

NSW Threatened Species Scientific Committee

Conservation Assessment of *Astrotricha* sp. Wallagaraugh (R.O.Makinson 1228) NSW Herbarium (Araliaceae)

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***Astrotricha* sp. Wallagaraugh (R.O.Makinson 1228) NSW Herbarium (Araliaceae)**

Distribution: New South Wales, Victoria

Current EPBC Act Status: Not listed

Current NSW BC Act Status: Endangered

Current Victorian Flora and Fauna Guarantee Act 1988 Status (as *Astrotricha* sp. 5, Wallagaraugh Star-hair): Critically Endangered

Proposed listing on NSW BC Act: Endangered

No change to listing.

Summary of Conservation Assessment

Astrotricha sp. Wallagaraugh (R.O.Makinson 1228) NSW Herbarium was found to be eligible for listing as Endangered under IUCN Criteria B1ab(iii)+B2ab(iii).

The main reasons for this species being eligible are: i) it has a highly restricted geographical range (EOO of 1515 km² and AOO of 72 km²); ii) it occurs at four threat-defined locations; and iii) there is continuing decline in area, extent, and quality of habitat due to threats from vegetation clearing for residential and other development, adverse fire regimes, and weeds, pests or pathogens.

Description and Taxonomy

Astrotricha sp. Wallagaraugh (R.O.Makinson 1228) NSW Herbarium (Merimbula Star-hair, Wallagaraugh Star-hair) (hereafter referred to as *Astrotricha* sp. Wallagaraugh) is described as “An inconspicuous small single- or multi-stemmed shrub up to 1 m (rarely to 1.8 m) tall, stems more or less erect; branchlets, leaf undersurfaces, and inflorescence axes covered with small stellate hairs. Leaves spreading, linear or sometimes broadening a little near the rounded tip, 20–40 mm long (to 60 mm in juveniles) and 1.5–2 mm wide; leaf upper surface convex with conspicuous short wrinkles, these often each capped with a small asperity, leaf margin recurved; leaf lower surface densely packed with stellate hairs. Inflorescence a loose compound panicle 30–100 (rarely 200) mm long, made up of pedunculate (stalked) umbels; petals 5, pale green, those of the terminal umbel slightly darker; stamens 5, soon falling. Fruit a laterally compressed obovoid schizocarp 3–3.5 mm long, c. 3 mm wide.” (PlantNET 2023; Figs 1 and 2).

Astrotricha sp. Wallagaraugh was first recognised under the interim Victorian name *Astrotricha* sp. 5 (Henwood *et al.* 1999) as part of an ongoing revision of *Astrotricha* by Henwood and Makinson. Henwood and Makinson (1992) had previously included *A.* sp. Wallagaraugh in a broadly defined *A. linearis* A.Cunn. ex Benth. A recent unpublished molecular study by R. Dimon supported recognition of *A.* sp. Wallagaraugh as discrete from *A. linearis* and found that *A.* sp. Wallagaraugh is most closely related to *Astrotricha* sp. Deua (R.O.Makinson 1647) NSW Herbarium (R. Dimon, pers. com. 10 July 2023).



Fig. 1: *Astrotricha* sp. Wallagaraugh, closeup of inflorescence. Image: Laura Canackle/ DPE.

Astrotricha sp. Wallagaraugh has also been referred to as *Astrotricha* sp. Wallagaraugh River (N.G.Walsh 3149) Vic. Herbarium, and as both *Astrotricha* sp. 'Wallagaraugh' and *Astrotricha* sp. B in Keith *et al.* (1999: pp. 247 and 270) (APC 2023).



Fig. 2: *Astrotricha* sp. Wallagaraugh, showing habit. Image: Laura Canackle/ DPE.

Astrotricha sp. Wallagaraugh can be distinguished from both *A.* sp. Deua (R.O.Makinson 1647) and *A. linearis* by its upper leaf surface with conspicuous short wrinkles, each often capped with a small asperity (upper leaf surface completely smooth in *A.* sp. Deua (R.O.Makinson 1647) and without conspicuous wrinkles but with small densely and uniformly distributed granules in *A. linearis*) (NSW Scientific

NSW Threatened Species Scientific Committee

Committee 2007; VicFlora, 2023). In Victoria, sterile material of *A. sp. Wallagaraugh* might also be confused with *A. parvifolia* Wakef., but the fruit of *A. parvifolia* is locellate (divided into small cavities), whereas the fruit of *A. sp. Wallagaraugh* is not (VicFlora 2023). Other narrow-leaved species of *Astrotricha* that could potentially be confused with *A. sp. Wallagaraugh* are distinguished in Henwood *et al.* (1999) and on VicFlora (2023).

Distribution and Abundance

Astrotricha sp. Wallagaraugh is known to occur in New South Wales (NSW) and Victoria, on the traditional lands of the Yuin and Bidwell First Nations people (Horton 1996). All known occurrences are within the Southeast Corner IBRA Bioregion (SEWPaC 2012). In NSW, *A. sp. Wallagaraugh* is known from the upper reaches of the Wallagaraugh River (in Yambulla and Timbillica State Forests), from the Tura Beach–Merimbula region and adjacent areas of Bournda National Park (NP), and from a single collection near Stockyard Creek, approximately 3–4 km southwest of Rocky Hall. All known NSW occurrences are within the Bega Valley Shire Local Government Area. In Victoria, *A. sp. Wallagaraugh* (known in Victoria as *Astrotricha sp. 5*) is recorded from the catchment of the lower Wallagaraugh River, within Croajingolong NP in far north-east Gippsland.

There are five known subpopulations [as defined by IUCN (2022)] of *Astrotricha sp. Wallagaraugh* (Table 1). Seed of *Astrotricha sp. Wallagaraugh* is dispersed enclosed in mericarps which lack wings, spines or other obvious specialisations for dispersal (Henwood and Makinson 1992). Seed dispersal distances are, therefore, likely to be short, in the scale of metres, unless mericarps are transported by river or stream flow. *Astrotricha sp. Wallagaraugh* has been observed to be visited by a variety of insects, suggesting a generalist insect pollination strategy (Atlas of Life 2018). Insect-mediated pollen dispersal distances have been shown to vary significantly among sites, depending on multiple variables including distance to nearest neighbour, intervening land use, vegetation structure and floral richness, pollinator richness and abundance, and microclimatic variables (Evans *et al.* 2017; Butcher *et al.* 2020). However, it is generally true that the likelihood of effective pollen dispersal decreases with distance from the pollen donor (Butcher *et al.* 2020). Sites separated by 3 km or more are considered in this assessment to constitute separate subpopulations. An exception is two sites separated by approximately 4 km along the Wallagaraugh River in NSW, which are considered to comprise a single subpopulation because of the potential for mericarp dispersal along the river.

The Wallagaraugh River subpopulation occurs in Yambulla and Timbillica State Forests in NSW, with two main sites known. The first site occurs predominantly in Yambulla State Forest, from Newtons Crossing Camp extending south to the junction of the Wallagaraugh River with Allan Brook, and west approximately 700 m along Allan Brook. Occurrences along Allan Brook were newly recorded in 2022 surveys (Schlunke 2022). The second site is approximately 4 km south in Timbillica State Forest near the Weir trail crossing of the river. Additional searches in the Yambulla State Forest area, both along the Wallagaraugh River and Imlay Creek and further into the forest from these watercourses, failed to find any additional occurrences (Schlunke 2022).

Table 1: Subpopulations of *Astrotricha sp. Wallagaraugh*, with survey counts and estimates (total individuals¹)

NSW Threatened Species Scientific Committee

Subpopulation	Survey counts and estimates pre-2019-2020 fires	Survey counts and estimates post-2019-2022 fires
Wallagaraugh River (NSW)	276	3,776
Bournda-Merimbula (NSW)	3,938	15,082
Stockyard Creek (NSW)	2	unknown
Cape Horn (Vic.)	c. 200–300	c. 3000–5000
Fairhaven Link Track (Vic.)	c. 10	unknown
Total individuals	c. 4,500	c. 24,000

¹ Counts are for total individuals. Counts for mature individuals are not available.

The Bournda–Merimbula subpopulation extends from the south-east corner of Bournda NP approximately 6.5 km south to Middle Beach, Merimbula. Approximately 28% of individuals recorded in 2022–2023 surveys of this subpopulation were located within the national park, with the remainder occurring in Tura Beach and Merimbula. In Tura Beach and Merimbula, plants occur in small patches of council-owned land, Crown Land and coastal reserves, along Sapphire Coast Drive and the powerline easement east of Merimbula tip, and on private land (Schlunke 2022, 2023). Prior to the last determination (NSW Scientific Committee 2007), known occurrences in this subpopulation were confined to a 3 km stretch alongside Sapphire Coast Drive and a disjunct site in Bournda NP. Recent survey results (Schlunke 2022, 2023) show the currently known distribution to be more or less contiguous, although the site at Middle Beach, Merimbula is about 2 km from other known occurrences. In Bournda NP, plants had previously been recorded either side of Widgeram Rd, but 2022 surveys found plants extending further from the road than previously known (Schlunke 2022). New survey sites of nearby similar habitat in 2022 did not locate any other individuals. These sites were at Tura - Red Hill Road and tip, south side of Back Lagoon, Merimbula, Bournda NP north of Bournda Lagoon and Widgeram fire trail, and Beowa NP, Pambula region (Schlunke 2022).

A third NSW subpopulation, not previously noted by NSW Threatened Species Scientific Committee (2007), is recorded from a single 1990 collection (NSW249443) from Stockyard Creek (a tributary of the Towamba River) approximately 3–4 km southwest of Rocky Hall and approximately 40 km west southwest of the Bournda-Merimbula subpopulation. This specimen was previously identified as *Astrotricha linearis*; the re-identification as *Astrotricha* sp. Wallagaraugh has been confirmed by staff of the National Herbarium of New South Wales (P. Jobson *in litt.* 21 August 2023). The collection site was recorded as Coolangubra State Forest but now falls near the boundary of South East Forests NP, following gazetting of Coolangubra NP in 1994 and its amalgamation into South East Forests NP in 1997 (NPWS 2006). The geospatial coordinates and description are not sufficiently precise to determine whether the record falls within the national park or just outside the boundary. At the time of collection, only two plants were seen (K. Mills, collection notes in RBGDT 2023). It is not known whether this subpopulation has persisted, although persistence in the soil seedbank is possible even if no standing individuals remain.

In Victoria, *Astrotricha* sp. Wallagaraugh (known as *Astrotricha* sp. 5) is “restricted to the catchment of the Wallagaraugh River, and the Top Lake area of Mallacoota Inlet near Cape Horn” (VicFlora 2023), south and east of Gipsy Point in Croajingolong

NSW Threatened Species Scientific Committee

National Park. Victorian occurrences are approximately 20 km south of the NSW Wallagaraugh River subpopulation. Two subpopulations are known, one near Cape Horn, and the other approximately 3 km northeast along the Fairhaven Link Track.

Area of Occupancy and Extent of Occurrence

Astrotricha sp. Wallagaraugh has a highly restricted distribution, with an estimated Extent of Occurrence (EOO) of 1515 km² and an estimated Area of Occupancy (AOO) of 72 km². Both EOO and AOO were calculated from all mapped occurrences using GeoCAT software (Bachman *et al.* 2011). The Extent of Occurrence is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022). The Area of Occupancy is based on 2 x 2 km grid cells, the scale recommended for assessing Area of Occupancy by IUCN (2022). Mapped occurrences included all records from the National Herbarium of New South Wales collections database 7 August 2023, Atlas of Living Australia (ALA 2023) and NSW BioNET (2023), excluding duplicate (from the same gathering) herbarium records and geospatial errors and inaccuracies greater than 1 km. Approximate sites of excluded records were represented by other occurrences that were included in the mapped extent. No additional records were found in the Victorian Biodiversity Atlas (2023).

Population size estimates

Available survey data and estimates of *Astrotricha* sp. Wallagaraugh are given in Table 1. Data for NSW subpopulations are from BioNET (2023) and from surveys carried out for the Saving our Species project (Schlunke 2022, 2023). Comprehensive survey data is not available for NSW before 2019. However, counts from 2019 are similar to estimates by NSW Scientific Committee (2007) of “low numbers of plants” in the Wallagaraugh River subpopulation and “several thousand plants” in the Bournda-Merimbula subpopulation. Estimates for Victorian subpopulations are from comments in collection notes (ALA 2023). A BushBlitz survey of Croajingolong NP was conducted in 2016 (Commonwealth of Australia 2017), which recorded *A. sp.* Wallagaraugh at Cape Horn, but subpopulation sizes were not estimated because the focus of the BushBlitz survey was taxonomic discovery.

Recent higher and lower counts (where available) are here used to estimate a range for the total number of individuals of *Astrotricha* sp. Wallagaraugh of 4,500 to >24,000. Only counts and estimates for all individuals are available; number or proportions of mature individuals cannot be estimated with any reliability. For most subpopulations, these counts represent before fire and after fire numbers, and therefore provide an estimate of the natural fluctuation in total individuals over fire intervals, although increased survey effort in 2022 compared with earlier surveys also accounts for part of the increase in numbers (Schlunke 2022). There are several sources of inaccuracy in this estimated range. Firstly, because survey counts can underestimate numbers of plants, the true number of individuals may be higher than this range, but it is unlikely to be lower. Survey effort in Tura Beach and Merimbula was lower relative to area than for other NSW sites surveyed in 2022–2023 (Schlunke 2022), and thus survey counts for this area particularly underestimate numbers of plants. Secondly, data for Victorian subpopulations is taken from comments in collection notes (ALA 2023), and so, in the absence of targeted survey data, size of these subpopulations is very uncertain.

Ecology

Life history, population dynamics and fire response

Astrotricha sp. Wallagaraugh reproduces from seed, flowering from October to December. Observations of visitations to flowers of *A.* sp. Wallagaraugh suggest a generalist insect pollination strategy (Atlas of Life 2018). The fruit is a schizocarp; mericarps lack wings, spines or other obvious specialisations for dispersal (Henwood and Makinson 1992). Limited resprouting from the base has been observed in response to slashing and cool hazard reduction burns in the NSW Bournda–Merimbula subpopulation (Schlunke 2022), but *A.* sp. Wallagaraugh appears to be a fire-killed obligate seeder, with hot fires required to stimulate a strong germination response (Schlunke 2022). More limited germination and occasional resprouting from the base has been observed in response to cooler hazard reduction burns and other types of disturbance (Schlunke 2022). All known individuals in the NSW Wallagaraugh River subpopulation burnt in 2019–2020 and were killed by the fires, followed by a very strong germination response (Schlunke 2022). A more limited germination response to less severe hazard reduction burns and other disturbance has been observed in the Bournda–Merimbula subpopulation, with observed recruitment in this subpopulation also possibly due, at least in part, to high rainfall over 2020–2022 associated with the La Niña climate pattern (Schlunke 2022, 2023).

Plants in the Wallagaraugh River subpopulation that had regenerated from seed following fire in early 2020 were starting to produce flowers in the 2022–2023 season (J. Schlunke, 2023, pers. comm. August 20). This suggests that seed is first produced within three years. Half-life of seed in the soil seedbank is not known, but seed is likely to be highly persistent. Longevity of *A.* sp. Wallagaraugh is unknown.

For plants with soil seedbanks, one method of calculating generation length is the length of the juvenile period plus either the half-life of seeds in the seedbank (commonly <1–10 years) or the median time to germination, whichever is known more precisely (IUCN 2022). Neither is known precisely, but because seed of *Astrotricha* sp. Wallagaraugh is thought to be highly persistent, a half-life of 5–10 years is assumed, resulting in an estimated generation length of 8–13 years. Generation length estimated based on median fire interval in the habitats of *A.* sp. Wallagaraugh would likely be much longer, with recorded past fire intervals around 30–45 (median 37) years (NPWS Fire History database 2021; DEECA 2023).

Habitat

Along the Wallagaraugh River in NSW and Victoria, and at Stockyard Creek, NSW, *Astrotricha* sp. Wallagaraugh occurs in fairly dry open forests on shallow gravelly granitic soils or sandy loam (Victoria), typically on dry rocky upper slopes (NSW Scientific Committee 2007; ALA 2023; VicFlora 2023). In these subpopulations, *A.* sp. Wallagaraugh appears to occupy a quite specific microhabitat, not more than 50 m from a river or creek, in areas of semi-shade but not in areas of deeper shade or drier ground (Schlunke 2022; B. Makinson, collection notes in ALA 2023). Rough-barked eucalypts including *Eucalyptus consideriana* and *E. croajingolensis* are typically dominant in these habitats, with *E. sieberi* and *Angophora floribunda* also recorded in association with Victorian subpopulations (NSW Scientific Committee 2007; DEECA

NSW Threatened Species Scientific Committee

2023). The shrub layer is diverse and may include *Acacia terminalis* (NSW) or *A. longifolia*, *Daviesia latifolia*, *D. ulicifolia* and *Daviesia* sp., *Dodonaea triquetra* (Victoria) and *D. viscosa* (NSW), *Banksia* sp., *Hakea* sp., *Kunzea* sp., *Leptospermum* sp. and *Pomaderris* sp. (all NSW), and *Cassinia* sp., *Goodenia ovata* and *Pteridium esculentum* (all Victoria) (NSW Scientific Committee 2007; DEECA 2023).

The habitat of the Bournda–Merimbula subpopulation of *Astrotricha* sp. Wallagaraugh is different. Much of this subpopulation occurs along roadsides or in relatively small patches of council owned land or other reserves, typically in deep grey-white sands. In Bournda NP, plants are mainly clustered around Widgeram Rd, although 2022 surveys found plants extending further from the road than previously recorded, particularly in areas subject to recent hazard reduction burns (Schlunke 2022). Associated species include *Eucalyptus globoidea* and *E. sieberi* with *Acacia longifolia*, *Banksia serrata*, and *Grevillea mucronulata* (NSW Scientific Committee 2007).

Number of threat-defined locations

There are four threat-defined locations for *Astrotricha* sp. Wallagaraugh, based on the most serious plausible threats of vegetation clearing for residential development (at Tura Beach and Merimbula) and adverse fire regimes (remaining locations).

Although comprising a single subpopulation, the Tura Beach and Merimbula area and Bournda NP are here considered separate threat-defined locations. Vegetation clearing for residential and other development is the most serious plausible threat to *A. sp.* Wallagaraugh in Tura Beach and Merimbula, and the most serious plausible threat to the species overall. Rezoning of council-owned or crown land in the area for housing or other development could reasonably be expected to further reduce area, extent and/or quality of habitat available for *A. sp.* Wallagaraugh within a generation.

Approximately 28% of surveyed individuals in the Bournda-Merimbula subpopulation are in Bournda NP, which is protected in perpetuity. The remaining 72% (45% of estimated total individuals) are located along Sapphire Coast Drive, in small patches of council owned land and coastal reserves, along the powerline easement east of Merimbula tip and on private land (Schlunke 2022, 2023) where they may be threatened by vegetation clearing practices. Threats to *Astrotricha* sp. Wallagaraugh in the Tura Beach and Merimbula area are, therefore, different from threats in Bournda NP and the remaining subpopulations of *A. sp.* Wallagaraugh.

In Bournda NP and the remaining subpopulations of *Astrotricha* sp. Wallagaraugh, threats are less obvious, but adverse fire regimes present the most serious plausible threat. Given the scale of the 2019–2020 fires, Wallagaraugh River and the Victorian subpopulations are here considered to comprise a single location (NPWS Fire History database 2021; Forest Fire Management Victoria 2023). Bournda NP is assessed as a separate location based on the threat of adverse fire regimes (high frequency fire; low severity fire). Not only because Bournda NP is geographically more distant from the remaining subpopulations, but also because the proximity of the southeast corner of Bournda NP to housing, the threat from too frequent hazard reduction burning regimes, or low severity hazard reduction burns not sufficiently stimulating seedling recruitment, is more plausible here than for the Wallagaraugh River and the Victorian

NSW Threatened Species Scientific Committee

subpopulations. The Wallagaraugh River and the Victorian subpopulations are more likely to be impacted by high frequency fires, should they occur before replenishment of the soil seedbank. The isolated Stockyard Creek subpopulation (if it has persisted) might constitute a third location based on the threat of high frequency fires, and a fourth threat-based location overall (including Tura Beach and Merimbula).

Threats

Vegetation clearing for residential and other development is the most serious plausible threat to the Tura Beach and Merimbula location, and, because of its area and abundance, to the species overall. Adverse fire regimes, maintenance of roads, powerline easements and public use facilities including weed control, and pests or pathogens might also threaten *A. sp.* Wallagaraugh at this location. Threats to *A. sp.* Wallagaraugh in Bournda NP and the remaining subpopulations are less obvious and may not be immediate. Adverse fire regimes present an inferred threat to *A. sp.* Wallagaraugh in Bournda NP, and, to a lesser extent, to the Wallagaraugh River and Victorian subpopulations. Although occurring in Yambulla and Timbillica State Forests, the Wallagaraugh River subpopulation occurs within an exclusion zone, with road maintenance the only permitted forestry activity (NSW Environment Protection Authority 2018), and so forestry activities other than road maintenance are not considered a threat to the subpopulation. Because the exact location of the Stockyard Creek subpopulation relative to land use is uncertain, threats for this subpopulation (if it has persisted) are difficult to assess.

Vegetation clearing for residential and other development

As *Astrotricha sp.* Wallagaraugh is known to benefit from disturbances such as slashing at appropriate frequencies along roadsides and under powerlines, vegetation clearing is a more serious and more plausible threat than other potential threats associated with the urban boundary. Past habitat loss and decline of habitat quality for *A. sp.* Wallagaraugh in Tura Beach and Merimbula is inferred from the pattern of known occurrences relative to housing and other infrastructure. The area is under continuing development pressure, with six new development applications for Tura Beach and Merimbula submitted in December 2023 alone, and another nine development applications currently undetermined (Bega Valley Shire Council 2024). *Astrotricha sp.* Wallagaraugh at Tura Beach and Merimbula is also threatened by a 'zombie' development application. 'Zombie' development applications are so called because they are old development applications approved under now outdated planning legislation and 'resurrected' by the developer. In this instance, approval for a large housing development at Mirador in the Tura Beach area, dating back to 1989 and therefore approved under the *Environmental Planning and Assessment Act 1979*, remains current (ABC News 2022). Ongoing conservation management is required or decline in area and quality of habitat for *A. sp.* Wallagaraugh in Tura Beach and Merimbula is projected to continue. Habitat quality at the southern edge of Bournda NP has also been impacted by illegal land clearing on adjacent private land (DPE 2023). 'Clearing of native vegetation' is listed as a Key Threatening Process under the *NSW Biodiversity Conservation Act 2016* and 'Land Clearance' is a listed Key

NSW Threatened Species Scientific Committee

Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Adverse Fire Regimes

Astrotricha sp. Wallagaraugh is a fire-dependent species, but adverse fire regimes could have a negative impact on the species. Prior to the 2019–2020 fires, the last recorded fires in the Wallagaraugh River subpopulation were a 1972–1973 wildfire and a 1977–1978 prescribed burn (NPWS Fire History database 2021). Similarly, prior to 2019–2020 fires, the Cape Horn subpopulation is thought to have last burnt in 1987 (DEECA 2023). This suggests *A. sp.* Wallagaraugh is able to persist with a low fire frequency, high fire severity fire regime. Plants are known to be fire-killed obligate seeders, with hot fires required to stimulate a strong germination response (Schlunke 2022). More limited germination and occasional resprouting from the base has been observed in response to cooler hazard reduction burns and other types of disturbance (Schlunke 2022). If cool hazard reduction burns do not stimulate germination sufficiently for replacement of senesced individuals, this could potentially cause decline in population size or extent or quality of habitat. Given the proximity to housing, this might be particularly relevant to plants in Bournda NP and in patches of vegetation within Tura Beach and Merimbula, where proximity to housing results in strong pressure for hazard reduction activities to protect property. At present, this is an inferred potential future threat, with no evidence currently of decline in subpopulation size or extent or quality of habitat under current hazard reduction regimes.

Astrotricha sp. Wallagaraugh is known to take three years from germination to reach reproductive maturity, and to be killed by hot fires. A second hot fire within a short space of time, before replenishment of the soil seedbank, would be likely to cause serious declines in numbers of mature individuals in affected subpopulations. Fire frequency is predicted to increase under climate change (Abatzoglou *et al.* 2018; Bowman *et al.* 2020; Nolan *et al.* 2021). However, it is considered unlikely that high severity fire would return within a three-year interval, even with climate change driving shorter fire intervals. ‘High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition’ is a key threatening process under the NSW Biodiversity Conservation Act 2016. ‘Fire regimes that cause declines in biodiversity’ is a key threatening process under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999.

Maintenance of roads, powerline easements and public use facilities including weed control

The distribution the Bournda-Merimbula subpopulation of *Astrotricha* sp. Wallagaraugh along Sapphire Coast Drive and Widgeram Rd makes this subpopulation particularly susceptible to road widening and maintenance of road verges and powerline easements, including slashing and weed control measures (NSW Scientific Committee 2007). In the Wallagaraugh River and Victorian subpopulations, maintenance of access roads and public use facilities including walking tracks and picnic areas presents a similar threat. Some resprouting after slashing has been observed, and *A. sp.* Wallagaraugh appears to benefit from some types of disturbance. However, the effect of repeated slashing on plant health is not

NSW Threatened Species Scientific Committee

known, and seed production is reduced until the plants regrow to an adequate size for flowering and seed set. This could potentially deplete the soil seedbank and compromise regeneration of the subpopulation after fire or other event causing plant mortality. Clearing of the picnic area at Newtons Crossing in the Wallagaraugh River subpopulation following the 2019–2020 fires resulted in newly germinated seedlings of *A. sp.* Wallagaraugh being cleared (L. Canackle, pers. comm. July 2023).

Pests and pathogens

In surveys in the first half of 2022, and again in late 2022, an unknown fungal pathogen, likely associated with above average rainfall, was observed on mature plants in the Tura Beach and Merimbula area, with the upper branches and inflorescence particularly affected (Schlunke 2022; 2023). A variety of insect herbivores were also noted in this subpopulation (Schlunke 2022). Adjacent urban land uses might increase the likelihood of introduction of pathogens and insect pests to this subpopulation. Initial concerns of a failure of seed set in the subpopulation in 2021–2022 was later thought incorrect, with timing of survey work likely to have been too late in the season to observe seed set (Schlunke 2023; J. Schlunke *in litt.* 28 September 2023). It is, therefore, uncertain what impact this unidentified pathogen and/or insect pests are having on the subpopulation.

Assessment against IUCN Red List criteria

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

Criterion A *Population Size reduction*

Assessment Outcome: Data deficient.

Justification The fire response of *Astrotricha sp.* Wallagaraugh means that the numbers of individuals and mature individuals in subpopulations fluctuate between fires, with a strong post-fire germination response from the soil seedbank followed by gradual attrition of individuals over time. Large increases in numbers of standing individuals observed in the Wallagaraugh River and Cape Horn subpopulations post the 2019–2020 fires reflect a shift in the relative proportions of standing individuals versus those in the soil seedbank. This should not be considered evidence of a trend towards increasing population size. Data over three generations and including several fire intervals would be needed to estimate population size trends, since patterns of fluctuation in population size around fire preclude extrapolating past population size or projecting future population size from available data. However, from available data, a population size reduction sufficient to meet the thresholds for any threat categories under criterion A is not suspected.

Criterion B *Geographic range*

Assessment Outcome: Endangered under Criterion B1ab(iii)+2ab(iii)

Justification: *Astrotricha sp.* Wallagaraugh has a highly restricted distribution. The estimated Extent of Occurrence (EOO) of 1515 km² meets the threshold for Endangered (<5,000 km²). The estimated Area of Occupancy (AOO) of 72 km² meets the threshold for Endangered (<500 km²).

NSW Threatened Species Scientific Committee

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

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

Assessment Outcome: Met for Endangered.

Justification: There are four threat-based locations based on vegetation clearing for residential and other development as the most serious plausible threat to *Astrotricha* sp. Wallagaraugh in the Tura Beach-Merimbula area and adverse fire regimes as the most serious plausible threat in Bournda NP and the remaining subpopulations.

Although subpopulations are geographically isolated relative to likely seed and pollinator dispersal distances, recent survey data and observations found that most subpopulations currently contain several thousand individuals and would be expected to be viable. Therefore, based on current data *A. sp.* Wallagaraugh is not considered severely fragmented.

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

Assessment Outcome: Met for continuing decline in (iii) area, extent and/or quality of habitat.

Justification: Continuing decline in area, extent and/or quality of habitat for *Astrotricha* sp. Wallagaraugh is inferred from the threat of vegetation clearing for residential and other development. The Tura Beach and Merimbula area includes 45% of estimated total individuals, where they are located along roadsides and powerline easements, in small patches of council owned land and coastal reserves, and on private land (Schlunke 2022, 2023). Past habitat loss and decline of habitat quality for *A. sp.* Wallagaraugh in Tura Beach and Merimbula is inferred from the pattern of known occurrences relative to housing and other infrastructure. Habitat quality at the southern edge of Bournda NP has also been impacted by illegal land clearing on adjacent private land (DPE 2023). The area is under continuing development pressure, and so decline in area, extent and/or quality of habitat is projected to continue without ongoing conservation management.

- c) Extreme fluctuations.

Assessment Outcome: Not met

Justification: The fire response of *Astrotricha* sp. Wallagaraugh means that the numbers of individuals and mature individuals in subpopulations fluctuate between fires, with a strong post-fire germination response from the soil seedbank followed by gradual attrition of individuals over time. This does not meet the IUCN (2022) definition of extreme fluctuation, but simply reflects the natural population dynamics of the species in response to fire.

Criterion C Small population size and decline

Assessment Outcome: Not met

NSW Threatened Species Scientific Committee

Justification: Population size data as mature individuals is not available, however total individuals are estimated to range from approximately 4,500 to >24,000. Lower estimates meet the threshold for Vulnerable (<10,000 mature individuals) but are unlikely to meet the threshold for Endangered because most counts included in this lower estimate are before fire and assumed to be predominantly mature individuals, and because survey data underestimate true numbers of plants. However, the required additional subcriteria are not met.

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: Data deficient

Justification: Insufficient data is available to estimate or project continuing decline in population size over the timespan required to meet this subcriterion (one to three generations, or 8 to 39 years). The natural pattern of fluctuation in numbers of mature individuals between fires precludes estimating or projecting over these timespans from the available data. Available data is not suggestive of population size decline.

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

Assessment Outcome: Data deficient

Justification: Insufficient data is available to estimate, project or infer continuing decline in population size. The natural pattern of fluctuation in numbers of mature individuals between fires precludes estimating, projecting or inferring continuing decline from the available data. Available data is not suggestive of population size decline. None of the three conditions below are met.

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

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

Assessment Outcome: Not met

Justification: Estimates of total individuals for the largest subpopulations exceed 3000 and so do not meet the threshold for Vulnerable (≤ 1000 mature individuals in each subpopulation).

- 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 of *A. sp. Wallagaraugh*, Bournda-Merimbula, includes an estimated 63–88% of total individuals.

- b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Not met

NSW Threatened Species Scientific Committee

Justification: The fire response of *Astrotricha* sp. Wallagaraugh means that the numbers of individuals and mature individuals in subpopulations fluctuate between fires, with a strong post-fire germination response from the soil seedbank followed by gradual attrition of individuals over time. This does not meet the IUCN (2022) definition of extreme fluctuation, but simply reflects the natural population dynamics of the species in response to fire.

Criterion D *Very small or restricted population*

Assessment Outcome: Not met

Justification: Although numbers of mature individuals are not accurately known, total individuals are estimated to range from approximately 4,500 to >24,000 plants. This is greater than 1,000 mature individuals, so does not meet the thresholds for any threat categories.

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: Although numbers of mature individuals are not accurately known, total individuals are estimated to range from approximately 4,500 to >24,000 plants.

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.

Assessment Outcome: Not met

Justification: The estimated area of occupancy for *Astrotricha* sp. Wallagaraugh is 72 km². Although the number of threat-defined locations (4) are ≤5, there is no known plausible future threat that could drive the species to CR or EX in a very short time.

Criterion E *Quantitative Analysis*

Assessment Outcome: Data Deficient

Justification: No Population Viability Analysis or other quantitative analysis of extinction risk has been undertaken for *Astrotricha* sp. Wallagaraugh.

Conservation and Management Actions

Astrotricha sp. Wallagaraugh is currently listed as Endangered 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 (SoS) 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. *Astrotricha* sp. Wallagaraugh sits within the site-managed species management stream of the SoS program.

Activities to assist this species currently recommended by the SoS program (DPE 2023; OEH 2019) include:

NSW Threatened Species Scientific Committee

Urban boundary threats including vegetation clearance

- Liaise with Bega Valley Shire Council to formulate an approach to increase community support for the species; address strategic planning issues as they arise.
- Engage with local community to foster interest in the conservation of the species.

Adverse slashing and/or track maintenance, public use area and road maintenance

- Ensure road maintenance activities in the Bournda-Merimbula subpopulation do not detrimentally interfere with the population.
 - The construction of bollards or fencing along the roadside population if slashing and vehicle access are identified as threatening process.
- d) Liaise with land managers including National Parks and Wildlife Service, Council and Essential Energy about species occurrence and management within tracks and powerline easements.
- Install interpretive signage at the Tura Beach Public Library to raise awareness of threatened species in the region.
 - Install interpretive signage at picnic area.
 - Reduce damage from recreational users and accidental damage at sites.

Adverse fire regimes

- Liaise with Forestry Corporation of NSW to ensure species is protected in State Forest.
- Investigate the long-term response of the species to fire.
- Undertake laboratory studies at the Australian PlantBank to determine optimal temperature regimes for seed germination.

Weeds

- Physical and chemical control of weeds during Summer.

Survey and monitoring

- Assist council and National Parks and Wildlife Service to undertake a survey of the extent of the Bournda-Merimbula subpopulation.
- Survey suitable habitat to locate new subpopulations and store spatial search data on GIS and upload spatial data into BioNet.

Ex situ conservation

- Collect seed for long- and short-term storage.
- Propagate plants from seed.

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NSW Threatened Species Scientific Committee

APPENDIX 1

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome:

Astrotricha sp. Wallagaraugh (R.O.Makinson 1228) was found to be Endangered under Clause 4.3(b)(d)(e,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: Endangered under Clause 4.3(b)(d)(e,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,

NSW Threatened Species Scientific Committee

	(ii)	the geographic distribution of the species,
	(iii)	habitat area, extent or quality,
	(iv)	the number of locations in which the species occurs or of populations of the species,
	(f)	extreme fluctuations occur in any of the following:
	(i)	an index of abundance appropriate to the taxon,
	(ii)	the geographic distribution of the species,
	(iii)	the number of locations in which the species occur or of populations of the species.

Clause 4.4 - Low numbers of mature individuals of species and other conditions

(Equivalent to IUCN criterion C)

Assessment Outcome: Not met

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

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

NSW Threatened Species Scientific Committee

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.
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