

In NSW, *Bertya opponens* occurs on moderately coarse sandstone-derived loamy sands and sandy clay loams on slightly elevated mallee ridges and low rises (NPWS 2002; NSW Scientific Committee 2010). The two subpopulations near Coolabah occur in mallee communities dominated by *Eucalyptus viridis* and *Callitris glaucophylla* (NPWS 2002; ANHSIR 2023). Co-occurring species at the subpopulations near

Narrabri include *Eucalyptus fibrosa*, *E. chloroclada*, *Corymbia trachyphloia*, *Callitris endlicheri*, and C*allitris glaucophylla* as dominants, with an understorey of *Acacia burrowii*, *Allocasuarina luehmannii*, *Allocasuarina diminuta*, *Philotheca ciliata*, *Phebalium squamulosum*, *Calytrix tetragona*, *Melichrus urceolatus*, and *Boronia glabra* (AMBS 2022; RBGDT 2023a).

In QLD, *Bertya opponens* occurs over a wider range of landforms and geologies than in NSW. Landforms on which the species has been recorded include rocky gullies, gorges, slopes, rocky ridges, boulders, and riparian zones (Queensland Herbarium 2023). Geologies include quartz sandstone, calcareous sandstone, laterite, rhyolite, basalt, granite, shale, and metasediments, with soils including red and brown sandy loam, grey loamy sand, red-brown clay sand, and sandy alluvium, often with abundant gravel or rocks (C. Eddie pers. comm. July 2023; DES 2023; Queensland Herbarium 2023). *Bertya opponens* occurs within a broader range of vegetation communities in QLD than it does in NSW. These include open *Eucalyptus* woodland, tall *Eucalyptus* woodland, *Callitris* woodland, *Acacia* woodland, marginal rainforest, and semi-evergreen vine thicket, where it often occurs at the margins of these communities (P. Forster *in litt*. July 2023*;* Queensland Herbarium 2023). Co-occurring species in open *Eucalyptus* woodland communities include *Eucalyptus mediocris*, *Corymbia leichhardtii*, *Lophostemon* sp., and *Santalum lanceolatum* in riparian open woodland, and *Eucalyptus crebra*, *E. fibrosa*, *E. gummifer*a, *E. major*, *Callitris glaucophylla*, *Corymbia clarksoniana*, *Psydrax odorata*, and *Bursaria incana* in ridgetop woodlands (Queensland Herbarium 2023). Co-occurring species in *Acacia* woodlands include *Acacia shirleyi* and *Eucalyptus decorticans*, while co-occurring species in *Callitris* woodlands include *Callitris glaucophylla*, *C. endlicheri*, *Alphitonia excelsa*, *Leptospermum sericatum* and *Gonocarpus elatus* (Queensland Herbarium 2023). Co-occurring species in semi-evergreen vine thickets include *Gossia bidwillii*, *Backhousia kingii*, *Brachychiton rupestris*, *Macropteranthes leichhardtii* and *Zieria vagans* (Queensland Herbarium 2023).

Disturbance ecology

Bertya opponens appears to be positively associated with disturbance, such as fire or mechanical disturbance, which appears to trigger germination and/or suckering (OEH 2023). Individuals are prolific along the edges of the firebreaks and tracks in Jacks Creek State Forest, suggesting physical disturbance of the soil substrate can be beneficial (NPWS 2002; M. Saunders pers. obs. September 2021). There have been four fires recorded in Jacks Creek State Forest since the late 1970s, which may be contributing to high levels of recruitment (NPWS 2023). The NSW Scientific Committee (2010) states that it is believed that most plants of *B. opponens* are killed by fire; however, the species has been observed to resprout after fire (P. Forster *in litt.* July 2023; C. Eddie *in litt.* July 2023). Observational data of subpopulations in QLD indicate that many of these subpopulations are dominated by mature individuals with limited recruitment evident, likely due to decreased fire frequencies across the landscape resulting from anthropogenic modifications (C. Eddie pers. comm. July 2023).

Flowering and pollination

Flowering in the NSW subpopulations generally occurs between July and August (PlantNet 2023), although flowering has been recorded in the Jacks Creek subpopulation as early as May (M. Saunders pers. obs. May 2022). In QLD, flowering

has been recorded predominantly from June to September, but has also been recorded in January, March, and April (Queensland Herbarium 2023). *Bertya opponens* is monoecious (separate male and female flowers on the same individual) (DES 2023) with plants typically supporting 100–200 flowers in varying ratios of male to female flowers (Austen 1999, cited in NPWS 2002).

It is considered likely that *Bertya opponens* is largely wind-pollinated, as the anthers and styles are exposed, and the flowers lack chemical and colour attractants associated with insect-pollination; however, bees have been recorded visiting the flowers of *B. opponens* (NPWS 2002). Other species of *Bertya* with similar flower morphology, such as *B. ingramii* and *B. rosmarinifolia*, are recognised as wind-pollinated and, as both of these species are self-compatible (Scott and Gross 2004), it is possible that *B. opponens* is as well. Fertilised flowers result in the development of seed capsules containing 1–3 seeds in a small cluster located at leaf nodes (NPWS 2002).

Despite *Bertya opponens* likely being wind-pollinated (NPWS 2002), the closely related wind-pollinated *B. ingramii*, which occurs as three subpopulations separated by < 2.5 km, has been shown to have restricted gene flow (Fatemi and Gross 2009). Therefore, genetic exchange between subpopulations of *B. opponens* is likely to be limited.

Seed ecology

Bertya opponens releases its seeds ballistically from the seed capsules, up to 1–2 m from the plant, typically on hot days in late spring or early summer (G. Phillips *in litt.* July 2023). Myrmecochory (dispersal of seeds by ants) has been shown to play a role in the dispersal of *B. opponens* seeds (G. Phillips *in litt.* July 2023), consistent with what has been documented in other *Bertya* species (Scott and Gross 2004). Where the substrate is sufficiently hard for water to run over it, water may also aid seed dispersal (NPWS 2002; G. Phillips *in litt.* July 2023); however, dispersal is likely to remain highly localised, with maximum dispersal distances unlikely to be greater than 10–20 m (G. Phillips *in litt.* July 2023).

Investigations into the seed germination cues and seed viability of *Bertya opponens* suggest the species has high seed viability (up to 88%) and a physiological dormancy, possibly related to an environmental cue, such a diurnal temperature shift or seasonal change (G. Phillips *in litt.* July 2023; RBGDT 2023b). Other members of the genus have high seed viability (*ca*. 97%) and contain conditional seed dormancies, with triggers including heat and/or scarification (Scott and Gross 2004). High rainfall events, such as those caused by La Niña, may also trigger germination of *B. opponens*, evidenced by the high proportion of seedlings present in 'The Grove' Biodiversity Stewardship Site in the Jacks Creek subpopulation in 2021–2022, following heavy rainfall the year prior (AMBS 2022).

Lifespan and generation length

It is estimated that *Bertya opponens* reaches sexual maturity at 4–5 years and has a maximum lifespan of 25–30 years (P. Forster *in litt.* July 2023). The generation length of *B. opponens*, which appears to rely on a combination of resprouting and seedling recruitment after disturbance, can be estimated using the age of first reproduction + *z* * length of reproductive period, where *z* is a number between 0 and 1 calculated on the relationship between survivorship and the relative fecundity of young versus old

individuals in the population (IUCN 2022). Using a maximum lifespan of 25–30 years, a primary juvenile period of 4–5 years, and a value for *z* of 0.21 as calculated for other plant species with similar lifespans (Fung and Waples 2017), the generation length of *B. opponens* is estimated at approximately 9.2–9.5 years.

Threats

A number of threats are considered to be operating on *Bertya opponens* across its wide geographic distribution. These threats include drought, adverse fire regimes and clearing and fragmentation of habitat.

The NSW Scientific Committee (2010) stated that "at present there appears to be no evidence that the total population of *B. opponens* is undergoing a continuing decline. The western-most population near Coolabah appears to be facing a number of threats but the very large population in Jacks Creek State Forest is apparently thriving." The presumed loss of the Windera subpopulation near Cobar can be considered a historical decline. It is apparent that subpopulations on non-reserved lands are experiencing continuing decline in the area, extent and quality of habitat, and number of mature individuals in modern times. This is largely due to activities associated with coal mining and gas, as well as in localised areas subject to the establishment and maintenance of access tracks.

Drought

Drought is a threat to *Bertya opponens* and has been observed to cause mortality of individuals (L. Copeland *in litt.* July 2023). The assumed extinction of the Windera subpopulation near Cobar may have been caused by extreme drought in the 1980s, which may have killed any seedlings that germinated following the 1984 bushfire (L. Miller pers. comm., cited in NPWS 2002). However, the subpopulation at Jacks Creek did not appear to have been significantly affected by the 2017–2019 drought, with plants of all age classes observed to be thriving in 2021 (M. Saunders pers. obs. Sept 2021). It is likely that subpopulations occurring on deeper soils, such as Jacks Creek, would fare better under drought conditions than those located on shallow or skeletal soils, due to inherent differences in root-moisture availability.

Drought may also interact with fire to drive continuing decline in *Bertya opponens*, especially in smaller subpopulations. In subpopulations that occur in wetter and more productive regions, such as those in the Temperate and Subtropical Köppen climate regions closer to the coast in Queensland, fire activity is often driven by drought occurrence as fuels are typically highly available (Pausas and Ribeiro 2013). Fire behaviour is also highly influenced by prolonged drought, with increasingly severe drought episodes producing more widespread and severe fires (Collins *et al.* 2022; Lindenmayer *et al.* 2022). These interactions show that any increases in drought, especially in subtropical and temperate areas, are also likely to be a primary driver in increased incidences of severe fire, which may cause further continuing declines in *B. opponens.*

On average, cool season rainfall is predicted to continue to decrease across many regions of eastern and southern Australia, which will likely lead to more time in drought (BOM and CSIRO 2022). Over most of the distribution of *B. opponens*, time spent in drought is projected, with medium confidence, to increase over the course of the century, with only the most northern subpopulations in White Mountains National Park

occurring in an area where changes in drought probability are uncertain (CSIRO 2023). Despite droughts operating over large geographical areas, *B. opponens* has a very large EOO and occurs on a broad variety of landforms and habitat types, greatly reducing the probability of drought affecting all subpopulations simultaneously and to the same extent. If the response of the Jacks Creek subpopulation to the 2017–2019 drought is indicative of the species' resilience to drought conditions, it may be at least a threat to subpopulations in the most marginal habitats. 'Anthropogenic Climate Change' is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016*. 'Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Adverse fire regimes

Bertya opponens has been identified as being vulnerable to fires which occur too frequently (Boyes 2004; OEH 2023) and with a probable juvenile period of 4–5 years (P. Forster *in litt.* July 2023), fires which occur more frequently than this timeframe may threaten the persistence of affected subpopulations. Conversely, long absences of fire appear to limit recruitment in *B. opponens*, resulting in subpopulations dominated with mature individuals and few juveniles (C. Eddie pers. comm. July 2023). There is a risk that continued absence of fire could lead to plant senescence and the degradation of the seedbank. Gallagher *et al*. (2021) gave *B. opponens* a medium risk ranking for cumulative loss of immature plants by high frequency fire; of the 4,926 species assessed as having sufficient data in that study, only 571 received this rating. Below a certain threshold of fire return interval, there is an inverse relationship between the resilience of fire-adapted plants and fire return interval (Keeley 2005), meaning that although *B. opponens* is fire-adapted, significant deviance from the fire intervals to which *B. opponens* has evolved is likely to affect its evolutionary fitness.

Despite climate change projections of increased fire weather and more frequent fires (Abatzoglou *et al*. 2019; Dowdy *et al*. 2019; Jones *et al*. 2022; AdaptNSW 2023), the widespread distribution of *Bertya opponens* means that changes to fire regimes are not considered likely to rapidly drive the species to extinction. Although Jacks Creek has had multiple historical fires, these have largely occurred in different sections of the state forest. Furthermore, there has not been a significant fire in Jacks Creek since 1991, with only a small fire recorded in 2013. Fire at such frequencies is likely to promote recruitment, while the species' ability to resprout after being burnt reduces the probability of repeat fires causing local extinctions. However, the species is predominantly an obligate seeder with juveniles that are unlikely to resprout after being burnt. Therefore, fire that occurs frequently enough to kill juvenile *B. opponens* prior to seed production is a threat, while low frequency fire has been identified as a causative factor in the low levels of observed recruitment in QLD subpopulations. Although adverse fire regimes are considered a primary threat to *B. opponens*, the threat is attenuated by the wide, sparse distribution of its population. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016*. 'Fire regimes that cause declines in biodiversity' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Clearing and fragmentation of habitat

The distribution of *Bertya opponens* occurs in areas which have historically been subjected to significant land clearing; the northwest slopes of NSW, the Brigalow Belt North and South in QLD, and the Great Barrier Reef Catchment in QLD (Seabrook *et al*. 2004; Bedward *et al*. 2007; Reside *et al*. 2017). This land clearing continues and poses a significant risk to biodiversity more broadly (Reside *et al*. 2017; Heagney *et al.* 2021). In QLD, the total amount of woody vegetation cleared between 2013 and 2020 was estimated at 2,892,344 ha (Nelder *et al*. 2017; DES 2021a; DES 2021b; DES 2022) while NSW cleared an estimated 177,000 ha of woody vegetation between 2013–2019 (NSW EPA 2021).

Activities associated with coal and gas mining continue to clear and fragment *Bertya opponens* habitat. A report by Eco Logical Australia (2019) found that land owned by Whitehaven Coal for the Narrabri underground coalmine in the Jacks Creek area supported an estimated 1,066,930 plants of *B. opponens*, with approximately 266,000 of those in areas subject to underground disturbance, and up to 26,654 of those potentially subject to direct impacts. Similarly, the Narrabri Gas Project operated by Santos was found to be directly affecting 10,309 *B. opponens* plants (DAFF 2020). *Bertya opponens* has also been recorded within the Santos Gladstone Liquefied Natural Gas project footprint in QLD (Santos 2014; DSD 2015).

Only 12 of the 45 subpopulations of *Bertya opponens* are fully or partially located in national parks or nature reserves. These include the significant QLD subpopulations occurring in Chesterton Range National Park and Bloodwood Creek Nature Refuge, which number in the thousands. There are at least three biodiversity offset sites within the Jacks Creek subpopulation which are fully protected (Eco Logical Australia 2014; Eco Logical Australia 2019; AMBS 2022; AMBS 2023). Eight subpopulations are fully or partially located in state forests, where they may be afforded partial protections. The state forests on the Gurgeena and Binjour plateaus, which support the Gurgeena Plateau and Fontainea Scrub subpopulations, are currently managed for conservation with some grazing for livestock allowed (P. Forster *in litt.* July 2023). Gurgeena State Forest also contains one offset site which supports *B. opponens* (WBB Environmental 2016). The main subpopulation at Jacks Creek predominantly occurs in a ‘special prescription zone’ of Jacks Creek State Forest, meaning that the area is “managed for conservation of identified values and/or forest ecosystems and their natural processes, while also facilitating other management and production activities” (SFNSW n.d.; FNSW 2008). Of the 45 subpopulations, 26 are fully or partially located on insecure land tenures – freehold land, mining lease, land lease, and Crown Land. These subpopulations are at a higher risk of land clearing due to the reduced protections governing non-reserved lands.

Vegetation disturbance and removal occurs in the Jacks Creek State Forest area along road verges as part of track/firebreak maintenance and to establish sites for apiarists (NPWS 2002). Clearing also occurs for the establishment of tracks associated with gas and coal mining activities in the Jacks Creek State Forest area (M Saunders pers. obs. May 2022) and in the vicinity of several subpopulations in QLD (C. Eddie pers. comm. July 2023). It is likely that similar small-scale clearing for track maintenance may occur at other subpopulations. However, *Bertya opponens* appears resilient to temporary clearing, commonly resprouting after clearing has occurred (NPWS 2002). The geographic spread of *B. opponens* and the proportion of subpopulations that are fully or partially protected means that clearing and fragmentation of habitat is unlikely to drive *B. opponens* to extinction in the near-term;

however, clearing continues to be a threat to subpopulations on non-reserved lands and is contributing to continuing decline in the area, extent and quality of habitat and the number of mature individuals and may be contributing to continuing decline in the AOO and number of subpopulations. One subpopulation in QLD with only *ca.* 2 individuals is currently threatened by development (Queensland Herbarium 2023). 'Clearing of native vegetation' is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016*. 'Land clearance' is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999*.

Pollination failure induced by the introduced Honeybee *Apis mellifera*

In the related species *Bertya ingramii,* European Honeybees have been observed to collect pollen from male flowers but have not been observed visiting female flowers (Scott and Gross 2004). It is possible this is occurring in *Bertya opponens,* which could lead to depressed seed set. "Competition from Feral Honeybees *Apis mellifera* L." is listed as a Key Threatening Process under the *Biodiversity Conservation Act 2016*.

Assessment against IUCN Red List criteria

For this assessment it is considered that the survey of *Bertya opponens* has been adequate and there is sufficient scientific evidence to support the listing outcome.

Criterion A Population Size reduction

Assessment Outcome: Not met.

Justification: There is no evidence of a population reduction in *Bertya opponens* within a three-generation timespan of *c.* 27.5–28.5 years. Although the subpopulation at Windera is assumed to have gone extinct, resulting in a historical population reduction the loss of this subpopulation occurred in the 1980's and is therefore outside of the three-generation timespan. Under a three-generation timespan, a population size reduction of ≥ 50% for reversible, understood, and ceased causes (A1) or ≥ 30% for continuing, not understood, or irreversible causes (A2, A3 and A4) has not been observed, nor is a quantifiable reduction able to be projected with confidence up to 28.5 years into the future.

Criterion B Geographic range

Assessment Outcome: Vulnerable under Criterion B2ab(ii,iii,iv,v)

Justification: *Bertya opponens* has a very wide geographic distribution in NSW and QLD, but generally occurs in small, discrete subpopulations. The extent of occurrence (EOO) of *B. opponens* is calculated at 606,408 km^2, above the 20,000 km^2 threshold for Vulnerable. The area of occupancy (AOO) is calculated to be 322 km^2, which meets the threshold for Endangered.

In addition to these thresholds, at least two of three other conditions must be met. These conditions are:

a) The population or habitat is observed or inferred to be severely fragmented or there is 1 (CR), ≤5 (EN) or ≤10 (VU) locations.

   Assessment Outcome: Met for Vulnerable.

Justification: The most serious plausible threat resulting in the lowest number of locations for *Bertya opponens* is considered to be drought, which results in the species having seven threat-defined locations.

Bertya opponens is known from 45 subpopulations. Based on the limited estimates for subpopulation sizes available, and descriptions of the species being 'common' or 'frequent' at many sites where abundance estimates are lacking, it is considered that more than 50% of the total area of occupancy consists of subpopulations large enough to be considered viable, despite long distances that would preclude dispersal between many subpopulations. As a result, *B. opponens* cannot be considered to be severely fragmented as most of the population occurs in relatively large, viable subpopulations.

b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals

Assessment Outcome: Met for continuing decline in ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of subpopulations; and (v) number of mature individuals.

Justification: It is estimated and inferred that continuing decline in the area, extent and quality of habitat, and number of mature individuals is occurring due to clearing and fragmentation of habitat, largely due to activities associated with coal mining and gas, as well as maintenance and establishment of tracks. It is inferred that continuing decline in the number of subpopulations and AOO will occur in the future, due to the existence of extremely small subpopulations comprised of one to two individuals. One subpopulation with *ca.* 2 individuals is currently threatened by development (Queensland Herbarium 2023). Such small subpopulations are also at inherent risk of loss through stochastic events arising from the combined effects of increasingly severe drought and adverse fire regimes. Subpopulations located on non-reserved lands will continue to be threatened by clearing due to the lack of protections governing these land tenures.

c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: There is no evidence that *Bertya opponens* undergoes extreme fluctuations, and being a relatively long-lived plant species, it is unlikely to.

Criterion C Small population size and decline

Assessment Outcome: Not met.

Justification: *Bertya opponens* has an estimated population of over five million individuals (Austen 1999, cited in NSW Scientific Committee 2010). While it is unknown what proportion of the population is comprised of mature individuals it is certainly >10,000, exceeding the threshold for Vulnerable.

At least one of two additional conditions must be met. These are:

C1. An observed, estimated or projected continuing decline of at least: 25% in 3 years or 1 generation (whichever is longer) (CR); 20% in 5 years or 2

generations (whichever is longer) (EN); or 10% in 10 years or 3 generations (whichever is longer) (VU).

Assessment Outcome: Not met.

Justification: While there is evidence of continuing decline in the number of mature individuals, the available data are insufficient to accurately quantify the percentage or rate of decline. However, based on figures of projected negative effects on *Bertya opponens* from development reports, it is estimated that there has been less than 0.01% decline in the number of mature individuals since 2019.

C2. An observed, estimated, projected or inferred continuing decline in number of mature individuals.

Assessment Outcome: Met.

Justification: It is estimated and inferred that continuing decline in the mature individuals is occurring due to clearing and fragmentation of habitat, largely due to activities associated with coal mining and gas, as well as maintenance and establishment of tracks. Subpopulations located on non-reserved lands will continue to be threatened by clearing due to the lack of protections governing these land tenures.

In addition, at least 1 of the following 3 conditions:

a (i). Number of mature individuals in each subpopulation ≤50 (CR); ≤250 (EN) or ≤1000 (VU).

Assessment Outcome: Not met.

Justification: Although some subpopulations of *Bertya opponens* are very small, several of the QLD subpopulations range from hundreds to thousands of individuals, while the Jacks Creek subpopulations is estimated to support over five million individuals (Austen 1999, cited in NSW Scientific Committee 2010). QLD subpopulations are frequently comprised of predominantly mature individuals (C. Eddie pers. comm. July 2023) and the Jacks Creek subpopulation exceeds 10,000 mature individuals, exceeding the threshold for Vulnerable.

a (ii). % of mature individuals in one subpopulation is 90-100% (CR); 95-100% (EN) or 100% (VU)

Assessment Outcome: Met for Endangered.

Justification: The Jacks Creek subpopulation is considered to support over 99% of the mature individuals of *Bertya opponens*, meeting the threshold for Endangered.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met.

Justification: There is no evidence that *Bertya opponens* undergoes extreme fluctuations, and being a relatively long-lived plant species, it is unlikely to.

Criterion D Very small or restricted population

Assessment Outcome: Not met.

Justification: *Bertya opponens* has an estimated population of over five million individuals (Austen 1999, cited in NSW Scientific Committee 2010). While it is unknown what proportion of the population is comprised of mature individuals, there are >1,000 mature individuals, exceeding the threshold for Vulnerable.

To be listed as Vulnerable under D, a species must meet at least one of the two following conditions:

D1. Population size estimated to number fewer than 1,000 mature individuals

Assessment Outcome: Not met.

Justification: *Bertya opponens* has an estimated population of over five million individuals (Austen 1999, cited in NSW Scientific Committee 2010). While it is unknown what proportion of the population is comprised of mature individuals it is >10,000, exceeding the threshold for Vulnerable.

D2. Restricted area of occupancy (typically <20 km^2) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Not met.

Justification: *Bertya opponens* has an Area of Occupancy of 322 km^2 and occurs in seven threat-defined locations. There is no plausible future threat that could drive the species to Critically Endangered or Extinct within a very short time.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient.

Justification: No quantitative analysis has been undertaken to assess the extinction probability of this species and there are currently insufficient data to undertake one.

Conservation and Management Actions

This species is currently listed on the NSW *Biodiversity Conservation Act 2016* and a conservation project has been developed by the NSW Department of Planning and Environment under the Saving our Species program. The conservation project identifies priority locations, critical threats and required management actions to ensure the species is extant in the wild in 100 years. *Bertya opponens* sits within the Site-managed species management stream of the SoS program and the conservation project can be viewed here (https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?profileid=10093).

References

Abatzoglou JT, Williams AP, Barbero R (2019) Global emergence of anthropogenic climate change in fire weather indices. *Geophysical Research Letters* **46**, 326–336.

AdaptNSW (2023) Interactive climate change projections map [Online]. Available at: https://www.climatechange.environment.nsw.gov.au/projections-map (accessed on 18 July 2023)

Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) (2023) Map of Indigenous Australia [Online]. Available at: https://aiatsis.gov.au/explore/map-indigenous-australia (accessed 10 July 2023)

Australian National Herbarium Specimen Information Register) (ANHSIR) (2023) *Bertya opponens* specimen records [dataset]. Australian National Herbarium (accessed 3 July 2023)

AMBS (AMBS Ecology & Heritage) (2022) Biodiversity Stewardship Site Report – The Grove. AMBS Ecology & Heritage, Consultancy report to Whitehaven Coal Limited.

AMBS (AMBS Ecology & Heritage) (2023) Biodiversity Stewardship Site Assessment Report – High Range. AMBS Ecology & Heritage, Consultancy report to Whitehaven Coal Limited.

Bedward M, Simpson CC, Ellis MV, Metcalfe LM (2007) Patterns and determinants of historical woodland clearing in central-western New South Wales, Australia. *Geographical Research* **45**(4), 348–57.

BioNet (2023). *Bertya opponens* records recorded until 3 July 2023. [dataset]. NSW Department of Planning and Environment.

Bowler JM, Johnston H, Olley JM, Prescott JR, Roberts RG, Shawcross W, Spooner NA (2003). New ages for human occupation and climatic change at Lake Mungo, Australia. *Nature* **421**(6925), 837–840.

Boyes B (2004) Biodiversity Recovery Plan for Gatton and Laidley Shires, South-East Queensland 2003-2008. Lockyer Catchment Association Inc., Forest Hill.

Bureau of Meteorology (2024). Climate classification maps. Available at: http://www.bom.gov.au/climate/maps/averages/climate-classification/?maptype=kpngrp (accessed 11 April 2024)

Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (BOM and CSIRO) (2022) State of the Climate 2022. Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation, Commonwealth of Australia (Online). Available at: http://www.bom.gov.au/state-of-the-climate/2022/documents/2022-state-of-the-climate-web.pdf (accessed 25 July 2023)

Clarkson C, Jacobs Z, Marwick B, Fullagar R, Wallis L, Smith M, Roberts RG, Hayes E, Lowe K, Carah X, Florin S (2017) Human occupation of northern Australia by 65,000 years ago. *Nature* **547**(7663), 306–310.

Collins L, Clarke H, Clarke MF, McColl Gausden SC, Nolan RH, Penman T, Bradstock R (2022). Warmer and drier conditions have increased the potential for large and severe fire seasons across south-eastern Australia. *Global Ecology and Biogeography* **31(10)**: 1933–1948.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2023) Climate Change in Australia: East Coast South projection summaries (Online). Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/regional-climate-change-explorer/sub-clusters/?current=ECSC&tooltip=true&popup=true (accessed 25 July 2023)

Council of Heads of Australian Herbaria (CHAH) (2023) Australian Plant Name Index (Online). Available at: https://biodiversity.org.au/nsl/services/rest/name/apni/114889/api/apni-format (accessed 24 July 2023)

Department of Agriculture, Fisheries and Forestry (DAFF) (2020) Narrabri Gas Project (EPBC 2014/7376) EPBC Act assessment updated legal considerations, 19 November 2020 (Online). Available at: https://www.agriculture.gov.au/sites/default/files/documents/22591.pdf (accessed 26 July 2023)

DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2023) Australia's bioregions (IBRA). Available at: https://www.dcceew.gov.au/environment/land/nrs/science/ibra (accessed 11 April 2024)

Department of Environment and Science (DES) (2021a) 2018–19 SLATS Report (Online). Available at: https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/slats/slats-reports/2018-19-report (accessed 27 July 2023)

Department of Environment and Science (DES) (2021b) Land clearing impact on woody native vegetation (Online). Available at: https://www.stateoftheenvironment.des.qld.gov.au/biodiversity/terrestrial-ecosystems/land-clearing-impact-on-woody-native-vegetation (accessed 27 July 2023)

Department of Environment and Science (DES) (2022) 2019–20 SLATS Report (Online). Available at: https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/slats/slats-reports/2018-19-report (accessed 27 July 2023)

Department of Environment and Science (DES) (2023) Species profile—*Bertya opponens* [Online]. Available at: https://apps.des.qld.gov.au/species-search/details/?id=11323 (accessed July 10 2023)

Department of State Development (DSD) (2015) Santos GLNG Gas Field Development project. Coordinator-General's evaluation report on the environmental impact statement December 2015. Department of State Development, QLD.

Dowdy AJ, Ye H, Pepler A, Thatcher M, Osbrough SL, Evans JP, Di Virgilio G, McCarthy N (2019) Future changes in extreme weather and pyroconvection risk factors for Australian wildfires. *Scientific reports* **9**(1), 10073.

Ecological Australia Pty Ltd (2014) Narrabri Mine On-site Biodiversity Offset Management Plan (Online). Report by Eco Logical Australia Pty Ltd on behalf of Narrabri Coal Operations Pty Ltd.

Ecological Australia Pty Ltd (2019) Narrabri Coal Mine Stage 1 and 2 Biodiversity Offset Strategy. Prepared for Narrabri Coal Operations Pty Ltd. Revision 3 –July 2019.

Fatemi M, Gross CL (2009) Life on the edge–high levels of genetic diversity in a cliff population of *Bertya ingramii* are attributed to *B. rosmarinifolia* (Euphorbiaceae). *Biological conservation* **142**(7), 1461–8.

Fatemi M, Gross CL, Bruhl JJ (2007) The first phenetic analysis of species limits in *Bertya* (Euphorbiaceae). *Australian Systematic Botany 20*(5), 448–463.

Forests NSW (FNSW) (2008). Forests NSW map of forest management zones - Western Region [Online]. Available at: https://www.forestrycorporation.com.au/__data/assets/pdf_file/0003/438357/forest-mgt-zones1-western-region.pdf (accessed 19 July 2023)

Fuentes I, Padarian J, Vervoort RW (2022) Spatial and temporal global patterns of drought propagation. *Frontiers in Environmental Science* **10**: 788248.

Fung HC, Waples RS (2017) Performance of IUCN proxies for generation length. *Conservation Biology* **31**(4), 883–893.

Gallagher RV, Allen S, Mackenzie BD, Yates CJ, Gosper CR, Keith DA, Merow C, White MD, Wenk E, Maitner BS, He K (2021) High fire frequency and the impact of the 2019–2020 megafires on Australian plant diversity. Diversity and Distributions. **27**(7), 1166–79.

Guymer GP (1985) A name change in the genus *Bertya* (Euphorbiaceae). *Austrobaileya* **2**(2), 147.

Halford DA, Henderson RJ (2002) Studies in Euphorbiaceae A.L.Juss. *sens. lat.* 3. A revision of *Bertya* Planch. (Ricinocarpeae Müll.Arg.,Bertyinae Müll.Arg.). *Austrobaileya* **6**(2), 187–245.

Heagney EC, Falster DS, Kovač M (2021) Land clearing in south-eastern Australia: Drivers, policy effects and implications for the future. *Land Use Policy* **102**, 105243.

IUCN Standards and Petitions Subcommittee (2022) Guidelines for Using the IUCN Red List Categories and Criteria. Version 15.1 [Online]. Available at: http://www.iucnredlist.org/documents/RedListGuidelines.pdf (accessed on 14 July 2023)

Jones MW, Abatzoglou JT, Veraverbeke S, Andela N, Lasslop G, Forkel M, Smith AJ, Burton C, Betts RA, van der Werf GR, Sitch S (2022) Global and regional trends and drivers of fire under climate change. *Reviews of Geophysics* **60**(3), e2020RG000726.

Keeley JE (2005) Fire as a threat to biodiversity in fire-type shrublands. Planning for biodiversity: bringing research and management together. USDA Forest Service General Technical Report PSW-GTR-195.

Lindenmayer D, Taylor C, Blanchard W, Zylstra P, Evans MJ (2022). What environmental and climatic factors influence multidecadal fire frequency? *Ecosphere* **14**: e4610.

National Parks and Wildlife Service (NPWS) (2002) *Bertya* sp. Cobar-Coolabah (Cunningham & Milthorpe s.n., 2/8/73) Recovery Plan. NSW National Parks and Wildlife Service, Hurstville NSW.

National Parks and Wildlife Service (NPWS) (2023). *NSW Fire History* [spatial dataset]. (accessed using ArcGIS Desktop 10.8.2, Esri Inc. 1999-2021).

Neldner VJ, Laidlaw MJ, McDonald KR, Mathieson MT, Melzer RI, Seaton R, McDonald WJF, Hobson R, Limpus CJ (2017). Scientific review of the impacts of land clearing on threatened species in Queensland. Queensland Government, Brisbane.

NSW Environmental Protection Agency (NSW EPA) (2021) Native Vegetation. Maintaining native vegetation in good condition is critical to the survival of the species and ecosystems that depend on it (Online). Available at: https://www.soe.epa.nsw.gov.au/all-themes/land/native-vegetation (accessed 27 July 2023)

NSW Scientific Committee (2010) *Bertya opponens* - vulnerable species listing (Online). Available at: https://www.environment.nsw.gov.au/Topics/Animals-and-plants/Threatened-species/NSW-Threatened-Species-Scientific-Committee/Determinations/Final-determinations/2008-2010/Bertya-opponens-vulnerable-species-listing (accessed 7 July 2023)

Office of Environment and Heritage (OEH) (2023) Coolabah Bertya - profile (Online). Available at: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10093 (accessed 9 July 2023)

Pausas JG, Ribeiro A (2013) The global fire-productivity relationship. *Global Ecology and Biogeography* **22(6)**: 728–736.

PlantNet (2023) *Bertya opponens* (F.Muell. ex Benth.) Guymer (Online). Available at: https://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Bertya~opponens (accessed 25 July 2023)

Queensland Herbarium (2023). *Bertya opponens* BRI herbarium records [dataset]. Queensland Herbarium [accessed 4 July 2023)

Reside AE, Beher J, Cosgrove AJ, Evans MC, Seabrook L, Silcock JL, Wenger AS, Maron M (2017) Ecological consequences of land clearing and policy reform in Queensland. *Pacific Conservation Biology* **23**(3), 219–30.

Royal Botanic Gardens and Domain Trust (RBGDT) (2023a). *Bertya opponens* specimen records [dataset]. NSW Herbarium specimen catalogue (accessed 3 July 2023)

Royal Botanic Gardens and Domain Trust (RBGDT) (2023b). *Bertya opponens* germination data [unpublished raw data]. Source: IrisBG Botanical Garden Collection Management program (exported 25 July 2023)

Santos (2014) Santos GLNG Project. Gasfield Development Project environmental impact statement. Appendix AB Offset Strategy (Online). Available at: https://eisdocs.dsdip.qld.gov.au/Santos%20GLNG%20Gas%20Field%20Development/AEIS/Appendix%20AB/santos-glng-gfd-project-revised-EIS-appendix-AB-offset-strategy.pdf (accessed 26 July 2023)

Scott B, Gross CL (2004) Recovery directions for monoecious and endangered *Bertya ingramii* using autecology and comparisons with common *B. rosmarinifolia* (Euphorbiaceae). *Biodiversity & Conservation* **13**, 885–99.

Seabrook L, McAlpine C, Fensham R (2006) Cattle, crops and clearing: Regional drivers of landscape change in the Brigalow Belt, Queensland, Australia, 1840–2004. *Landscape and Urban Planning* **78**(4), 373–85.

State Forests of NSW (SFNSW) (n.d.) Managing our forests sustainably: Forest management zoning in NSW Sate Forests. (State Forests of NSW)

Turpin G, Ritmejerytė E, Jamie J, Crayn D, Wangchuk P (2022) Aboriginal medicinal plants of Queensland: ethnopharmacological uses, species diversity, and biodiscovery pathways. *Journal of Ethnobiology and Ethnomedicine* **18**(1), 1–5.

Wide Bay Burnett Environmental Consulting Services (WBB Environmental) (2016) Photopoint Monitoring Vegetation Offset Gurgeena State Forest – Year 2 -April 2016. Prepared for Ahearn Earthmoving. Wide Bay Burnett Environmental Consulting Services.

WildNet (2023). *Bertya opponens* records recorded until 3 July 2023. [dataset]. QLD Department of Environment and Science.

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APPENDIX 1

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: *Bertya opponens* was found to be Vulnerable under Clause 4.3(c)(d)(ei,ii,iii,iv).

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Not met

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

Clause 4.3 - Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)
Assessment Outcome: Vulnerable under Clause 4.3(c)(d)(ei,ii,iii,iv)

The geographic distribution of the species is:			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted,
and at least 2 of the following 3 conditions apply:			
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,	
	(e)	there is a projected or continuing decline in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	habitat area, extent or quality,
		(iv)	the number of locations in which the species occurs or of populations of the species,
	(f)	extreme fluctuations occur in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	the number of locations in which the species occur or of populations of the species.

Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)
Assessment Outcome: Not met

The estimated total number of mature individuals of the species is:						
	(a)	for critically endangered species			very low, or	
	(b)	for endangered species			low, or	
	(c)	for vulnerable species			moderately low,	
and either of the following 2 conditions apply:						
	(d)	a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):				
		(i)	for critically endangered species		very large, or	
		(ii)	for endangered species		large, or	
		(iii)	for vulnerable species		moderate,	
	(e)	both of the following apply:				
		(i)	a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and			
		(ii)	at least one of the following applies:			
			(A)	the number of individuals in each population of the species is:		
				(I)	for critically endangered species	extremely low, or
				(II)	for endangered species	very low, or
				(III)	for vulnerable species	low,
			(B)	all or nearly all mature individuals of the species occur within one population,		
			(C)	extreme fluctuations occur in an index of abundance appropriate to the species.		

Clause 4.5 - Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Not met

The total number of mature individuals of the species is:			
	(a)	for critically endangered species	extremely low, or
	(b)	for endangered species	very low, or
	(c)	for vulnerable species	low.

Clause 4.6 - Quantitative analysis of extinction probability
(Equivalent to IUCN criterion E)
Assessment Outcome: Data deficient

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or
	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

Clause 4.7 - Very highly restricted geographic distribution of species– vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Not met

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.