

NSW Threatened Species Scientific Committee

Conservation Assessment of *Hibbertia superans* Toelken (Dilleniaceae)

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***Hibbertia superans* Toelken (Dilleniaceae)**

Distribution: Endemic to the Greater Sydney region of NSW

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Endangered

Proposed listing on NSW BC Act: Critically Endangered

Reason for change: Genuine change based on a very large reduction in the abundance of the species.

Summary of Conservation Assessment

Hibbertia superans was found to be eligible for listing as Critically Endangered under Criterion A2bc+A4bc.

The main reason for this species being eligible is an observed and estimated very large population reduction as a result of clearing for residential development, low fire frequency, habitat degradation from disturbance and competition from weeds.

Description and Taxonomy

Hibbertia superans was originally described as *H. sericea*, or *Pleuranda sericea* in 1817 as part of a species complex now recognised as twelve species and three subspecies (Toelken 2000). In the 2001 Final Determination (NSW Scientific Committee 2001) an endangered population previously known as *H. incana* was included in the assessment, however this species is now known as *H. crinita* (PlantNET 2022a) and is not included in this assessment.

PlantNET (2022b) describes *H. superans* as “Low spreading shrubs with few to many, weak twisting branches to 40 cm long. Leaves linear, rarely linear-elliptic, (5.6-) 7.5 - 10 (-12.3) mm long, 0.9 - 1.2 (-1.4) mm wide; apex acuminate to acute; base gradually tapering to petiole, petiole to 0.5 mm long; margins revolute, appearing thickened. Young branches and leaves covered with long silky hairs over a dense indumentum of short stiff hairs. Longer hairs often wearing off with age. Some scattered stellate hairs also present, particularly on the younger branches and the lower surface of leaves. Flowers single; sessile or shortly pedicellate; terminal on main branches (or rarely on short shoots); bracts linear, 8.3 - 9.5 mm long, 1.0 - 1.3 mm wide, leaf-like with distinct central vein, villous sometimes becoming tomentose above and below. Calyx not accrescent; outer calyx lobes linear-lanceolate, acute, with slender central vein, villous-tomentose, mostly 7.5 - 9 mm long and 1.4 - 1.7 mm wide, much longer than inner lobes; inner calyx lobes oblong-elliptic to obovate, obtuse to rounded, 4.2 - 6.5 (-7.6) x 1.9 - 2.7 mm, outside villous over more or less appressed pubescent, inside rarely with a few appressed hairs towards the apex. Petals broadly obovate, 5.5 - 6.7 mm long, emarginate. Stamens 6 - 9, subequal; filaments basally connate, but often some more than others; anthers narrowly oblong, (1.4-) 1.6 - 1.8 mm long, dehiscing mainly by lateral slits. Pistils 2; ovaries laterally compressed, each with 4 ovules; style

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from outer apex of ovary, curved outwards and around the cluster of stamens to end at the apex of the outer anthers. Fruit villous with very dense erect simple hairs. Seeds oblong-obovoid, often oblique, 1.5 - 1.7 x 1.1 - 1.4 mm, fleshy aril expanding into a scarcely lobed sheath adpressed to the base of seed, often to one side of base of seed." *Hibbertia superans* has been recorded up to 40cm high and spreading up to 1 m wide (R. Miller *in litt.* December 2022).

Distribution and Abundance

Hibbertia superans is endemic to the Greater Sydney region of NSW. It mainly occurs in the northwest Sydney region between Baulkham Hills and Wisemans Ferry. It has also been recorded in very small numbers in the Berowra Valley, Belrose, North Turramurra, Dural and Manly, and in the lower Blue Mountains between Blaxland and Faulconbridge. It was previously thought to occur at a disjunct occurrence near Mt Boss (inland from Kempsey) on the mid north coast of NSW (NSW Scientific Committee 2001), but this record now belongs to a separate taxon and not included in this assessment (H. Toelken *in litt.* December 2022).

In this conservation assessment a site is defined as a geographically distinct area that is separated from another site by at least 250 metres, and may contain one or more occurrences, or records, of *H. superans*. Each occurrence may contain one or more individuals.

The current distribution estimate is based on 835 unique records compiled from NSW Bionet Atlas, Atlas of Living Australia, herbarium specimens, 17 survey records from BAM Assessment data (Department of Planning and Environment (DPE) 2022a) and 49 records from a survey of nine sites in 2022 (Miller 2022).

Extent of Occurrence and Area of Occupancy

The Extent of Occurrence (EOO) is 1,427 km² and the Area of Occupancy (AOO) is 160 km². 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 AOO is based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2022). The EOO and AOO were calculated using Kew Geospatial Conservation Assessment Tool (GeoCAT; Bachman *et al.* 2011) and encompasses the entire known past and extant distribution of the species. The AOO may be an underestimate as there has been no systematic survey effort for *H. superans* across its distribution so there may be a very small number individuals that have not been recorded.

Population Size and Trends

The total population size of *H. superans* is estimated to be approximately 750 mature individuals. Historically the species has been recorded from around 45 sites, with eleven sites with over 100 individuals and much smaller numbers at the other sites. All record counts are assumed to be of mature individuals as without flowers this species is very difficult to find and identify. The two largest sites of *H. superans* are adjacent to Cattai Creek, Kellyville. The current largest site of *H. superans* is at Cattai Creek Drive, Kellyville, where 277 plants were recorded in 2020 (WSP 2020). An approved development application for residential housing at this site plans to clear 77 individuals (WSP2020). The second largest site is near Heath Rd and Saltwater Crescent, Kellyville, where there are currently 190 individuals. The number of

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individuals at this site declined from 650 in 2008 (Bionet LDMPI0115664) to 480 in 2019 (Bionet records) and then to 190 in 2022 after vegetation was cleared for a housing development (ArcGIS Online 2022).

Hibbertia superans has undergone a large reduction in population size since the late 1990s and early 2000s. Population trend data is available for 92% of the population recorded in the late 1990s (3,092 individuals at 16 sites) and early 2000s (3,380 individuals at 45 sites). This large subset of the population has declined 77% to 722 individuals (2-3 generations) as a result of land clearing for residential and rural-residential development, low fire frequency, habitat degradation from human disturbance and competition from weeds. The population trajectory of the other 8% of the population (288 individuals) is unknown but it is reasonable to infer a similar decline in the presence of the current known ongoing threats. At least 100 individuals have been identified from approved or in progress development applications to be cleared in the near future (DPE 2022a).

Hibbertia superans is found on a mixture of land tenures: 23 sites (>50% of sites) are on private land or part on private or unreserved Crown land, 11 are on, or part on, Council or Crown reserves, four are in a NPWS reserve, two are on Aboriginal Land Council land and one in State Forest.

Cultural significance

Hibbertia superans occurs on the traditional lands of the Eora, Dharug and Gundungarra people who have a strong and ongoing cultural connection with their traditional lands and waters (AIATSIS 2022). Aboriginal Peoples have cared for Country for tens of thousands of years (Bowler *et al.* 2003; Clarkson *et al.* 2017). In northern NSW *Hibbertia scandens* was used by the Yaegl people as a medicinal plant to treat sores and rashes (Packer *et al.* 2012).

Ecology

Hibbertia superans is a small spreading perennial shrub with softly woody branches and distinctive bright yellow flowers (Toelken 2000). *Hibbertia superans* flowers from July – December (PlantNET 2022b). In the Sydney region it occurs in Dry Sclerophyll Forest on sandstone ridgetops, often close to the shale/sandstone transition (James 2012; PlantNET 2022b; Toelken 2000). *Hibbertia superans* is often associated with canopy species such as *Allocasuarina littoralis*, *Angophora bakeri*, *A. hispida*, *Corymbia gummifera*, *C. eximia*, *Eucalyptus piperita*, *E. sclerophylla*, *E. sp. Cattai*, *E. squamosa* and a large diversity of understory shrubs including other threatened flora such as *Acacia bynoeana*, *Darwinia biflora*, *Epacris purpurascens* var. *purpurascens*, *Leucopogon fletcheri* subsp. *fletcheri*, *Persoonia hirsuta* and *Pimelea curviflora* var. *curviflora* (Millar 2022; NSW Scientific Committee 2001). *Hibbertia superans* has been recorded in three Sydney Basin Bioregion threatened ecological communities, Sydney Turpentine-Ironbark Forest and Duffy's Forest Ecological Community. It had also been recorded close to but not in the mapped distribution of Shale Sandstone Transition Forest (DPE Threatened Ecological Communities for Greater Sydney spatial layer).

Flowers first appear from resprouting material about two years after fire (DPE 2022b). The time to first flowering of seedlings is unknown. The fruit is dehiscent, and the seed has a fleshy aril which encourages ant dispersal (Benson and MacDougall 1995). The

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average lifespan of another species of *Hibbertia*, *H. tenuis* is estimated to be 10–20 years (TSSC 2010) and this estimate is used in this *H. superans* assessment as it is consistent with the large declines in individuals recorded 20 years after fire. Using this information, the generation time for *H. superans* is inferred to be 7-12 years, with three generations being 21-36 years.

The germination requirements of *Hibbertia* species are complex and vary between species. Seed dormancy is imposed by the seed coat as well as by the embryo (Hidayati *et al.* 2012; Ralph 2011). In many *Hibbertia* species germination is increased by scarification and/or smoke water (Allan *et al.* 2004; Dixon *et al.* 1995; Schatral 1996; Schatral *et al.* 1997). Variation in dormancy length among individual seeds may result in naturally staggered germination over several years (Hidayati *et al.* 2012; Ralph 2011; Schatral *et al.* 1997). The longevity of *H. superans* seeds in the seedbank is unknown, however *Hibbertia* species are thought to have a persistent seedbank (Cuneo *et al.* 2018; TSSC 2016).

Fire Ecology

Hibbertia superans is a facultative seeder that is well-adapted to repeated fire in the landscape. It recovers well after fire mostly from re-growth from rootstock (James 2012). Seed germination may require high fire intensity (James 2012), as it does in the small, rare western Sydney *Hibbertia spanantha* (Toelken and Robinson 2015). Populations fluctuate with large numbers recorded 2-4 years after fire and falling as vegetation increases in height and density (James 2012).

In the absence of fire, the low, spreading *H. superans* is outcompeted by taller and larger understory shrub and trees species such as *Pittosporum undulatum*, *Allocasuarina littoralis*, *Kunzea ambigua*, *Syncarpia glomulifera* (Miller 2022). In long-unburnt sites, a dense detritus layer comprised of leaf litter, fallen branches and twigs smothers *H. superans* and suppresses seedling germination (Miller 2022). Dense, long unburnt vegetation becomes unsuitable habitat for *H. superans* and if a no-fire regime is maintained the species is unlikely to persist in an area, or if it has disappeared, is unlikely to recover as the seed bank, while persistent, has a limited lifespan (Miller 2022).

High frequency fire is unlikely to be a threat to this species, even with climate change forecasts of increasing fire frequency and severity (Abatzoglou *et al.* 2019; Bowman *et al.* 2020; Jones *et al.* 2022) as the majority *H. superans* sites are long unburnt and likely to remain as such given proximity to residential and rural residential areas. The recommended fire interval is not less than seven years (NSW Rural Fire Service 2013). Evidence that the seedbank of *H. superans* can survive more than one fire is found at Kenthurst Park site on the corner of Roughly Road and Griffin Place where 31 plants were found in 2007 after the site burnt twice in the 2002-2003 fire season (Miller 2022).

Pollination, seed dispersal and gene flow

Hibbertia spp. have been reported to be pollinated by native bees, honeybees *Apis mellifera*, pollen-seeking "hoverflies", and pollen consuming beetles (Armstrong 1979; Tucker & Bernhardt 2000). *Hibbertia superans* has zygomorphic flowers, where the stamens are aggregated in one side of the flower, and it is thought that native bees

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are the most effective pollinators of such flowers (Tucker and Bernhardt 2000). Honeybees have the potential to pollinate over long distances, up to 12 km, however, mostly forage closer to a hive, influenced by the locations of suitable foraging patches (Beekman and Ratnieks 2001). Native bees forage over much shorter distances. A study of three native bees found them to forage up to 700 m from the hive (Smith *et al.* 2016). However, native bee may be able to pollinate over longer distances as a review of studies of foraging distance of 62 bee species found that body size predicts foraging distance and the largest bees foraged over more than 1 km distance (Greenleaf *et al.* 2007). Beetles have the potential to pollinate over hundreds of metres to many kilometres (Hedin *et al.* 2007; Hodek *et al.* 1993; Rink and Sinch 2006).

The seeds of *Hibbertia* are thought to be dispersed by physical forces of wind and water and ants which are attracted to the fleshy aril (Rice and Westoby 1981). In sclerophyll vegetation near Sydney, ants have been found to disperse seeds between mostly less than 2m and rarely over 4 m (Westoby *et al.* 1991). If ants and physical forces are the dispersal agents for this species, then it is highly unlikely that seeds are transported far from any cluster of individuals.

Subpopulations

There are eleven subpopulations of *H. superans* based on a geographic separation of >2.5 km between clusters of occurrences, which restricts gene flow from either pollination or seed dispersal (Table 1). Based on the potential pollination distances of honeybees, all *H. superans* occurrences would be a single subpopulation. However, the geographic pattern of *H. superans* occurrences consists of clusters of sites located within around 2.5 km of each other and separated from other clusters of sites by greater distances of cleared and developed land. Cleared and developed land is likely to act as an effective barrier to all but extremely rare episodes of genetic exchange, which defines a subpopulation in the IUCN Guidelines (2022). Native bees, which are considered the most effective pollinator of zygomorphic *Hibbertia* species forage over much shorter distances than honeybees, 700 m to over 1000 m (Greenleaf *et al.* 2007; Smith *et al.* 2016), which is likely to make effective pollination distance within a couple of kilometres rather than in the order of up to 10 km. The largest subpopulation by far is located in northwest Sydney from Castle Hill to Glenorie, encompassing over 30 sites. All other subpopulations are very small. The three Blue Mountains sites are separated by 5-7 kms of national park land and if unknown occurrences of *H. superans* exist, then the lower mountain occurrences could be one or two subpopulations.

Table 1. *Hibbertia superans* subpopulations

Area
Castle Hill to Glenorie
Maroota 1
Maroota 2
Maroota 3
North Rocks and Baulkham Hills
Berowra Valley
Ku-Ring-Gai Chase NP
Falconbridge
Winmalee
Mount Riverview

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Threats

Hibbertia superans is threatened by vegetation clearing for residential and rural residential development, low frequency fire, habitat degradation from human activity, competition from weeds and disease (Miller 2022; NSW Scientific Committee 2001)

Vegetation clearing for residential and rural residential development

Hibbertia superans has been severely impacted by residential and rural residential development over the last few decades with most of its ridgetop habitat now developed (Miller 2022). The small remaining bushland habitat areas that have not been cleared for development face many pressures as a result of adjacent development and substantial human activity. "Clearing of Native Vegetation" is listed as a key threatening process under the BC Act.

Many old records from northwest Sydney suburbs are now located under housing developments. In recent years, a housing development adjacent to Cattai Creek, on Heath Rd and Saltwater Crescent, cleared 289 of 479 individuals (61%), once the largest known stand of *H. superans*. Similarly on Cattai Creek, at Cattai Creek Drive, an approved housing developed is planned to clear 77 of 277 individuals in the near future. At Kenthurst Park, the Hills Shire is currently upgrading facilities in the southern portion of the park, which may impact *H. superans*. Other proposed developments in Ellerman Park, Belrose and Maroota may impact on small stands of this species.

Low frequency fire

Long term absence of fire at *H. superans* sites is inferred to be a major cause of decline (Miller 2022). Most of the largest recorded patches of *H. superans* are long unburnt (18 – 20+ years) and large declines in number of individuals (40-95%) have been recorded since the previous fire. This includes sites at Cattai Creek Drive, Bill Woods Reserve, Cadwell Road, Porters Road, Clarke Road, Millars Road and Kemp Place, Robson Road and Bannerman Road. "Fire regimes that cause declines in biodiversity" is listed as a Key Threatening Process under the EPBC Act.

At long unburnt bushland sites in the Sydney Basin the native vegetation becomes denser and taller, outcompeting the low, spreading *H. superans* and suppressing seedling germination (Miller 2022). Without fire to break seed dormancy and open up the understory to allow seedlings to grow and mature, *H. superans* is unlikely to be able to persist and recolonise these sites. Where *H. superans* sites are on private land or in reserves surrounded by urban development, hazard reduction burning is logistically difficult and seldom conducted. Wildfire risk is low. Isolation of bushland remnants in the greater Sydney area prevent species migrating to adjacent areas where a different disturbance regime may provide suitable habitat. In Sydney peri-urban bushland remnants plant species diversity driven by shrub species richness has been found to increase with fire frequency (Pendall *et al.* 2022) or mature understory clearing (V. O'Donovan pers. comm. 12 December 2022).

While the maturation of the bush is a natural landscape process, with larger shrubs often outcompeting smaller ground covering plants like *H. superans* as plants age, long-term absence of fire in the Sydney Basin bushland is likely a relatively recent

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phenomenon because of fragmentation and isolation of remnants from increasing urbanisation. Traditional Owners used fire to manage the landscape of the Sydney Basin for thousands of years and are likely responsible for an elevated fire frequency in this landscape (Black *et al.* 2007; Mooney *et al.* 2007). The historic peak fire frequency was about eight episodes per century (Mooney *et al.* 2007). No apparent change in fire history occurred during the transition between Aboriginal custodianship and the European occupation of Australia until the latter part of the 20th century, when the fire frequency and intensity/severity dramatically increased in some areas because of anthropogenic climate change in combination with changing land use (Constantine 2022) and in other areas has declined as a result of fragmentation.

The recommended maximum fire interval for *H. superans* is 25 years (DPE 2022b), however the declines recorded for *H. superans* at sites burnt 18-20 years ago suggest that a shorter maximum fire interval is needed to prevent larger native shrub and tree species outcompeting this species.

Habitat degradation from human activities.

The proximity of the majority of *H. superans* sites to residential suburbs and rural-residential properties has resulted in human activities impacting the species' habitat in many ways, including by rubbish dumping, weed invasion, property maintenance, nitrification from urban runoff, road and utility easement maintenance and high levels of recreation use (Miller 2022; E Roper pers. comm. February 2023).

During 2022 surveys, household rubbish and domestic garden waste was observed dumped at *H. superans* sites, including Porters Road, Clarke Road, Bannerman Road and Kenthurst Park (Miller 2022). The dumped refuse included lawn clippings and large quantities of the invasive weed African Lovegrass *Eragrostis curvula* (Miller 2022).

Road works and adjacent vegetation management is an ongoing inferred threat to *H. superans* habitat on roadsides and utility easements. Road works and associated vegetation clearing at the Renown Road site, a narrow strip of land between a wire safety fence and a road cutting, could potentially removal of the entire population (Miller 2022). At the corner of Miller Rd and Kemp Place, roadside maintenance and electricity easement works periodically impact the remnant roadside vegetation (Miller 2022).

Hibbertia superans habitat adjoining private land has been observed to be variously managed by property owners with some areas modified to lawn, frequently under-scrubbed, or retained but semi-modified (Miller 2022). This has been observed adjacent to Bill Woods Reserve and at the site at the corner of Miller Road and Kemp Place (Miller 2022).

Hibbertia superans bushland sites that are public land adjacent to residential and some rural-residential areas are impacted by high levels of foot and bike traffic (Erin Roper pers. comm. February 2023). These impacts are probably the highest in the two largest remaining clusters of *H. superans* adjacent to Cattai Creek, at Neich Road and also Bill Woods Reserve. These impacts will only increase with the continued development of land and ever-growing Sydney population.

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The Hawkesbury Sandstone soils of Sydney are naturally low in nutrients and the native flora, which is well adapted to growing in these soils, can be adversely affected when exposed to higher concentrations of nutrients from urban stormwater run-off and other sources (Thomson and Leishman 2004). Increases in soil nutrients in urban bushland are associated with the presence of exotic species and the decline in the diversity of native species, with the survival of native plants decreased with increasing nutrient concentrations (Thomson and Leishman 2004). Run off from adjacent land can transport weed species into bushland (Miller 2022). At the Kenthurst Park site, nitrification from run off from the adjacent sports oval has altered the vegetation structure favouring species such as Black She-Oak, which creates a thick ground layer of needles and dead branches that suppress ground covering vegetation (Miller 2022). At the Bannerman Road site nitrification of the soil has occurred from intensive horticulture use of adjacent land. The Millers Road site has been compromised through residential nitrified runoff, subsequent weed invasion and slashing of vegetations. At the Renown Rd site, *H. superans* habitat is affected from runoff from adjacent council nursery and sports reserve.

Competition from weeds

With the majority of occurrences of *H. superans* adjacent to or on residential or rural residential land, competition from weeds, especially garden escapes, is an inferred, ongoing threat to *H. superans*. Weeds outcompete individual plants and degrade habitat. The Renown Road site is chronically infested with garden escapes including Honeysuckle, Asparagus Fern and Freesias from the adjacent Bidjiwong Community Nursery, reserve, Baulkham Hills Sports Club and residences that adjoin the reserve (Miller 2022). Of concern at the Bill Woods Reserve site is the invasion of vigorous grass species, over time, such as African Lovegrass, Whiskey Grass, *Ehrharta erecta*, turf species such as Kikuyu, Couch and Buffalo and also *Aristea ecklonii*. Nitrification of soil from high levels of dog traffic along edges of tracks increases the further probability of weed invasion (Miller 2022). At Millers Road weed blooms were observed spilling downslope and dead plants were frequent. At Kenthurst Park, *Sollya heterophylla* is well established.

Disease

Phytophthora cinnamomi is an inferred, ongoing threat to *H. superans*, because it affects other *Hibbertia* species (McDougall et al 2005; Wan et al. 2019; Weste and Ashton 1994). *Hibbertia stricta* from south-eastern Queensland and *H. amplexicaulis* from western Australia are known to be highly susceptible to *Phytophthora* (McDougall et al. 2005; Weste 1994). The rare western Sydney *H. spanantha* was found to be of intermediate susceptibility (Wan et al. 2019). *Phytophthora cinnamomi* was suspected to be present at the Clarke Rd site with a number of the *Xanthorrhoea* plants showing the classic symptoms and other small shrubs found dead nearby (Miller 2022). Given the location of *H. superans* sites within and adjacent to the urban environment, it is likely that *P. cinnamomi* is also present at other sites. 'Infection of native plants by *Phytophthora cinnamomi*' is listed as a Key Threatening Process on the BC Act.

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Assessment against IUCN Red List criteria

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

Criterion A *Population Size reduction*

Assessment Outcome: Critically Endangered A2bc+A4bc.

Justification: *Hibbertia superans* has undergone a very large reduction in population size since the late 1990s and early 2000s. The generation time for *H. superans* is inferred to be 7-12 years or three generations 21-36 years. Population trend data is available for 92% (at 16 sites) of the population of *H. superans* recorded in the late 1990s and early 2000s (3,380 mature individuals at 45 sites). From this large subset of the population (3,092 mature individuals), there has been a 77% decline in 2-3 generations to 722 mature individuals as a result of land clearing for residential and rural-residential development, low fire frequency and human disturbance. The population trajectory of the other 8% of the population (280 individuals) is unknown but is inferred to have experienced a similar decline on the basis of known or likely active threats. A population decline of 77% meets Criterion for A2 for Endangered and is very close to the threshold for Critically Endangered of >80% decline. However, given that the decline of the remaining 8% of the population is unknown and IUCN Guideline (2022) suggest taking a precautionary approach to selecting threat levels then *H. superans* is likely to meet Criterion A2 for Critically Endangered. The decline in populations of *H. superans* is projected to continue with residential and rural residential development applications that have found *H. superans* on site both approved and in progress. At least 100 mature individuals are identified to be cleared for development in the near future, which equates to total reduction in population size of 80% since the late 1990s and early 2000s which meets the threshold for A4 for Critically Endangered.

Criterion B *Geographic range*

Assessment Outcome: Endangered B1ab(ii)(iii)(v) + B2ab(ii)(iii)(v)

Justification: The Extent of Occurrence (EOO) is 1,427 km² and the Area of Occupancy (AOO) is 160 km². 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 AOO is based on 2 x 2 km grid cells, the scale recommended for assessing area of occupancy by IUCN (2022). *Hibbertia superans* meets the Endangered threshold for EOO (<5,000 km²) and the Endangered threshold for AOO (<500 km²).

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: *Hibbertia superans* is severely fragmented.

Justification: The number of threat-defined locations for the two most serious plausible threats to *H. superans*, vegetation clearing for development and low fire frequency is greater than 10. The IUCN Guidelines (2022) state that

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“Where the most serious plausible threat is habitat loss that occurs gradually and cumulatively via many small-scale events, such as clearance of small areas for small-holder grazing, a location can be defined by the area over which the population will be eliminated or severely reduced within a single generation or three years, whichever is longer.” There are 28 recorded sites of *H. superans* on private land or part on private land and these make a single location. There are an additional six locations that are at threat of vegetation clearing, two are on Aboriginal Land Council Land, four on unreserved crown land. The threat of vegetation clearing does not apply to six sites in Council or Crown Reserves or to four sites on NPWS reserve and another method must be used to determine the number of locations. *Hibbertia superans* on the Crown and Council Reserves are threatened by low fire frequency and could be considered an additional six locations. The sites on NPWS land do not have any active threats (low fire frequency is unlikely to be a threat as park fire management regimes maintain periodic burning) and the number of subpopulations may be used as the number of locations, in this case four.

The threat of low frequency fire is present at 18 sites where the known time since fire is greater than 20 years. A further 22 sites have no recorded fire history, which does not necessarily mean that they have not burnt as records are incomplete. However, their proximity to urban and peri-urban areas suggests that they are unlikely to have burnt in the last 20 years. Three sites burnt 13 years ago, one site burnt 10 years ago, and one site burnt 4 years ago. If low fire frequency is used to determine locations, then the number is likely to be greater than 10, even though all current long unburnt sites could be considered one location. According to the IUCN Guidelines (2022) the time frame that is relevant to define a location is within one generation and in this time a small number of *H. superans* sites may burn from hazard reduction, wildfire or cultural burning, increasing the number of locations from one to a many. The IUCN guidelines (2022) state that "Where the most serious plausible threat is...fire...locations may be defined by the predicted extent of fire paths". In the case of *H. superans* fire extent is likely to be site specific as sites are isolated and fragmented in the urban and peri-urban landscape. In addition, the sites on NPWS land, which are not threatened by low frequency fire, add four locations based on the number of subpopulations.

Hibbertia superans is severely fragmented because >50% of the total AOO consists of stands of the species that are considered unviable, the definition required by the IUCN Guidelines (2022) for a species to be severely fragmented. 128 km² (80%) of the remaining AOO of *H. superans* contain stands of 12 or less individuals which is considered unviable.

- 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: Subcriterion met for (ii), (iii) and (v)

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Justification: *Hibbertia superans* has an estimated, inferred and projected continuing decline in AOO, habitat quality and mature individuals from vegetation clearing for residential and rural residential development, low frequency fire, habitat degradation from human activities and competition from weeds. There is no evidence that any of the current threats to this species are being managed for this species. There are multiple Development Applications approved and in progress that have recorded *H. superans* (DPE 2022a). Where *H. superans* sites are on private land or in reserves surrounded by urban development, hazard reduction burning is logistically difficult and seldom conducted and wildfire risk is low. There is no targeted weed or human impact management for this species at any site. The risk of *P. cinnamomi* infection in at urban and peri-urban sites is ever-present.

c) Extreme fluctuations.

Assessment Outcome: Data deficient

Justification: There are insufficient data to assess against this Subcriterion.

Criterion C Small population size and decline

Assessment Outcome: Endangered C1

Justification: The estimate for the number of mature individuals is approximately 750, which meets the threshold for Endangered. There is an estimated and projected continuing decline of at least 20% in two generations and an estimated and projected continuing decline in number of mature individuals from vegetation clearing for residential and rural residential development, low frequency fire, habitat degradation from human activities and competition from weeds.

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: Subcriterion met at Endangered

Justification: The generation time for *H. superans* is inferred to be 7-12 years or two generations 14-24 years. It is known that 92% of the population (3,092 mature individuals at 16 sites) declined by 77% from the late 1990s and early 2000s to 2022 which meets the upper bound for the generation time estimate for *H. superans*. The level of decline in this timeframe is well above the 20% threshold needed for an Endangered outcome. At further sites, 100 individuals have been identified as approved or planned to be cleared for development in the near future. Given the very large population decline estimated over two generations, it is possible that the species also meets the threshold for Critically Endangered (25% decline in 1 generation). However, the approximate two generation time interval between most data points available to measure population size trend means that the timing of decline over one generation is unknown at most sites and for this reason the Subcriterion has not been assessed as Critically Endangered.

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

Assessment Outcome: Subcriterion met at Vulnerable

Justification: *Hibbertia superans* has an estimated, inferred and projected continuing decline in AOO, habitat quality and mature individuals from vegetation clearing for residential and rural residential development, low frequency fire, habitat degradation from human activities and competition from weeds. The number of mature individuals in each subpopulation is less than 1000 but greater than 250, which meets the threshold for Vulnerable.

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: Subcriterion met for Vulnerable

Justification: The number of mature individuals in the largest subpopulation is 670+, located in northwest Sydney from Castle Hill to Glenorie which is ≤ 1000 but greater than 250, which meets the threshold for Vulnerable.

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

Assessment Outcome: Subcriterion not met

Justification: The largest subpopulation in northwest Sydney from Castle Hill to Glenorie contains 90% of the mature individuals which does not meet the thresholds for Endangered or Vulnerable

- b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Data deficient

Justification: There are insufficient data to assess against this Subcriterion.

Criterion D Very small or restricted population

Assessment Outcome: Vulnerable D1

Justification: The number of mature individuals is estimated to be approximately 750 which meets 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: Subcriterion met for Vulnerable

Justification: The number of mature individuals is estimated to be approximately 750 which meets the threshold for Vulnerable.

- D2. Restricted area of occupancy (typically < 20 km²) 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.

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Assessment Outcome: Subcriterion not met.

Justification: The AOO for *H. superans* is 160 km² and it has >10 locations which does not meet the threshold for this Subcriterion. There is no plausible future threat that could drive this taxon to extinction in a very short time.

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification:

Conservation and Management Actions

Hibbertia superans is currently listed on the NSW BC Act 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. *Hibbertia superans* sits within the Site-managed species stream of the SoS program and the conservation project can be viewed here: <https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10403>.

References

- Abatzoglou JT, Williams AP, Barbero R (2019) Global emergence of anthropogenic climate change in fire weather indices. *Geophysical Research Letters* **46**, 326–336.
- Allan SM, Adkins SW, Preston CA & Bellairs SM (2004) Improved germination of the Australian natives: *Hibbertia commutata*, *Hibbertia amplexicaulis* (Dilleniaceae), *Chameascilla corymbosa* (Liliaceae), and *Leucopogon nutans* (Epacridaceae). *Australian Journal of Botany*, **44**, 213–222.
- ArcGISOnline (2022) Imagery Best Available_World. DPE spatial layer.
- Armstrong JA (1979) Biotic pollination mechanisms in the Australian flora – a review. *New Zealand Journal of Botany*, **17**, 467–508.
- Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) (2022) 'Map of Indigenous Australia,' available at: <https://aiatsis.gov.au/explore/map-indigenous-australia> [Verified 01 September 2022].
- Bachman S, Moat J, Hill AW, de la Torre J, Scott B (2011) Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool, in Smith V & Penev L (eds) e-Infrastructures for data publishing in biodiversity science. *ZooKeys* **150**, 117–126. (Version BETA)
- Beekman M, Ratnieks FLW (2000) Long-range foraging by the Honey-bee, *Apis mellifera* L. *Functional Ecology*, **14(4)**, 490–496.
- Benson D, MacDougall L (1995) Ecology of Sydney plant species. Part 3: Dicotyledon families Cabombaceae to Eupomatiaceae. *Cunninghamia* **4(2)**: 143-431
- 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.

NSW Threatened Species Scientific Committee

- Bowman DM, Kolden CA, Abatzoglou JT, Johnston FH, van der Werf GR, Flannigan M (2020) Vegetation fires in the Anthropocene. *Nature Reviews Earth & Environment* **1(10)**, 500–515.
- Black MP, Mooney SD, Haberle SG (2007) The fire, human and climate nexus in the Sydney Basin, eastern Australia. *The Holocene*, **17(4)**, 469–480.
- 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.
- Constantine IV (2022) *Getting more, and less from charcoal: A reconstruction of the fire histories of two lakes in the Sydney Basin, south-eastern Australia, using FTIR spectroscopy and chemometrics* (Doctoral dissertation, UNSW Sydney).
- Cuneo P, Emery N, Errington G, Sherieff A (2018) Assisted run (a) way: translocation planning to secure the Bankstown *Hibbertia*. *Australasian Plant Conservation: Journal of the Australian Network for Plant Conservation*, **27(1)**, 23–25.
- Department of Planning and Environment (2022a) Survey Records (*Hibbertia superans*)[dataset]. BAM Assessment data, exported 15 September 2022.
- DPE (2022b) *Hibbertia superans* – profile. Available at: <https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10403#:~:text=Description,%2C%207.5%20%2D%2010%20mm%20long> (accessed on 23 Jan 2023)
- Dixon KW, Roche S, Pate JS (1995) The promotive effect of smoke derived from burnt native vegetation on seed germination of Western Australian plants. *Oecologia*, **101**, 185–192.
- Greenleaf SS, Williams NM, Winfree R, Kremen C (2007) Bee foraging ranges and their relationship to body size. *Oecologia* **153(3)**, 589–596.
- Hedin J, Ranius, Nilsson SG, Smith HG (2008) Restricted dispersal in a flying beetle assessed by telemetry. *Biodiversity and Conservation*, **17(3)**, 675–684.
- Hidayati SN, Walck JL, Merritt DJ, Turner SR, Turner DW, Dixon KW (2012) Sympatric species of *Hibbertia* (Dilleniaceae) vary in dormancy break and germination requirements: implications for classifying morphophysiological dormancy in Mediterranean biomes. *Annals of botany*, **109(6)**, 1111–1123.
- Hodek I, Ipert GAEL, Hodkova M (1993) Long-distance flights in Coccinellidae (Coleoptera). *European Journal of Entomology*, **90(4)**, 403–414.
- IUCN Standards and Petitions Subcommittee (2022) Guidelines for Using the IUCN Red List Categories and Criteria, Available at: <http://www.iucnredlist.org/documents/RedListGuidelines.pdf> (accessed on 25 May 2022)
- James T (2012) Threatened Species Management Plan for a significant area along Paulls Road, South Maroota (Hills Shire Council)
- Jones MW, Abatzoglou JT, Veraverbeke S, Andela N, Lasslop G, Forkel M, Smith A JP, Burton C, Betts RA, Werf GR, Sitch S, Canadell JG, Santín C, Kolden C, Doerr SH, Le Quéré, C (2022) Global and regional trends and drivers of fire under climate change. *Reviews of Geophysics*, <https://doi.org/10.1029/2020rg000726>
-

NSW Threatened Species Scientific Committee

- McDougall KL (2005) The responses of native Australian plant species to *Phytophthora cinnamomi*. Appendix 4. In 'Management of *Phytophthora cinnamomi* for biodiversity conservation in Australia: Part 2. National best practice'. (Eds E O'Gara, K Howard, B Wilson, GEstJ Hardy) (Department of the Environment and Heritage: Canberra). Available at: <https://environment.gov.au/system/files/resources/23925ac2-8fda-4036-aa56-5451f5d8b06d/files/part2.pdf> (accessed 16 December 2022)
- Miller R (2022) Key sites survey for *Hibbertia superans* in north-west Sydney, NSW. Cumberland Flora and Fauna Interpretive Services.
- Mooney SD, Webb M, Attenbrow V (2007) A comparison of charcoal and archaeological information to address the influences on Holocene fire activity in the Sydney Basin. *Australian Geographer*, **38(2)**, 177–194.
- NSW Scientific Committee (2001) *Hibbertia superans* (a low spreading shrub) – endangered species listing. Available at: <https://www.environment.nsw.gov.au/Topics/Animals-and-plants/Threatened-species/NSW-Threatened-Species-Scientific-Committee/Determinations/Final-determinations/2000-2003/Hibbertia-superans-a-low-spreading-shrub-endangered-species-listing> (accessed 19 December 2022)
- NSW Rural Fire Service (2013) Threatened Species Hazard Reduction List – Part 1-Plants. Available at: https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0017/24335/Web-Version-ThreatenedSpeciesHazardReductionList-Part1-Plants-06-04-2017.pdf
- Packer J, Brouwer N, Harrington D, Gaikwad J, Heron R, Yaegl Community Elders, Ranganathan S, Vemulpad S, Jamie J (2012) An ethnobotanical study of medicinal plants used by the Yaegl Aboriginal community in northern New South Wales, Australia. *Journal of ethnopharmacology*, **139(1)**, 244–255.
- Pendall E, Hewitt A, Boer MM, Carrillo Y, Glenn NF, Griebel A, Steenbeeke GL (2022) Remarkable Resilience of Forest Structure and Biodiversity Following Fire in the Peri-Urban Bushland of Sydney, Australia. *Climate*, **10(6)**, 86.
- PlanetNET (2022a) New South Wales Flora Online page for *Hibbertia incana*. Available at: <https://plantnet.rbg Syd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Hibbertia~crinita> (accessed 19 December 2022)
- PlanetNET (2022b) New South Wales Flora Online page for *Hibbertia superans*. Available at: <https://plantnet.rbg Syd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Hibbertia~superans> (accessed 19 December 2022)
- Ralph M (2011) Growing Australian native plants from seed (2nd ed.). (Bloomings Books, Australia.)
- Rice B, Westoby M (1981) Myrmecochory in sclerophyll vegetation of the West Head, New South Wales. *Australian Journal of Ecology*, **6(3)**, 291–298.
- Schatral A (1996) Dormancy in seeds of *Hibbertia hypericoides* (Dilleniaceae). *Australian Journal of Botany*, **44**, 213–222.

NSW Threatened Species Scientific Committee

- Schatral A, Osborne JM, Fox JED (1997) Dormancy in seeds of *Hibbertia cuneiformis* and *H. huegelii* (Dilleniaceae). *Australian Journal of Botany*, **45**, 1045–1053.
- Smith JP, Heard TA, Beekman M, Gloag R (2017) Flight range of the Australian stingless bee *Tetragonula carbonaria* (Hymenoptera: Apidae). *Austral Entomology*, **56(1)**, 50–53.
- Thomson VP, Leishman MR (2004) Survival of native plants of Hawkesbury Sandstone communities with additional nutrients: effect of plant age and habitat. *Australian Journal of Botany* **52**, 141–147.
- Toelken H (2000). Notes on *Hibbertia* (Dilleniaceae) 3. *H. sericea* and associated species. *Journal of the Adelaide Botanic Gardens*, **19**, 1–53.
- Toelken HR, Robinson AF (2015) Notes on *Hibbertia* (Dilleniaceae) 11. *Hibbertia spanantha*, a new species from the central coast of New South Wales. *Journal of the Adelaide Botanic Gardens*, 11–14.
- Threatened Species Scientific Committee (TSSC) (2010) Commonwealth Listing Advice on *Hibbertia tenuis*. Department of the Environment, Water, Heritage and the Arts. Canberra, ACT: Department of the Environment, Water, Heritage and the Arts. Available from:
<http://www.environment.gov.au/biodiversity/threatened/species/pubs/76189-listing-advice.pdf>. In effect under the EPBC Act from 19-Aug-2010.
- TSSC (2016) Conservation Advice *Hibbertia spanantha* Julian's *hibbertia*
<http://www.environment.gov.au/biodiversity/threatened/species/pubs/88475-conservation-advice-07122016.pdf>
- Tucker SC, Bernhardt P (2000) Floral ontogeny, pattern formation, and evolution in *Hibbertia* and *Adrastaea* (Dilleniaceae). *American Journal of Botany*, **87(12)**, 1915–1936.
- Wan JS, McDougall KL, Liew EC (2019) The susceptibility of rare and threatened NSW species to the root-rot pathogen *Phytophthora cinnamomi*: 1. Initial testing and identification of key research questions. *Australian Journal of Botany*, **67(7)**, 510–516.
- Weste G, Ashton DH (1994) Regeneration and survival of indigenous dry sclerophyll species in the Brisbane Ranges, Victoria, after a *Phytophthora cinnamomi* epidemic. *Australian Journal of Botany*, **42(2)**, 239–253.
- Westoby M, French K, Hughes L, Rice B, Rodgerson L (1991) Why do more plant species use ants for dispersal on infertile compared with fertile soils? *Australian Journal of Ecology*, **16(4)**, 445–455.
- WSP (2020) Lot 151 DP1007387 – Cattai Creek Drive, Kellyville. Biodiversity Development Assessment Report

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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:

Hibbertia superans was found to be **Critically Endangered** under Clause 4.2(a)(b)(c)

Clause 4.2 – Reduction in population size of species

(Equivalent to IUCN criterion A)

Assessment Outcome: **Critically Endangered** under Clause 4.2(a)(b)(c)

(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 4.3(b)(d)(e)(i)(ii)(iii)

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,

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	(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: Endangered under (b)(d)(ii)

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.

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Clause 4.5 - Low total numbers of mature individuals of species (Equivalent to IUCN criterion D)

Assessment Outcome: Vulnerable under Clause 4.5(c)

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: Clause 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.
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