Conservation Assessment of *Pomaderris bodalla* N.G.Walsh & Coates (Rhamnaceae)

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***Pomaderris bodalla* N.G.Walsh & Coates (Rhamnaceae)**
Distribution: Endemic to NSW
Current EPBC Act Status: Not listed
Current NSW BC Act Status: Vulnerable
Proposed listing on NSW BC Act: Vulnerable

The NSW Threatened Species Scientific Committee published a notice of final determination for *Pomaderris bodalla* in 2005 (NSW Scientific Committee 2005). This Conservation Assessment report has found that there is no change to the listing status of this taxon on the *Biodiversity Conservation Act 2016* schedules. The report provides an updated assessment for the risk of extinction for the taxon against the criteria in the *Biodiversity Conservation Regulation 2017* using the Common Assessment Method. The Common Assessment Method is the agreed method for assessing the extinction risk of species by the Australian Government and all state and territory governments. This document should be read in conjunction with the 2005 final determination.

Summary of Conservation Assessment

Pomaderris bodalla was found to be eligible for listing as Vulnerable under Criteria B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v)+C2a(i).

The main reasons for this species being eligible are: (1) the species has a highly restricted geographic distribution with an extent of occurrence of 6,549 km^2 and an area of occupancy of 124 km^2; (2) the species is known from a maximum of nine threat-defined locations; (3) continuing decline in the geographic distribution, extent and quality of habitat, number of subpopulations, and number of mature individuals is inferred due to adverse fire regimes and land clearing; (4) the species population is estimated to be a minimum of 1,082 mature individuals; and (5) all subpopulations consist of low numbers of mature individuals, with the largest containing 349 mature individuals.

Description and Taxonomy

Pomaderris bodalla (family Rhamnaceae) was first described by Walsh and Coates (1997). PlantNET (2022) states that *P. bodalla* is a “Shrub 2–4 m high, young stems with spreading rusty simple hairs and dense greyish stellate hairs. Leaves elliptic, broad-elliptic, broad-obovate to ± rhombic, mostly 2–3 cm long and 12–15 mm wide, margins entire but ± undulate; upper surface dark green and glabrous with veins not or slightly impressed; lower surface pubescent with sparse spreading rusty hairs above short greyish stellate hairs. Flowers cream, in dense panicles. Sepals not persistent in fruit. Petals absent. Capsule and hypanthium stellate-pubescent or with simple hairs obscuring stellate hairs” (PlantNET 2022).

Pomaderris bodalla is readily distinguishable from co-occurring *Pomaderris* species based on the presence of rusty stellate hairs on stems and new growth of mature plants and seedlings (Le Breton *et al.* 2022).

Distribution and Abundance

Pomaderris bodalla is endemic to NSW and is currently known to occur on the South Coast between Bodalla and Merimbula, and in the Upper Hunter Valley near Muswellbrook (NSW Scientific Committee 2005). Most of the known distribution of *P. bodalla* lies within the Southeast Corner Bioregion; however, the two northern-most occurrences are within the Sydney Basin Bioregion (DCCEEW 2020a). These are the traditional lands of the Yuin, Djiringanj, Walbanga, Wonnarua and Geawegal First Nations people (Horton 1996; NSW NPWS 2001; 2004; 2011; DPIE 2019; Tindale 1940).

Since its initial listing by the NSW Scientific Committee (2005), new occurrences have been found on the South Coast increasing the number of known sites that the species occurs in. Although there have been several targeted surveys for *Pomaderris bodalla* on the South Coast, they have primarily focused or expanded on previous incidental records visible from roads or tracks. Some of the newer occurrences are also incidental, however several were found by Forestry Corporation NSW (FCNSW) during targeted searches for *P. bodalla* and other threatened species in State Forest compartments scheduled for harvesting. This suggests targeted surveys in less accessible areas on the South Coast may detect additional individuals and subpopulations. Despite intermittent surveys of the two northern-most occurrences in and near Wollemi National Park and other areas of the Hunter Valley, no further occurrences have been detected in that region (S. Bell *in litt.* 2022; G. Phillips *in litt.* 2022).

The current distribution and abundance estimates are based on 2,069 cleaned records compiled from NSW Bionet Atlas (DPE 2022a); Atlas of Living Australia (ALA 2022); Australia's Virtual Herbarium (AVH 2022); Australian National Herbarium Specimen Information Register (ANHSIR 2022); National Herbarium of NSW specimen collection data (RBGDT 2023); and survey records from 2019 to 2023. The georeferences of four records were revised based on their descriptions and a further four records were excluded due to high uncertainty in their spatial accuracy, or subsequent identification as hybrids.

Area of Occupancy and Extent of Occurrence

The area of occupancy (AOO) is 124 km^2 and the extent of occurrence (EOO) is 6,549 km^2. The AOO and EOO consist of all the cleaned records including the two northern-most occurrences in the Upper Hunter. The AOO is based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2022) and the 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 and AOO were calculated using ArcGIS (Esri 2015).

Population Size, Structure and Trends

The total population size of *Pomaderris bodalla* is estimated to be between 1,082 and 4,325 individuals. The lower population range estimate of 1,082 is the estimated number of mature individuals and is based on the collation of the most recent count data for each site of occurrence. This may be an overestimate however, as some of the field surveys recorded plants >1 m in height as mature and <1 m in height as juvenile. Juvenile *P. bodalla* can grow quite fast, particularly when there is dense regrowth, and many 1–3 year old plants >1 m have been observed to not yet be reproductive (T. Le Breton *in litt.* February 2023; C. Dunne pers comm. March 2023).

As such, categorising the age/reproductive stage of *P. bodalla* using 1 m as a proxy is likely to overestimate the number of mature individuals.

The upper population size estimate of 4,325 is based on conservative seedling survivorship estimates combined with the approximate number of mature individuals. According to the IUCN Red List Guidelines (IUCN 2022) "for taxa that naturally lose all or a subset of mature breeding individuals at some point in their life cycle, the estimate should be made at the appropriate time, when mature individuals are available for breeding" and "where population size fluctuates, use a lower estimate". As many subpopulations of *Pomaderris bodalla* are currently at a stage of their lifecycle where they have lost all mature breeding individuals, seedling survivorship estimates based on the lower bound of seedlings estimated in post-fire surveys can be used for the subpopulations burnt during the 2019–20 bushfires to infer population size. If equal survivorship of 10% is assumed for all subpopulations burnt during the 2019–2020 bushfires that were surveyed post-fire, 2,066 of the estimated 19,829–25,997 seedlings could be expected to survive and mature, resulting in 3,121 mature individuals (including the estimates of mature plants at present) in 2030–2032 (8–10 years post-fire). However, these estimates do not consider environmental variation between subpopulations and sites of occurrence. Site characteristics, vegetation community structure and composition, seedbanks, fire intensity, interval, and season (Ooi 2010), seedling density, post-fire weather and moisture conditions can influence seedling survivorship rates (Benwell 1998). If we use a precautionary approach and assume that subpopulations with high seedling densities and occurrences on roadsides and creekbanks are likely to have lower seedling survivorship (10%), and subpopulations with low seedling densities that do not occur on roadsides or creekbanks are likely to have higher seedling survivorship (50–70%), then this could result in the survival and maturation of 3,235 seedlings and therefore a total of approx. 4,325 mature individuals in 8–10 years post-fire (Table 1).

There are currently 27 known subpopulations of *Pomaderris bodalla* following the IUCN definition (IUCN 2022), however four or five of these may now be locally extinct, with the most recent searches failing to locate any live plants (Table 1). For this assessment, subpopulations of *P. bodalla* are defined as occurrences within 1 km, with the minimum distance between any subpopulation being approximately 1.4 km. This accounts for the typical pollination distances of insect pollinators and the low seed dispersal distance generally observed in *Pomaderris* species (Levin 1981; Berg 1975; Lengyel *et al.* 2009; Patykowski *et al.* 2014).

There are currently three populations confirmed on NSW National Parks and Wildlife Service (NPWS) managed estate - two known subpopulations of *Pomaderris bodalla* in Kooraban National Park, one subpopulation in Wollemi National Park – with another unconfirmed subpopulation in Wingen Maid Nature Reserve which is possibly a misidentified stand of *Pomaderris graniticola* (G. Phillips pers. obs. June 2022). Sixteen subpopulations occur in Forestry Corporation of NSW (FCNSW) State Forest including eleven in Bodalla State Forest, three in Moruya State Forest, one in Yurammie State Forest and a portion of one in Murrah State Forest Flora Reserve. Murrah State Forest Flora Reserve is in FCNSW Forestry Management Zone (FMZ) 1 and is managed by the NPWS. One subpopulation occurs in a Travelling Stock Reserve (TSR), and the remaining five and a portion of one occur on private property, local council reserves or Zone C2 (Environmental Conservation) (Table 1).

One subpopulation located in Moruya State Forest currently contains the greatest portion of mature individuals (32% of the population size), followed by the subpopulation spanning across Murrah State Forest Flora Reserve and adjacent private property (28%), and a subpopulation on private property along Dignams Creek (11%).

Thirteen to fifteen (48–55%) of the subpopulations are solely comprised of seedlings and juveniles due to the death of mature plants in the 2019–2020 bushfires (see Table 1). No mature individuals have been observed in Kooraban National Park or Wollemi National Park since the 2019–2020 bushfires (Schlunke 2022; S. Bell *in litt.* 2022; Le Breton *et al.* 2022). Only 87 mature individuals in two subpopulations have been observed in Bodalla State Forest, 442 mature individuals in two subpopulations in Moruya State Forest, 14 mature individuals in Yurammie State Forest, and 79 mature individuals in Murrah State Forest Flora Reserve (Schlunke 2022; Bell and Phillips 2022, Le Breton *et al* 2022).

Number of locations

The most serious plausible threat resulting in the lowest number of locations for *Pomaderris bodalla* is considered to be adverse fire regimes, which results in the species having 5–9 threat-defined locations. These locations are defined where a single fire event could plausibly affect all individuals in an area due to geographic proximity, surrounding land use and local fire history, rapidly resulting in changes to the local fire regime. The locations are:

1. Yurramie State Forest and surrounds, encompassing subpopulations 1 and 2.
2. Stands on the south side of the Merimbula township, encompassing subpopulation 4.
3. Stands to the north of the Merimbula township, encompassing subpopulation 3.
4. Murrah Flora Reserves and surrounds, encompassing subpopulation 6.
5. All subpopulations within the footprint of the 2020 Badja Rd Fire, encompassing subpopulations 7–20 and 22–23.
6. Stands in the Kianga area just east of the footprint of the 2020 Badja Rd Fire, encompassing subpopulation 21.
7. Stands in the Turlinjah and Wamban areas, just east of the footprint of the 2020 Badja Rd Fire, encompassing subpopulations 24–25.
8. The stand in Wollemi National Park, encompassing subpopulation 26.
9. The stand in Wingen Maid Nature Reserve, encompassing subpopulation 27.

In the event that large scale fires were spread into the future, the number of locations could plausibly be as low as five. In such a case, the number of locations on the south coast (*i.e*., locations 1–7) could be as low as three, with the northern locations remaining discrete. This means that the plausible number of threat-defined locations of *Pomaderris bodalla* is 5–9.

Cultural and community significance

Pomaderris bodalla occurs on the traditional lands of the Yuin, Djiringanj, Walbanga, Wonnarua and Geawegal First Nations people (Horton 1996; NSW NPWS 2001; 2004; 2011; DPIE 2019; Tindale 1940). This species does not appear to have any specific cultural or customary significance to the Yuin people (P. Brown *in litt.* 2023), however

further consultation with the traditional owners may provide awareness of traditional knowledge and management practices on country that may benefit this species.

Table 1: Subpopulation, Suburb, Local Government Area (LGA), tenure and estimates for number for number of mature individuals. Reserved tenure is in bold text.

Sub-pop #	Suburb, LGA	No. Mature Individuals	No. Mature + seedling survivorship estimate
1	Lochiel, Bega Valley	12	12*
2	Lochiel, Bega Valley	14	14*
3	Berrambool, Bega Valley	4	4*
4	Merimbula, Bega Valley	28	28*
5	Wallagoot, Bega Valley	23	23*
6	Murrah; Cuttagee, Bega Valley	307	307*
7	Dignams Creek, Eurobodalla	118	118*
8	Wandella, Bega Valley	0	0^
9	Dignams Creek, Bega Valley	0	561[70]
10	Dignams Creek; Tinpot, Eurobodalla	0	53[70]
11	Narooma, Eurobodalla	7	128[70]
12	Narooma, Eurobodalla	0	0^
13	Tinpot, Eurobodalla	0	36[70]
14	Tinpot, Eurobodalla	0	35[70]
15	Tinpot, Eurobodalla	0	286[50]
16	Tinpot, Eurobodalla	0?	0[#]
17	Tinpot, Eurobodalla	0?	69[#]
18	Tinpot, Eurobodalla	0?	1[#]
19	Tinpot, Eurobodalla	0	940[10]
20	Tinpot, Eurobodalla	0	0^
21	Kianga, Eurobodalla	80	88*
22	Bodalla, Eurobodalla	0	858[10]
23	Bodalla, Eurobodalla	0	271[70]
24	Bodalla; Turlinjah, Eurobodalla	349	349*
25	Wamban, Eurobodalla	120	124*
26	Martindale, Upper Hunter	0	0~
27	Dry Creek, Upper Hunter	20	20*
	Total	1,082	4,325
	Unreserved Subtotal (excl. Murrah SF FR)	903	3,665

* = unburnt during the 2019-2020 bushfires
^ = none found during 2021 search
~ = none found during 2022 search
[#] = no post-fire surveys have been conducted –pre-fire no. mature individuals used for estimate
[10] = 10% seedling survivorship estimate used
[50] = 50% seedling survivorship estimate used
[70] = 70% seedling survivorship estimate used

Ecology

Habitat

Pomaderris bodalla mainly occurs in moist, open forest along sheltered gullies or along stream banks on the South Coast; however, the two disjunct subpopulations in the Hunter Valley occur in open forest or woodland on open slopes (NSW Scientific Committee 2005). On the South Coast, the species generally occurs in the ecotone between wetter riparian forest along creeks and drier forest on adjacent lower slopes, on clay soils derived from Ordovician siltstones (Miles 2019). Tree canopy gaps created by roads, watercourses or powerlines are common at most occurrences, and the species has not been observed in tall wet forest with dense understoreys (Miles 2019). The species occurrence in disturbed areas is likely a consequence of its life history as an obligate seeder with physically dormant seeds (Le Breton *et al.* 2020).

The South Coast riparian zones that *Pomaderris bodalla* currently occupies may be acting as refugia from unfavourable fire regimes, representing relicts of subpopulations formerly more widely distributed (Le Breton *et al.* 2020). This may also explain its occurrence in substantially different habitat in the northern-most sites, where fewer and less frequent fires have been recorded.

According to the IUCN Global Ecosystem Typology v2.1, habitat on the South Coast is dominated by wet sclerophyll forest communities within the temperate pyric humid forests functional group (Keith & Mac Nally 2020). The northern areas of the species occurrence are dominated by communities within the temperate pyric sclerophyll forests and woodlands functional group (Keith *et al.* 2022) (minor occurrence) and/or the Tropical/Subtropical dry forests and thickets functional group (Pennington *et al.* 2022).

Pomaderris bodalla has been recorded in the Plant Community Types (PCT) South Coast Gully Shrub Forest (3189), South Coast Stringybark-Monkey Gum Wet Forest (3193), and South Coast Riverflat Peppermint Forest (3188) (DPE 2022a, 2022d, 2022e, 2022f). However, the species is not likely to be restricted to these PCTs and could be found in other PCTs within the area.

Lifespan and generation length

The time to reproductive maturity of *Pomaderris bodalla* is unknown but is believed to be approximately 8–10 years (Le Breton *in litt.* March 2023). The longevity is also unknown, but it likely lives for 40+ years judging by time since last fire and stem diameter at breast height up to 10 cm of some plants observed in the field (Le Breton *et al.* 2016). These are consistent with estimates for other *Pomaderris* species of >2 years (3–5 years (5 species), 5–10 years (4 species) and 5–20 years (64 species)) to reproductive maturity and 20–50 years longevity of standing plants (Patykowski *et al.* 2014; Falster *et al.* 2021; White *et al.* 2020).

Although the generation length for *Pomaderris bodalla* is unknown due to limited data on lifespan and fecundity, it is possible to infer conservative estimates using the data available. Generation length is determined as age of first reproduction + z $*$ length of reproductive period, where z is a number between 0 and 1 depending on survivorship

and the relative fecundity of young verses old individuals in the population (IUCN Standards and Petitions Committee 2022). A z value that was calculated for other woody shrub species (Fung and Waples 2017), can be used as an approximation for the z value of *Pomaderris*. A generation length of 14.7 years can be calculated assuming 8 years as the minimum age of reproduction for *P. bodalla*, a z value of 0.21 and 32 years as the length of reproductive period. If a more conservative estimate of 10 years is assumed as the minimum age of reproduction, and 30 years as the length of reproductive period, a generation length of 16.3 years can be calculated. The shortest plausible generation length of 12.2 years can be calculated assuming 8 years as the minimum age of reproduction and 20 years as the shortest plausible length of reproductive period.

Disturbance response and fire ecology

Pomaderris bodalla is generally an obligate seeder which is killed by fire and relies on persistent, soil-stored seed banks for regeneration following fires. The species produces physically dormant seeds which require extremely high soil temperatures (c. 100–120°C) for dormancy to be broken and germination to occur (Le Breton 2016; Le Breton *et al.* 2020; Le Breton *et al.* 2022). Obligate seeders naturally experience fluctuations within populations, as many, if not all mature individuals may be killed during a single fire event. Furthermore, if that fire event is not sufficiently severe to heat the soil to the temperatures necessary to break seed dormancy, the population will have a limited capacity to regenerate.

Surveys prior to the 2019–2020 bushfires only observed mature and juvenile plants with few if any seedlings at most sites (Le Breton 2016; Miles 2019). Additionally, some of the “juveniles” observed may have been resprouts (mature plants recovering from dieback) or mature plants which had not reached sufficient size to flower due to competition, resource limitation or shading.

During the 2019–2020 bushfires, approximately 59% of the known subpopulations of *Pomaderris bodalla* were burnt (DPIE 2020; DPE 2022b, Le Breton *et al.* 2022). A subset of these subpopulations was included in a study by Le Breton *et al.* (2022) which investigated the effect of fire frequency and severity on the species. They found less recruitment at more frequently burnt sites, and a humped-shaped germination response to fire severity which peaked at sites with high fire severity and declined at sites with extreme fire severity (Le Breton *et al.* 2020, 2022).

Recruitment in the absence of the fire has been observed to occur at two subpopulations which have been unburned for up to 47 years suggesting the species does have the capacity to persist independently of fire (Le Breton 2016). However, recruitment during the inter-fire period may be detrimental for obligate seeding species if the population is burnt before recruits mature and replenish the seedbank (Ooi *et al*. 2012).

Resprouting and suckering has been observed following physical disturbance of plants, and the species likely resprouts in response to floods and possibly very low severity fires where there is not 100% leaf scorch (Le Breton *et al.* 2020; Percival 2017).

Reproduction and hybridisation

There is evidence suggesting that *Pomaderris bodalla* reproduces asexually through apomixis, and this may result in low genetic diversity within subpopulations. Although pollination is required for fertilisation and seed development to occur, the genetic material from the pollen is not passed on to the embryo. In other words, it produces clonal progeny through seed (Chen *et al.* 2019). *Pomaderris bodalla* may also be able to reproduce sexually, however further sampling and genetic analysis would be required to confirm this (S. Chen *in litt.* 2023). If asexual reproduction in *P. bodalla* is facultative (rather than obligate), it could account for plants which have been recorded as likely hybrids with *Pomaderris brogoensis* (S. Chen *in litt.* 2023; Walsh and Coates 1997).

Pollination and seed dispersal

Pomaderris bodalla typically flowers in spring (Le Breton *et al.* 2022). Insects are believed to be the primary pollinators for *Pomaderris* species; however, there is limited information about which insects (Le Breton 2017). Hoverflies have been observed visiting flowers of *Pomaderris vacciniifolia,* and nectar feeding moths have been suggested as possible pollinators for *Pomaderris* which emit a slight nocturnal fragrance (Patykowski *et al.* 2014). Pollen is rarely transported beyond 1,000 m in most plants (Levin 1981). This is most likely because pollinators generally fly to near neighbours, suggesting that cross pollinations are principally between neighbouring plants.

The seeds of *Pomaderris bodalla* are small (<6 mm and 0.6(±0.1) g (Le Breton 2016; Ooi 2021; Royal Botanic Gardens Kew 2023)), and *Pomaderris* species generally tend to be poor dispersers relying on gravity and ants, with an average seed dispersal distance of 1 m (Berg 1975; Gomez 1998; Lengyel *et al.* 2010; Patykowski *et al.* 2014). *Pomaderris bodalla* seems to follow this trend (Le Breton and Auld *in litt.* 2019). The majority of *P. bodalla* seed are physically dormant and require high, fire-induced soil temperatures (c. 100–120°C) to break dormancy; however, a small portion (≤17%) are non-dormant and may germinate in response to other stochastic disturbance events, such as flooding (Le Breton 2016; Le Breton *et al.* 2020). It is unknown how long the seeds remain viable in the soil, however, persistence over many years seems likely given the persistence of many other physically dormant species in the region (Le Breton *et al*. 2020; Ooi *et al.* 2012). The semi-hardened seeds of *Pomaderris vacciniifolia* are suspected to remain viable in the soil for at least 20 years (Patykowski *et al.* 2014).

The association of known populations with riparian areas and drainage lines suggests there may be the minor possibility of secondary dispersal via water, however, the significance of this is unknown (Le Breton 2016). The short-range dispersal of seeds by gravity and ants suggests the species is susceptible to fragmentation. Secondary dispersal via streams and rivers may offset this at least along rivers if not across catchments (Le Breton and Auld *in litt.* 2019).

Threats

The NSW Scientific Committee (2005) noted a number of threats to *Pomaderris bodalla*, most of which are still considered plausible. These include high fire frequency, road maintenance activities, residential development, trampling and grazing from

livestock, small-scale clearing activities, and disturbance from logging operations. The small size of many of the subpopulations puts them at risk of declines or extinction related to stochastic events and limits their capacity to adapt to climate change.

Adverse fire regimes

The NSW Scientific Committee (2005) identified frequent fire events as a threat to *Pomaderris bodalla* due to its relatively long primary juvenile period of c. 10 years. Subsequent research supports this with further evidence of low severity fires, and the combination of high frequency and low severity fire, having a detrimental effect on the species (Le Breton *et al.* 2022; Le Breton *et al.* 2020; Le Breton 2016).

Fewer recruits have been observed at more frequently burnt sites, suggesting high fire frequency has an overall negative effect on recruitment as it limits the availability of seeds stored within the soil seedbank (Le Breton *et al.* 2022). The requirement for high temperatures (~100–120˚C) to maximise breaking of seed dormancy also makes it vulnerable to repeated relatively low severity fires such as prescribed/hazard reduction burning in cool seasons. Such fires kill mature plants but may not be hot enough to stimulate germination of the seedbank (Le Breton 2016). Low pre-fire population size (1–2 plants), high fire frequency (3–4 fires in 60 years) and short fire intervals (3–7 years) have been attributed to the local extinction of at least one subpopulation, and one site of occurrence of another subpopulation (Le Breton *et al.* 2022).

There is evidence suggesting that *Pomaderris bodalla* is vulnerable to extreme severity fires, and the combination of extreme severity and high frequency fires (Le Breton *et al.* 2022; Le Breton 2016). Lower seedling densities were observed in areas burnt at extreme severity during the 2019–2020 bushfire event, than those burnt at high severity (Le Breton *et al.* 2022). This is likely because: (i) seed dormancy break and germination peak at temperatures associated with high severity fire and decline at those following extreme severity; and (ii) a higher portion of seed is killed at temperatures associated with extreme severity fires, than high severity fires (Le Breton *et al.* 2022). Lower germination levels were also observed in areas where extreme severity fires overlapped with high fire frequency, than those where high severity fires overlapped with high fire frequency (Le Breton *et al.* 2022). This is likely due to a higher portion of the seedbank being stimulated or killed at extreme severity, and recruits being killed by subsequent fires before they mature and replenish the seedbank. High to extreme severity fire resulting in maximal germination and depletion of the soil seedbank will put the species at risk of decline and local extinction if it is burnt again too soon (within 10–12 years) (Le Breton *et al.* 2022).

There will likely be an increase in the frequency and severity of fires in southern and eastern Australia due to climate change; however, the extent to which this will affect *Pomaderris bodalla* is uncertain. Projected declines in rainfall in winter and spring are likely to increasingly precondition southeast Australia to forest fire by increasing fuel dryness (Abram *et al*. 2021; Evans *et al.* 2014). There has also been a trend for more frequent dry lightning events in coastal southeast Australia, which are a natural source of ignition (Dowdy 2020).

'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 *BC Act*. "Fire regimes that cause declines in biodiversity" is listed as a Key Threatening Process under the *EPBC Act*.

Clearing of habitat

Twenty of the twenty-seven subpopulations have been identified as at risk of clearing or damage due to road or track maintenance, a substantial increase from the two subpopulations mentioned at risk in the original determination (NSW Scientific Committee 2005). Plant mortality and damage due to road and track works (such as grading, slashing, tittering, and poisoning) has been observed in at least five of these subpopulations (Miles 2005, 2015; Dunne *in litt.* 2023; Le Breton *in litt.* 2021; Schlunke 2022). The majority of known subpopulations (81–85%) occur outside of national parks or reserves and are therefore at greater risk of adverse effects from ongoing habitat clearing and fragmentation (Le Breton 2016) that are likely to lead to future declines.

'Clearing of native vegetation' is listed as a Key Threatening Process under the *BC Act*. 'Land clearance' is listed as a Key Threatening Process under the *EPBC Act*.

Grazing and trampling by feral goats, feral deer and domestic stock

The grazing effects of deer and goats is an inferred ongoing threat to *Pomaderris bodalla*. Although direct evidence of the negative effects of deer and goat browsing has not been recorded, they are both known to be present in much of the species' distribution and could pose a plausible threat post-fire or during drought.

Both deer and goats were removed in Wingen Maid NR during a recent NPWS aerial shooting program. They are still present in the reserve, however anecdotal reports from local staff suggest that goat numbers have decreased over the last few operations. Although there is no on-ground monitoring of direct effects, deer and goat browsing is considered to have general negative effects on native vegetation within the reserve (Anon *in litt.* 2023).

NPWS staff have not detected goats near the Wollemi NP subpopulation, however they are mindful that they could become an active threat to the species if they do become established there. The nearest known goat population is on a mountain approximately 4 km east and although deer are known to be in nearby valleys, they have not yet been detected as far up the escarpment as the species' historic site of occurrence (S. Forty *in litt.* 2023).

NPWS staff have not detected deer, goats, or pigs in Murrah SF FR, and note that the nearest known populations on National Park estate are in the south-western side of Wadbilliga National Park (P. Brown *in litt.* 2023).

Although the direct effects from domestic stock were not observed during the most recent surveys, most of them were not conducted on private property. Currently, domestic stock does not appear to be present in the property adjacent to Murrah SF FR, however there is potential for stock to negatively affect four subpopulations that occur on other private property and one subpopulation that occurs on the Travelling Stock Reserve during periods of drought, or during post-fire recovery.

'Competition and habitat degradation by feral goats (*Capra hircus*) and 'Herbivory and environmental degradation caused by feral deer' are listed as Key Threatening Processes under the *BC Act*. 'Competition and land degradation by unmanaged goats' is listed as a Key Threatening Process under the *EPBC Act.*

Assessment against IUCN Red List criteria

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

Criterion A *Population Size reduction*

Assessment Outcome: Data Deficient

Justification: To be listed as threatened under Criterion A the species must have experienced a population reduction of ≥30% over three generations or 10 years (whichever is longer). There is insufficient data to estimate, infer or project the magnitude of past or future reductions in population size for this species over three generations (36–49 years).

Criterion B *Geographic range*

Assessment Outcome: Vulnerable under Criterion B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v)

Justification: *Pomaderris bodalla* has a highly restricted geographic distribution with an estimated area of occupancy (AOO) of 124 km^2, measured using 2 x 2 km grids as per IUCN Guidelines (2022). This falls below the Endangered threshold of <500 km^2. The extent of occurrence (EOO) is 6,549 km^2 based on convex hull polygon as per IUCN Guidelines (2022), which falls below the Vulnerable threshold of <10,000 km^2.

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 with <10 locations

   Justification: The most serious plausible threat resulting in the lowest number of locations for *Pomaderris bodalla* is considered to be adverse fire regimes, which results in the species having 5–9 threat-defined locations.

   The species does not appear to be suffering from severe fragmentation as most subpopulations occur in patches large enough to support 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 (i)(ii)(iii)(iv)(v)

   Justification: A continuing decline in (i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and quality of habitat, (iv) number of subpopulations and (v) number of mature individuals is inferred from the threat of high frequency, low severity and extreme severity fires, and risk of direct damage and further habitat loss, fragmentation and degradation due to proximity to roads, residential areas and powerline easements.

c) Extreme fluctuations.

Assessment Outcome: Not met

Justification: There is no evidence to suggest the species is experiencing extreme fluctuations at present.

Criterion C Small population size and decline

Assessment Outcome: Vulnerable under Criterion C2a(i)

Justification: The current estimated population *for Pomaderris bodalla* is a minimum of 1,082 mature individuals, meeting the threshold for Endangered. In addition to this threshold, one of at least two other conditions must be met to qualify for listing under Criterion C.

These conditions 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: There is currently insufficient data to quantify potential declines in mature individuals over 1–3 generations (16–55 years).

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

Assessment Outcome: Met

Justification: Continuing decline is inferred in the number of mature individuals *of Pomaderris bodalla*. This is as the most recent searches failed to locate any live plants in four of the 27 known subpopulations, low severity and/or high frequency fires in its habitat stifle recruitment and recovery from previous fire events, and the proximity of many subpopulations to roads, residential areas and powerline easements place it at risk of further disturbance, habitat loss, fragmentation degradation.

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

a (i).Number of mature individuals in each subpopulation ≤50 (CR); ≤250 (EN) or ≤1,000 (VU).

Assessment Outcome: Met for Vulnerable

Justification: Twenty-five of the 27 known subpopulations contain <250 mature individuals. The remaining two subpopulations contain approx. 307 mature individuals (Murrah State Forest Flora Reserve and Private Property) and approx. 349 mature individuals (Moruya State Forest). If survivorship estimates are used for the number of seedlings and juveniles in each subpopulation burnt during the 2019–2020 bushfires to approximate how many mature individuals the subpopulations may consist of in 8–10 years post-fire, then all of the known subpopulations may contain <1,000 and 19 of the 27 known subpopulations may contain <250.

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

Assessment Outcome: Not met

Justification: The largest subpopulation currently contains 32% of the mature individuals. If survivorship estimates are used for the number of seedlings and juveniles in each subpopulation burnt during the 2019–2020 bushfires to approximate how many mature individuals the subpopulations may consist of in 8–10 years post-fire, the largest subpopulation may contain approximately 22% of mature individuals.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met

Justification: There is no evidence to suggest the species is experiencing extreme fluctuations at present.

Criterion D Very small or restricted population

Assessment Outcome: Not met

Justification: There are currently estimated to be approx. 1,082 mature individuals of *Pomaderris bodalla*. As many subpopulations of *P. bodalla* are currently at a stage of their lifecycle where they have lost all mature breeding individuals, seedling survivorship estimates have been used to infer a population size of 4,325 mature individuals.

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: There are currently estimated to be 1,082 mature individuals, however 4,325 can be approximated if seedling survivorship estimates are used to take into account the lifecycle stage of the subpopulations burnt during the 2019–2020 bushfires. These estimates do not meet the threshold for this Subcriterion.

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: The species is not so restricted geographically as to qualify as CR or EX in a very short time in light of any currently known threats.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: There is insufficient data to quantify the Extinction Risk for this species.

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. *Pomaderris bodalla* sits within the Data Deficient management stream of the SoS program.

There is no National Recovery Plan for this species. The following is derived from the NSW Saving our Species program, the threat information and an approved draft update to the Threatened Species Hazard Reduction List (TSHRL).

Habitat loss, disturbance and modification

- Prevent clearing of populations in and around residential areas, powerline easements and road verges.
- Ensure appropriate fire regimes are maintained with respect to fire frequency and fire severity. Specifically, prescribed fires must not occur within 10 years of a previous fire (planned or unplanned) and must be of moderate-high intensity to ensure sufficient soil heating to stimulate recruitment from the soil seed bank.
- Prevent unplanned fires from negatively affecting the populations within 10 years of the previous fire (planned or unplanned) to maximise the opportunity for plants to mature and replenish the seed bank.
- Prevent prescribed and unplanned fires from all occurrences (including those which have not had a fire for more than 10 years) until a larger portion of the total population have reached maturity.

Invasive species

- Identify and remove invasive weed species at recently burnt sites to avoid competition with seedlings.
- Control feral herbivore populations such as goats in Wingen Maid Nature Reserve, or fence populations as a short-term solution to over-browsing should this be observed.

Ex situ conservation

- Develop a targeted seed collection program for ex situ seed banking, current seed collections are limited in both number and representativeness with most collections coming from populations in the far south of the species range. Attempts should be made to both revisit and collect seed from the disjunct northern populations in the Hunter Valley.

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.

- Liaise with NPWS operations staff and FCNSW ecologists to improve awareness of the species.

Survey and Monitoring priorities

- Surveys of Northern populations including both known sites and potentially suitable locations, the search should be expanded to include all areas with comparable habitat between the northern and southern populations.
- Monitoring for increased habitat degradation
- Regular surveys to determine whether there is a decline in the population and general population trends
- Post-fire monitoring for recruitment, seedling survivorship and mortality of mature plants.

Information and Research priorities

- Work with Traditional Owners to divulge any traditional knowledge associated with the species ensuring the practices to record, store and share this knowledge are mutually supported.
- Further research into the germination requirements of the species is required in particular the moisture requirements of the seed and seedlings may be a contributing factor to its association with moist areas.
- Research into the growth of the species and the age/size at which it is likely to mature would be valuable to more accurately determine minimum fire intervals for management.
- Further sampling of subpopulations for genetic analysis, including the northern subpopulations and suspected hybrids would be valuable for determining whether the species is able to reproduce sexually, and if so, whether gene flow is occurring within and between the sub-populations.

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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:

Pomaderris bodalla was found to be Vulnerable under Clause 4.3(c)(d)(ei,ii,iii,iv) and Clause 4.4(c)(ei,iiA(III)).

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Data Deficient

(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: Vulnerable under Clause 4.4(c)(ei,iiA(III))

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.