Conservation Assessment of *Pimelea bracteata* Threlfall

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NSW Threatened Species Scientific Committee

***Pimelea bracteata* Threlfall (Thymelaeaceae)**
Distribution: Endemic to NSW
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Not listed

Proposed listing on NSW BC Act and EPBC Act: Critically Endangered

Conservation Advice: *Pimelea bracteata*

Summary of Conservation Assessment

Pimelea bracteata was found to be eligible for listing as Critically Endangered under Criterion A4a.

The main reason for this species being eligible is: the estimated total population decline over the past 6 years has been very large (44-77%). Based on this decline, the projected decline over three generations (including the past and the future) is estimated to be 99-100%.

Description and Taxonomy

Pimelea bracteata is described by PlantNET (2019) as a "shrub to 2 m high, stems glabrous. Leaves narrow-elliptic to oblanceolate, those immediately below the involucre often wider, usually 6–10 mm long, 3–6 mm wide, often with a purplish tinge. Flowers in bracteate heads, bracts completely surrounding the head; head usually nodding on short lateral shoot; peduncle 1–5 mm long. Bracts 6–8, 10–18 mm long, 7–15 mm wide, glabrous, yellow-green often tinged with purple or red. Flowers 15–26 in each head, 12–17 mm long, pale yellow. Fruit 3–4.5 mm long, green."

Pimelea bracteata has been referred to as *Pimelea ligustrina* var. *glabra* Maiden & Betche and *Pimelea* sp. B *sensu* Jacobs & Pickard (1981).

Distribution and Abundance

Pimelea bracteata is endemic to New South Wales, occurring in the Southern Tablelands between Micalong Swamp in the north to Bago State Forest in the west, Pretty Plain (Kosciuszko National Park) in the south and Yaouk Swamp (Scabby Range Nature Reserve) in the east (K. McDougall and G. Wright *in litt.* August 2017). The majority of populations are in Kosciuszko National Park, a few in State Forests (Bago, Maragle and Micalong), one in Scabby Range Nature Reserve, and one on freehold land adjoining Bago State Forest.

The current distribution of *Pimelea bracteata* is shown in Figure 1. Old herbarium records for the Kiandra district (collected in 1897, 1901, 1949 and 1951), Batlow (1957), and Laurel Hill, Tumbarumba (1903) may have referred to the general area

of the collection rather than the location specifically. Hence, the location description was considered too vague for a number of these old herbarium records for accurate mapping of the species. It is likely most of these old records correspond to currently known populations in the vicinity of Kiandra and Bago State Forest, respectively. There is no suitable habitat on Laurel Hill itself (K. McDougall and G. Wright *in litt.* August 2017).

Three Bionet Atlas sightings were deemed unreliable: a record from Rainbow Lake in the southern area of Kosciuszko National Park (a misidentification, K. McDougall *in litt.* November 2018); a record from near Tinderry Nature Reserve to the east of the current range of the species; and a sighting east of Braidwood at Half Moon Flat Wildlife Refuge, 100 km to the east in a non-alpine area. All of these sightings were outside the currently known range of *P. bracteata*, from habitat that is atypical for the species, all lack a voucher specimen and hence were considered to most likely be misidentifications and were not included in this assessment.

Pimelea bracteata typically grows along creek lines, and a population may have a linear distribution along a creek for many kilometres (K. McDougall and G. Wright *in litt.* August 2017).

Pimelea bracteata has a highly restricted geographic distribution. The extent of occurrence (EOO) was estimated to be 4161 km^2 based on a minimum convex polygon enclosing all reliably mapped occurrences of the species, the method of assessment recommended by IUCN (2017). The area of occupancy (AOO) was estimated to be 116 km^2. This calculation was based on the species occupying 29 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017).

Abundance

In 2013, many woody species were observed to be in poor health in Kosciuszko National Park including *Pimelea bracteata* which was showing signs of foliage dieback (McDougall *et al.* 2018). A total population size of between 7500 and 15000 mature individuals was estimated prior to the dieback, based on broadly defined populations or geographic clusters of *P. bracteata* (K. McDougall and G. Wright *in litt.* August 2017). Populations of *P. bracteata* are difficult to define and quantify as the plants are scattered in riparian areas and occur linearly along the edges of waterways, often for many kilometres. In addition, parts of riparian habitats can be difficult to access. Targeted surveys in 2016/17 (G. Wright and K. McDougall *in litt.* May 2017) and 2018/19 (K. McDougall and G. Wright *in litt.* March 2019) were conducted to monitor the species across its range and assess the degree of dieback and decline. Decline was observed via direct counts, estimates and photo points throughout the species' range. The most severe decline was seen at Rocky Plain and Kellys Plain where most plants (estimated to be up to 1000 in each) were either dead or showing signs of dieback. There were several recruits seen at many of the sites, however, where resampling subsequently occurred, the recruits appeared to be succumbing to dieback. For example, healthy recruits observed at Wares Yard in Nungar Creek, Kosciuszko National Park, in 2016 were scarce when the site was re-inspected in January 2019 (K. McDougall and G. Wright *in litt.* March 2019).

Dieback has been observed in *P. bracteata* populations throughout their known range, although two sites could not be visited so it is uncertain if dieback is occurring

there. From 12 sites (out of approximately 21 known sites), estimates of mature plant abundance over two time periods are available, i.e. from 2013 to either 2016 or 2019. These data suggest a decline in the number of mature individuals in the order of 44-77% over this time. The current estimated number of mature individuals is likely to be greater than 2500 (the threshold for Endangered) but less than 7000. The minimum bound population estimate from 12 of the 21 known sites in 2019 was 2369 mature plants, while the maximum bound estimate was 3859. If it is assumed that the other nine sites not sampled have the same relative population abundances, then the most likely current range is 4146 to 6753 mature plants.

Ecology

Pimelea bracteata is a localised shrub of bogs and stream edges in high altitude treeless subalpine valleys (K. McDougall and G. Wright *in litt.* August 2017; PlantNET 2019). It has been recorded in wet heathland (Community 3: *Baeckea gunniana – Callistemon pityoides - Sphagnum cristatum* as described in McDougall and Walsh (2007), and closed heath (Community 53: *Podocarpus lawrencei - Epacris paludosa* as described in McDougall and Walsh (2007). These overlap with subalpine wet heathland (community u193 *Hakea microcarpa - Epacris breviflora - Epacris paludosa*) (Armstrong *et al.* 2013), which extends to lower elevations in State Forests and Scabby Range Nature Reserve (K. McDougall and G. Wright *in litt.* August 2017).

The populations of *Pimelea bracteata* do not appear to be even-aged, indicating that recruitment is not solely dependent on disturbance events such as fire. Regeneration from seed has been observed within many populations (G. Wright and K. McDougall *in litt.* May 2017). Regeneration following a fire in Kosciuszko National Park in 2003 was observed from both resprouting plants and the establishment of seedlings (Walsh & McDougall 2004). There is evidence that fire may promote germination in many *Pimelea* species through the response of seeds to smoke (Dixon *et al*. 1995; Willis *et al.* 2003), although Clarke *et al*. (2000) found no such effect in *Pimelea linifolia*. Gross and Vary (2014) found *P. linifolia* seed had physiological dormancy, was collected by ants and germinated in ant middens.

The lifespan of *Pimelea bracteata* is unknown, however based on other subalpine or resprouting *Pimelea* species (NSW Fire Response Database 2014) it is estimated to be at least 15-50 years. While juveniles start to flower after a few years, peak reproduction in resprouters will be delayed and is likely to be from (10?)-15-25 years in *P. bracteata*. Generation length (the average age of parents, IUCN 2017) is likely to be around the peak reproduction period of 15-25 years.

Threats

The main threat to *Pimelea bracteata* is inferred to be pathogens or invertebrates causing plant dieback and death. The species is also threatened by habitat disturbance from feral horses, pigs and deer, as well as access to sites by people and vehicles. One site may be partially submerged in the future as a part of the Snowy 2.0 plan (K. McDougall *in litt.* June 2019).

Dieback

In 2014, the population of *Pimelea bracteata* at Rocky Plain in Kosciuszko National Park near Kiandra was showing signs of poor health with symptoms of chlorotic leaves that were quickly shed, leaving a few scattered young leaves at stem tips (McDougall *et al.* 2018; K. McDougall and G. Wright *in litt.* August 2017). A year later, the majority of plants had died with no regeneration seen. All size classes of plants were affected. Further surveys were undertaken across other known populations of *P. bracteata* to determine the extent of dieback and to investigate the causes (K. McDougall and G. Wright *in litt.* August 2017).

There were three separate factors identified that may be causing plant dieback in *P. bracteata*:

1. The pathogenic water-mould *Phytophthora gregata* was detected in samples of *Pimelea bracteata* with collar rot. It was observed that plant collars (tissue between the roots and stems at the soil surface), were typically necrotic and often quite rotten in the plants that were dead or dying, even though the roots were largely unaffected. In addition, two collars collected from Bago State Forest tested positive to *Phytophthora cryptogea* (McDougall *et al.* 2018). *Phytophthora gregata* was first described in Australia by Jung *et al*. (2011) from several plant species showing collar rot (*Patersonia* sp., *Xanthorrhoea preissii, Hakea* sp., *Pinus radiata, Banksia prionotes*) in natural vegetation and pasture soil from Western Australia. While its native range is unknown, it has been found in China (Huai *et al*. 2013) and the US (Swiecki & Bernhardt 2017). K. McDougall and G. Wright *in litt.* August (2017) report that "In extensive surveys of *Phytophthora* distribution in Australia (Burgess *et al*. 2017), *P. gregata* was only isolated from soil in Bamarang Nature Reserve near Nowra, Kosciuszko National Park near Wilson Valley and in Tasmania." *Phytophthora cryptogea* is non-native (Burgess *et al*. 2017) but widespread in Australia and has been found in the Australian Alps Bioregion (and in all its jurisdictions: ACT, NSW and Victoria). It is known to affect a number of horticultural and agricultural crops (e.g. alfalfa, wheat, ornamentals, pines) and native Western Australian plants.
2. Mycelia similar to those produced by *Armillaria luteobubalina,* an aggressive native pathogen of woody plants, were found on the lower stems of symptomatic plants at Kellys Plain and Bago State Forest. Although the presence of this fungus has not been confirmed for *Pimelea bracteata*, it has recently been implicated in the deaths of subalpine shrubs and the poor condition of eucalypt woodland near Round Mountain in Kosciuszko National Park (McDougall *et al.* 2018).
3. The mite *Aceria pimeliae* was previously only known from New Zealand (though it is uncertain if it may also be native to Australia), where it causes the plant deformity known as 'witches broom' on *Pimelea* species (McDougall *et al.* 2018). This mite was identified on *Pimelea bracteata* samples with witches broom growth on the foliage. Witches broom is a symptom of plant disease that occurs as an abnormal brushlike cluster of dwarfed weak shoots arising at or near the same point (https://www.britannica.com/science/witches-broom). It was common in *Pimelea bracteata* but interestingly, was not

observed on *Pimelea pauciflora*, which grows with *P. bracteata* at many sites (McDougall *et al.* 2018).

Any one of these factors may be the cause of the dieback in *Pimelea bracteata* or dieback may involve a combination of them, along with environmental factors. Collar rot from *Phytophthora* infection is considered the most likely cause because *Pimelea bracteata* has no capacity to recover once its water and nutrient transport system is severed (K. McDougall and G. Wright *in litt.* August 2017).

Dieback has been observed in *P. bracteata* populations throughout their known range, although two sites could not be visited so it is uncertain if dieback is occurring at these sites. Field observations suggest that as dieback progresses it leads to large scale plant mortality at a site. Some limited seedling recruitment has been observed at some sites following adult mortality. However, McDougall *et al.* (2018) suggest that "plants of all sizes of this shrub are killed and regeneration is poor or non-existent."

Whilst most of the occurrences of *Pimelea bracteata* across its distribution have been affected to various extents by dieback, Kellys Plain and Rocky Plain have sustained the greatest mortality to date. They are also the most accessible sites. These two plains are not connected, with Rocky Plain in the Eucumbene River catchment and Kellys Plain in the Nungar Creek catchment. At Kellys Creek (nearby to Nungar Creek) the 2013 estimate of between 500 – 1000 plants were all observed to be dead or very close to being dead when revisited in 2019. There was a small number of very young plants (perhaps 50 – 100), some of which were in flower (K. McDougall and G. Wright *in litt.* March 2019).

In the last seven years, the vegetation structure of Rocky Plain has changed from shrubby wetlands into areas of sparse shrubs due to the dieback in *Pimelea bracteata* (K. McDougall pers. comm. November 2018). Whilst there had been some recruitment (of up to 50 plants and < 5% of the population area) it was only observed in one section of the site, and absent elsewhere. All plants in the population, previously estimated to be at least 1000, were dead when the site was revisited in November 2018 (K. McDougall *in litt.* December 2018).

Scabby Range is one of the few areas that had a population of mostly healthy *Pimelea bracteata* plants, although some dieback was evident on the most recent visit (5% of plants affected in 2016) and the extent of dieback may increase over time. This site is outside Kosciuszko National Park and does not appear to have the feral horse problem that is seen in Kosciuszko National Park, but there are likely to be pigs in the area that may distribute pathogens and disturb sites (K. McDougall *pers. comm.* November 2018).

Possible vectors for the spread of dieback include people and vehicles (there are management trails that cross creeks in affected populations), horses, pigs and deer (McDougall *et al.* 2018).

Cycles of death and regeneration are common in Australian vegetation and are seen in a number of species in the Alps such as *Poa* species (due to two moth species feeding on their roots) and *Eucalyptus lacrimans* (due to beetle attack). However, the decline in *Pimelea bracteata* plants does not appear to be cyclical (McDougall *et al.* 2018) as death is not confined to older individuals but affects plants of all size classes with many recruits also succumbing to dieback. Unlike dieback related to insect

attack, which have fluctuations relating to insect populations, *Phytophthora* species are persistent in the soil (K. McDougall and G. Wright *in litt.* March 2019).

Trampling of habitat by horses, feral pigs and deer

Disturbance to the creek line habitat by horses has been observed. Horses tend to cross creeks at the same spot, which leads to broad and denuded areas (K. McDougall pers. comm. November 2018). *Pimelea bracteata* habitat in Bago State Forest was observed to be heavily grazed by horses (G. Wright and K. McDougall *in litt.* May 2017). Deer are an increasing problem, particularly in the northern area of Kosciuszko National Park. Deer tend to disturb the creeks by wallowing. Pigs tend to occur in the grasslands rather than the creeks but may disturb the habitat. Wombats may also cause disturbance in the creeks (K. McDougall pers. comm. November 2018).

Impact of 2019-2020 fires

Pimelea bracteata resprouts and recruits from seed following fire. An estimated 50% of the range of *P. bracteata* was burnt during the 2019-2020 fire season. The ability of the species to recover from the fires may be compromised by pathogens, drought and post-fire disturbance of habitat by feral horses and deer.

Number of locations

In the IUCN guidelines (2017), the term location "defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all of the individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations". The main threat affecting *Pimelea bracteata* is plant dieback, thought to be mainly caused by one or more pathogens. This dieback has been observed in *P. bracteata* populations throughout their known range, although two sites could not be visited so it is uncertain if dieback is occurring at those sites. Hence, the number of locations for *P. bracteata* is estimated to be between one and three. The lower bound (one location) assumes that dieback has reached all sites, while the upper bound (three locations) assumes dieback has not yet reached the unsurveyed sites at Pretty Plain and McPhersons Plain.

Two populations could not be sampled, one (Pretty Plain, Kosciuszko National Park) due to its remoteness and another (McPhersons Plain) as it is on freehold land and required permission for access (K. McDougall and G. Wright *in litt.* August 2017). The presence of dieback in these populations is uncertain. It is likely the McPhersons Plain plants are affected as this site is within the known area of dieback occurrence. The Pretty Plain area is the southern-most record of *P. bracteata* but has not been assessed recently for the species' presence (record dated 2002) or for the presence of dieback.

Three populations of *P. bracteata* are disjunct from the main area of occurrence in Kosciuszko National Park, but all have dieback present. At one of these (Scabby Range Nature Reserve) only 5% of plants were affected in 2016. This may indicate the spread of the pathogen/s to the site is more recent (possible vectors include water, people, vehicles, and feral animals (horses, deer and pigs)). However, as seen

in Kosciuszko National Park, the progress of dieback may rapidly impact plants at the site over time.

Rate of decline

There have been observations of death and dieback of *Pimelea bracteata* across most of its range (K. McDougall and G. Wright *in litt.* March 2019). A number of sites are showing severe dieback with 100% of mature individuals dead or dying (e.g. Rocky Plain and Kellys Plain). Other areas are currently affected to a lesser degree, e.g. the Upper Murrumbidgee catchment where a 50-75% decline since 2013 was estimated (K. McDougall *in litt.* June 2019), but dieback may continue over time.

Twelve sites (out of approximately 21 known sites) have estimates available of mature plant numbers made on two separate occasions (a baseline of 2013 and again 3-6 years after the 2013 baseline). Although most other sites have been visited to assess dieback, no comparative estimates of mature plant abundance over time are available for them. The decline observed in *Pimelea bracteata* individuals at the 12 sites since 2013 is estimated to be approximately 44-77%. This range of decline is based on the smallest abundance change (lowest bound of 2013 estimate versus highest bound of 2019 estimate) to the largest abundance change (highest bound of 2013 estimate versus lowest bound of 2019 estimate). The decline is projected to continue.

IUCN Red List Criterion A4 allows calculation of total population decline using a time frame (10 years or 3 generations, whichever is greater) that includes both the past and the future where the causes of reduction have not ceased or may not be reversible. Assuming a constant decline rate, an estimate of decline into the future over three generations (45-75 years), comprising 6 years in the past and the rest in the future (IUCN criterion A4), can be made using:

$$\text{Reduction} = 1 - (\text{Observed Change})^{(3\text{Generation} / \text{Observed Period})}$$ (IUCN 2017)

Observed change for *P. bracteata* was inferred from the difference between the sum of the estimated mature total population size data from 12 sites in 2013 minus the sum of the estimated mature total population size data from 12 sites in 2016 or 2019. Note, the term ‘population’ is here defined in IUCN (2012) as the total number of (mature) individuals i.e. it is used in a specific sense in the Red List Criteria that differs from its common biological usage. The term ‘observed’ in the equation is used in the general sense and refers, in this case, to the inferred total estimates of *Pimelea bracteata* individuals based on the sites with available data. These sites were considered to be representative of decline in the species across most of its range (McDougall and Wright *in litt.* March 2019). Upper and lower bounds of observed change were estimated, i.e. the smallest observed population change (lowest bound of 2013 mature population estimate versus highest bound of 2019 mature population estimate) and the largest observed population change (highest bound of 2013 mature population estimate versus lowest bound of 2019 mature population estimate) to estimate a range of possible reductions. Three generations were 45 (lower bound) to 75 (upper bound) years and reduction was also estimated across both these bounds. The observed period was six years, as 10 of the 12 sites with population change data had an observed period of some six years. The other two sites had an observed

period of 3 years and hence potentially underestimates likely decline over six years at those two sites.

The estimates of decline (Reduction*100%) over 3 generations under IUCN Criterion A4 were found to range from 99-100% (assuming a 15-year generation length) to 100% (assuming a 25-year generation length) (Table 2).

Severe fragmentation

IUCN Red List Guidelines (2017) and NSW TSSC Guidelines (2018) state that *"the phrase 'severely fragmented' refers to the situation in which increased extinction risks to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a reduced probability of recolonization……...A taxon can be considered to be severely fragmented if most (>50%) of its total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, and (2) separated from other habitat patches by a large distance."*

The potential habitat of *Pimelea bracteata* occurs in scattered locations in Kosciuszko National Park and surrounding areas. The habitat patches are not small and are not separated from other habitat patches by a large distance. The potential for the habitat being affected by the pathogens such that it will no longer be capable of supporting viable populations of *P. bracteata* is a concern. At present, *P. bracteata* is not considered to be severely fragmented, but it may become so if an increasing number of sites become non-viable due to dieback.

Assessment against IUCN Red List criteria (IUCN 2012)

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

Criterion A Population Size reduction

Assessment Outcome: Critically Endangered under Criterion A4a.
Justification: IUCN criterion A4 considers decline over any 10 year period or three generations (up to a maximum of 100 years into the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or may not be understood or may not be reversible.

For *Pimelea bracteata*, there has been an inferred decline in the number of mature individuals across multiple sites across the range of the species since 2013/14 due to dieback. This decline has not ceased and may not be reversible. While mature plant abundance data were not available from all known sites, an estimate of abundance was made from 12 (out of a possible 21) sites from 2013 to 2018/19 (or in some cases from 2013 to 2016). These sites cover much of the range of the distribution of the species and include most of the sites with a large number of plants. The generation length for *P. bracteata* is thought to be between 15-25 years and hence 3 generations is 45-75 years. Assuming a constant decline rate, decline over 3 generations was estimated based on the summed mature population size data from 2013 to 2019 and then extrapolated into the future.

The estimates of decline over 3 generations under IUCN A4 were found to range from 99-100% (assuming a 15 year generation length) to 100% (assuming a 25 year generation length). Both these estimates meet the Critically Endangered threshold.

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)

Justification: *Pimelea bracteata* has a highly restricted geographic distribution.

Extent of Occurrence: The EOO was estimated to be 4161 km^2 based on a minimum convex polygon enclosing all reliably mapped occurrences of the species, the method of assessment recommended by IUCN (2017). To be listed as Endangered under Criterion B1 a species must have an EOO of <5000 km^2. *Pimelea bracteata* meets the EOO threshold for Endangered under Criterion B1.

Area of Occupancy: The AOO was estimated to be 116 km^2. This calculation was based on the species occupying 29 (2 km x 2 km) grid cells, the spatial scale of assessment recommended by IUCN (2017). To be listed as Endangered under Criterion B2 a species must have an AOO of <500 km^2. *Pimelea bracteata* meets the AOO threshold for Endangered under Criterion B2.

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 Endangered for number of locations.

   Justification: The number of locations was estimated to be between 1 and 3 based on the major threat posed by the observed dieback throughout most of the range of the species. Whilst the lower bound of the number of locations is at the Critically Endangered threshold, Criterion B, it is only eligible for the category of Endangered based on the EOO and AOO estimations above.

   Pimelea bracteata is not currently considered to be severely fragmented. Most habitat patches are not smaller than would be required to support a viable population and are not separated from other habitat patches by a large distance. However, it may become severely fragmented if an increasing number of sites become non-viable due to dieback.

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 (i,ii,iii,iv,v).

   Justification: There is death and dieback of *Pimelea bracteata* individuals throughout most of its range. The extent of occurrence and area of occupancy have been recently reduced by the loss of the Micalong Swamp population that is thought to be extinct. The quality of the habitat has been reduced by the presence of pathogens that are causing dieback, and the prevalence of feral animals trampling the habitat. The number of mature

individuals has been reduced due to the dieback. There is also likely to be an adverse effect of both drought and dieback on plant recovery in areas burnt in the 2019-2020 fire.

c) Extreme fluctuations.

Assessment Outcome: Not met.

Justification: *Pimelea bracteata* resprouts and recruits from seed following fire. However, recruitment is not solely reliant on a disturbance event such as fire, with populations apparently not even-aged and seedlings observed at a wide range of times since fire. Whilst dieback events do occur in other species in subalpine areas, observations over the last 6 years suggest the dieback occurring in *P. bracteata* is persistent rather than cyclical (K. McDougall and G. Wright *in litt.* March 2019). Current evidence suggests the species is declining rather than experiencing a fluctuation. Hence, extreme fluctuations are unlikely.

Criterion C Small population size and decline

Assessment Outcome: Vulnerable under Criterion C1

Justification: It is difficult to estimate the number of mature individuals due to the linear nature of the species' distribution, widely scattered populations and remote locations. Prior to dieback, there were estimated to be between 7,500 and 15,000 mature individuals. From 12 of the 21 known sites, estimates from 2013 to either 2016 or 2019 suggest a decline in the number of mature individuals in the order of 44-77% over this time. The current estimated number of mature individuals is likely to be greater than 2500 but less than 7000. The minimum bound population estimate from 12 of the 21 known sites in 2019 was 2369 mature plants, while the maximum bound estimate was 3859. If it is assumed that the other nine sites not sampled have the same relative abundances, then the most likely current range is 4146 to 6753 mature plants. As C1 is met at the critically endangered threshold, the overall assessment for Criterion C depends on the current estimate of the number of mature individuals. While there is uncertainty in the estimate of the number of mature individuals, both the lower and upper bounds of the current estimate fall within 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) (CE); 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: C1 is met at the Critically Endangered threshold, however the main criterion (number of mature individuals) is only met at Vulnerable.

Justification: There has been >25% decline over the last generation. This is based on data from 12 out of 21 known sites, where the number of mature

individuals has declined 44-77% over the past 3-6 years. The decline is projected to continue.

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

Assessment Outcome: C2 is not met. There is continuing decline, but the subclauses below are not met.

Justification: There has been a decline observed in *Pimelea bracteata* individuals since 2013 (approximately 44-77% decline). The decline is projected to continue.

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: While it is difficult to define a subpopulation (the plants occur along creeklines), counts of mature individuals across clusters of sites are available and at least one of these is thought to have more than 1000 mature individuals.

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

Assessment Outcome: Not met

Justification: Individuals are spread over many subpopulations.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met.

Justification: *Pimelea bracteata* resprouts and recruits from seed following fire. The populations do not appear to be even-aged indicating recruitment is not solely reliant on a disturbance event such as fire. Seedlings were observed regularly within the populations as well as after fire. Whilst dieback events do occur in other species in subalpine areas, evidence suggests the dieback occurring in *P. bracteata* is persistent rather than cyclical (K. McDougall and G. Wright *in litt.* March 2019). Current evidence suggests the species is declining rather than experiencing a fluctuation. Hence, extreme fluctuations are unlikely.

Criterion D Very small or restricted population

Assessment Outcome: Vulnerable under Criterion D2

Justification: see below

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: The current estimated number of mature individuals is likely to be between 2500 to 7000.

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: met

Justification: The area of occupancy exceeds 20 km^2. The number of locations is estimated to be 1-3. The threat from dieback has resulted in a very high level of decline and dieback is a plausible future threat that could drive the taxon to CR or EX in a very short time.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: Currently there are not enough data to undertake a quantitative analysis to determine the extinction probability of *Pimelea bracteata.*

Conservation and Management Actions

There is no National Recovery Plan and no NSW Save our Species program for this species. The following is derived from the threat information and management actions initiated by Biodiversity Conservation Division, South-east, NSW Department of Planning, Industry and Environment, many of which are documented by McDougall *et al.* (2018).

Habitat loss, disturbance and modification

- Determine the cause of the dieback. Determine appropriate dosage rates for application of phosphonate for control of symptoms caused by *Phytophthora* species.

Invasive species

- Develop phytosanitary guidelines for site visits and for field work in known habitat to minimise spread of pathogens.
- Develop a targeted plan to reduce the impact of feral animals in the habitat of *Pimelea bracteata.*

Ex situ conservation

- Develop a seed collection program for *ex situ* seed banking.
- Continue to maintain an *ex situ* living collection to save genetic material from sites currently being lost. Develop a strategy to prioritise further collections based on capturing the maximum genetic diversity across the species.

Stakeholder Management

- Inform land owners and managers of sites where there are known populations and consult with these groups regarding options for conservation management and protection of the species.

Survey and Monitoring priorities

- Monitoring for increased habitat degradation due to physical disturbance.
- Survey sites not recently visited to determine if healthy plants still exist, while ensuring adequate phytosanitary precautions are taken during survey work.
- Regular surveys to determine the extent of the decline in the population of adult plants. Monitor the survival and health of juvenile plants and seedlings to see if they succumb to dieback. Determine at what age or stage of development the juveniles become susceptible to dieback.
- Conduct ongoing monitoring for recruitment and survival of recruits.
- Mapping *P. bracteata* populations and their disease status will be important for monitoring the condition of the overall population and the effectiveness of management measures.
- Monitor for any disease resistant plants across populations.

Information and Research priorities

- Investigate key factors of the species life history including recruitment, seedling and adult survival, plant growth, pollination, breeding system, seed predation, dispersal.
- Research into the nature of the dieback pathogens and invertebrates and their impact on *Pimelea bracteata*.
- Understand the interactive effects of multiple contemporaneous threats (e.g. fire, pathogens and drought).

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Expert Communications

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APPENDIX

Assessment against BC Act criteria

Overall Assessment Outcome (Clause(s) with the highest category of threat)
Critically Endangered under Clause 4.2 1(a); 2(a).

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Critically Endangered under Clause 4.2(1)(a);(2)(a).

(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: Endangered under Clause 4.3 (b) (d) (e i, 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: Vulnerable under Clause 4.4 (c)(d)(i).

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: Vulnerable under Clause 4.7.

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.

Figure 1. Distribution of *Pimelea bracteata.*

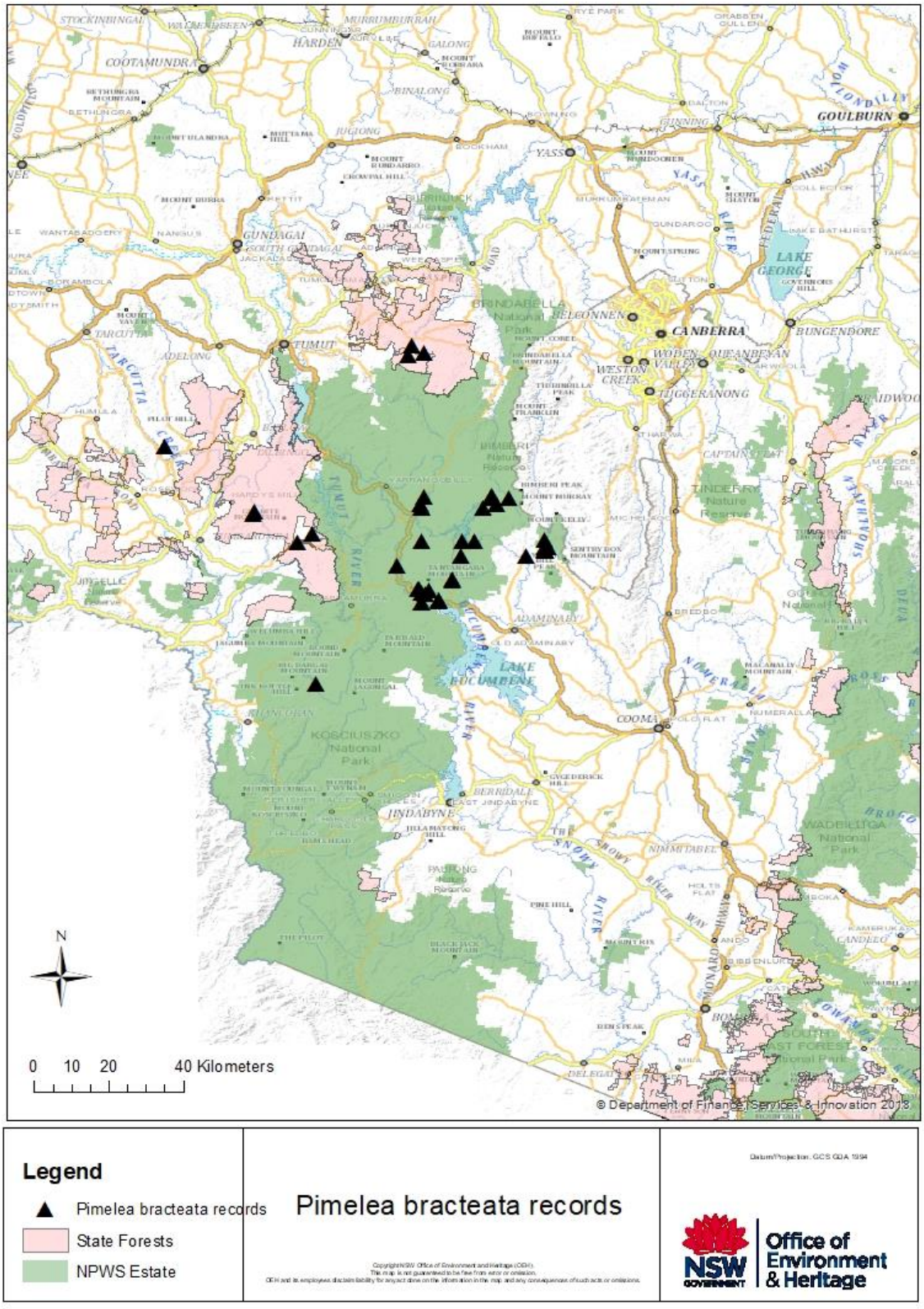

Table 1. Populations estimates for *Pimelea bracteata*.
Table 1 has been removed from the public document as it contains sensitive information.

Table 2. Estimates of reduction in *Pimelea bracteata* under IUCN A4

Population estimate 2013	Population estimate 2019	Generation length (years)	Observed period	Decline (%)
Lowest bound (6880)	Highest bound (3859)	15	6	98.7
Highest bound (10130)	Lowest bound (2369)	15	6	100
Lowest bound (6880)	Highest bound (3859)	25	6	99.9
Highest bound (10130)	Lowest bound (2369)	25	6	100