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Distribution, ecology and conservation of the endangered shrub, *Acacia meiantha* (Fabaceae) in Central West New South Wales

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***Abstract*:** *Acacia meiantha* Tindale & Herscovitch, (Fabaceae) a low to medium shrub with root suckering, is only known to occur at three locations, Clarence, Carcalgong and Mullion Creek in Central West New South Wales. These disjunct populations each separated by >60 km, are considered as isolated subpopulations. A compilation of recent field surveys shows that of the 42,000 stem clusters/aggregates of *Acacia meiantha* estimated across the three geographic locations, the majority, 39,900 (96%) occur in the Mullions Range State Forest subpopulation, where 61% of clusters occur in the remnant native forest areas and 39% in the plantation forestry compartments. At Carcalgong 1,566 stem clusters were recorded along narrow roadside reserves. The Clarence subpopulation consists of < 400 stem clusters precariously situated among a confluence of road, railway and electricity power-line easements.

Ecological observations of habitat are presented; information relating to genetic diversity, seed biology, reproductive biology and response to fire is found to be Data Deficient. The threatened species listing as Endangered under both State and Commonwealth legislation is warranted; the species does not occur on any conservation lands, has restricted distribution and abundance, and is vulnerable to ongoing threats. The area (AOO) and extent of occupancy (EOO) are calculated. It occurs at three locations (< 5), has an estimated EOO of 2,900 km^2 (< 5,000 km^2) and an AOO of 80 km^2 (< 500 km^2) (IUCN (2019) thresholds in brackets); there are significant threats to the extent and quality of habitats.

Additional opportunities for improving the conservation of the species, particularly in the Mullions Range State Forest, over and above those outlined in the site-managed initiatives of the current Saving our Species program, are presented.

Keywords: Threatened, rare, conservation, Mullions Range State Forest, ramet, clonal

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Introduction

Acacia meiantha Tindale & Herscovitch is a multi-stemmed shrub (family Fabaceae) to ± 2 m high with a loose clump-forming root suckering habit (Tindale et al. 1992; Kodela 2018). The species was originally described with two populations, Clarence, near Lithgow, and Mullion Creek, near Orange in the Central West of NSW (Tindale et al. 1992). In 2011 the author identified a third previously unknown colony near Carcalgong, south of Mudgee. The Clarence and Carcalgong sites occur within the Central Tablelands Botanical Subdivision, east and west of the Great Dividing Range respectively, whereas the Mullion Creek population is situated along the Central Tablelands/ Central West Slopes Botanical Subdivisions border. In 2015 *Acacia meiantha* was gazetted as Endangered under the *NSW Biodiversity Conservation Act 2016* (BC Act) (Scientific Committee 2015) and subsequently as Endangered under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) using the Common Assessment Method (Dept. of Environment & Energy 2020). Under the Biodiversity Conservation Act the species has been assigned to the Site-managed species stream of the Saving our Species (SoS) program (OEH 2020), which has spawned recent surveys of extent and distribution at all three locations. Other environmental assessment surveys have been undertaken for infra-structure developments at Clarence and Carcalgong, and plantation forestry operations at Mullion Creek.

This paper provides an updated assessment of the distribution and population size of *Acacia meiantha* at the three locations along with overviews of ecological information from recent independent surveys and considerations to improve conservation of the species.

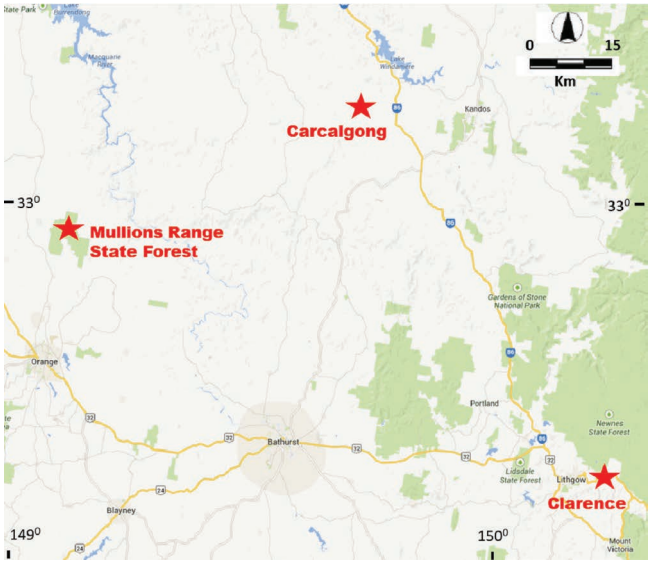

Figure 1. Geographic location of each of the three known subpopulations of *Acacia meiantha* within the Central West of NSW.

Materials and Methods

At the Clarence subpopulation, plants of *Acacia meiantha* were first recorded near Chifley Road by G.W. Althofer in 1975; there are 27 subsequent specimen records (AVH 2020). A Plan of Management developed for the associated Dargans Creek Crown Land Reserve listed threatened species recorded/predicted for the area, including *Acacia meiantha* (Eco Logical Australia 2011). In January 2016 Coote (2016) familiarised himself with plants and geographical associations along and around Chifley Road, before surveying nearby parcels of freehold lands (in-holdings to the Dargans Creek Crown Land Reserve). Coote's survey, which targeted disturbed and/or open areas, including track edges, easements and areas with evidence of relatively recent fire, involved meandering transects on foot using a GPS to record 8 km of tracks within an area of about 16 ha. In September 2017 Priday (2017) conducted a further survey of the Clarence population during full flowering (to maximise detection) with foot traverses of locations with historical records in the northern areas of Dargans Creek Crown Land Reserve, Chifley Road Reserve and contiguous areas of Crown land. He identified and circumscribed two aggregate colonies of the species to determine density, area covered, geographic limits and site floristics. For upgrading works along Chifley Road, a main access road between Sydney and the Central West, Roads and Maritime Services (2018) also undertook surveys in the area.

The Carcalgong population was discovered by the author in 2011; there are seven subsequent specimen records (AVH 2020). The population was surveyed during flowering in September 2017 by Priday, with a preliminary road traverse by car to identify boundary limits along the narrow roadside reserves of Aarons Pass and Perke Roads. Foot traverses within the defined boundaries were then undertaken along 1.5 km of Aarons Pass Rd and 1 km along Perke Rd, to record population density, area and site floristics (Priday 2017). A separate foot traverse survey undertaken by Eco Logical Australia (2019) along 20 km of Aarons Pass Rd during September-October 2018 aimed to identified the species occurrence in relation to roadwork upgrades.

The Mullion Creek population occurs mostly within Mullions Range State Forest No. 176. The first collection was by B.V. Boyles in 1936, then W.E. Giles in 1959 (designated as the Holotype), and subsequently some 48 records added (AVH 2020). Priday (2017) surveyed most of the 2,300 ha of remnant native forest during flowering in September 2017, with about 30 km of foot transects, and an additional 50 km of forest fire trails by vehicle recording occurrences within 50-70 m of the transects. Priority was given to surveying remnant parts lacking historical records. Plant associations and assemblages recorded along transects, combined with existing data for the State Forest and nearby Mullion Range State Conservation Area, enabled the derivation of an 'expert' classification of vegetation assemblages for the area to identify habitat preferences.

Surveys of silviculture areas of Mullions Range SF in the latter half of 2016 aimed to establish the extent of *Acacia*

meiantha within the accredited timber plantation zone. Certain plantation areas were excluded from survey, based on preliminary inspections, in order to focus on areas most likely to support the species, and to this end the plantation zone was classified into two broad 'priority' areas for survey (Anon. 2016). Priority 'one' compartments involved areas of mature standing forests scheduled for harvest, and priority 'two' compartments encompassed compartments recently harvested and/or re-established as second rotation plantings, excluding areas that had been subjected to blanket herbicide applications in preparation for replanting. To accommodate harvesting schedules, surveys of priority one areas could be undertaken at any time of the year along parallel transects at 80 m intervals. In priority two areas surveying was restricted to the flowering period of July to October along parallel transects 50 m apart. Data capture included geo-referencing and the number of *Acacia meiantha* plants observed for each sighting, along with elevation, landform, geology, slope, aspect and soil type for independent transects (Anon. 2016).

Acacia meiantha has clonal suckering habit, so traditional methods used to census individuals are inappropriate, as genets cannot be readily distinguished from ramets. In all of the surveys, therefore, estimating population size involved counting stems in clusters or in aggregate areas, although the methodology appears to have been subjectively adapted within and across the various surveys. Geo-referencing of individual central point clusters together with the number of stems and area of each cluster along line transects provided surrogate population statistics. Larger 'area' transects were deployed in some parts of both the Carcalgong and Mullions Range SF populations where high densities of stems masked obvious clustering. Here, transects defined by polygon coordinates were converted to determine areas and stem counts were estimated into class intervals. In central point records, stem clusters with area permitted an estimate of cluster size per stem; this was not feasible for area transects where only aggregate statistics were recorded (approx. stem numbers within total transect area). Convex polygons circumscribing each population provided separate estimates of the Area of Occurrence (AOO) for each of the three subpopulations. The AOO was also calculated using the standard method of placing a 2 km x 2 km grid over a map of each of the three location sites and tallying occupied grids (IUCN 2019). Extent of Occurrence (EOO) was estimated by circumscribing a convex polygon around the three geographic locations (IUCN 2019).

Table 1. Physiography, population size, geology, vegetation communities and floristic composition within each subpopulation of *Acacia meiantha*.

	Clarence	Carcalgong Aarons Pass Rd	Carcalgong Perke Rd	Mullions Range native forest remnants	Mullions Range silviculture
Approx. centre of population Lat./ Long.	33° 28' 21.85" S 150° 14' 29.25" E	32° 52' 35.86" S 149° 41' 50.65" E		33° 03' 57.02" S 149° 08' 57.84" E	
Altitude (m)	1 065-1 070	950-965	915-960	875-1 000	
Number of stems or clusters	390	610	956	24 400	15 400
Total area of clusters (m^2)	c. 75	15 861 [n = 22]	12 358 [n = 23]	63 595 [n = 203]	na
Mean size of clusters (m^2 $stem^{-1}$)	c. 0.19	2.8 [n = 9]	2.7 [n = 19]	4.2 [n = 194]	na
Subpopulation Area of Occurrence (AOO) (ha)	0.0075	20		1 940	
Geology	Sydney Basin Triassic Narrabeen chert sandstone	Permian Sydney Basin Shoalhaven Group of polymictic conglomerate		Mullions Range Volcanics consisting of Middle to Late Silurian rhyolite and dacite lavas and intraformational clastic rocks	
Vegetation community	Narrow-leaved Peppermint - Silvertop Ash - Mountain Grey Gum shrubby open forest upper Blue Mts, Sydney Basin Bioregion	Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion		Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	
Nearest resembling Plant Community Type	967	1093		1093	
Main tree species	*Eucalyptus radiata* subsp. *radiata*, *Eucalyptus sieberi, Eucalyptus blaxlandii*	*Eucalyptus rossii, Eucalyptus sparsifolia, Eucalyptus lactea* [syn. *Eucalyptus praecox*]		*Eucalyptus rossii, Eucalyptus macrorhyncha, Eucalyptus dives, Eucalyptus mannifera* subsp. *mannifera*	

	Clarence	Carcalgong Aarons Pass Rd	Carcalgong Perke Rd	Mullions Range native forest remnants	Mullions Range silviculture
Shrub and ground layer species	*Acacia asparagoides* *Acacia terminalis* *Amperea xiphoclada* *Banksia spinulosa* *Daviesia latifolia* *Daviesia ulicifolia* *Grevillea laurifolia* *Lepidosperma laterale* *Lomandra glauca* *Lomatia silaifolia* *Persoonia chamaepitys*	*Acacia clandullensis* *Acacia terminalis* *Acacia obtusifolia* *Bossiaea obcordata* *Cassinia* spp. *Chrysocephalum apiculatum* *Indigofera australis* *Lomandra confertifolia* subsp. *pallida* *Olearia elliptica* *Patersonia sericea* *Persoonia linearis* *Podolobium ilicifolium* *Pomaderris eriocephala* *Rytidosperma pallidum* *Styphelia triflora*		*Acacia buxifolia/A. leucolobia* *Boronia microphylla* *Bossiaea foliosa* *Calytrix tetragona* *Cassinia sifton* *Daviesia leptophylla* *Dillwynia phylicoides* *Grevillea ramosissima* *Leucopogon microphyllus* *Lomandra filiformis* subsp. *coriacea* *Monotoca scoparia* *Persoonia rigida* *Philotheca salsolifolia* *Pultenaea procumbens* *Rytidosperma pallidum* *Styphelia triflora* *Tetratheca bauerifolia*	

Results and Discussion

Distribution and population size

Acacia meiantha is known to occur only at three disjunct locations, Clarence, east of Lithgow; Carcalgong, south of Mudgee; and Mullions Range SF, north of Orange (Fig. 1). The distances separating the sites means the populations potentially act as discrete subpopulations (IUCN 2019); there is apparent opportunity for genetic exchange within them, but not between them.

The Clarence subpopulation is east of the Great Dividing Range near the headwaters of Dargans Creek, in an upper catchment of the Coxs River, about 8 km east of Lithgow, about mid-way between the Clarence and Dargan localities, and near the southern perimeter of the Newnes Plateau. The locality has an altitude of 1065-1070 m. The subpopulation consists of two small aggregates on Crown tenure precariously situated among a confluence of road, railway and electricity power-line easements. The land is the very north-easternmost tip of the Dargans Creek Crown Land Reserve which has two freehold in-holdings and is bisected by service trails and a railway corridor (Eco Logical Australia 2011; Coote 2016). No *Acacia meiantha* were located on the aforementioned private inholdings (Coote 2016), nor in targeted surrounding areas associated with the current (2020) Chifley Road upgrade where as a consequence of the various infrastructure impositions, associated vegetation has been subjected to ongoing disturbances, though currently quarantined from the adjacent major roadworks (Roads & Maritime Services 2018). The Clarence population is the smallest of the three subpopulations with 390 stem clusters covering around 75 m^2 (calculated from Priday (2017) data) (Table 1).

Carcalgong (altitude of 915-970 m) is situated along Aarons Pass Road, around the junction of Perke Road, approx. 18 km north-west of Ilford, and 33 km south of Mudgee (Fig. 1). It is in the Central Tablelands Botanical Subdivision, west of the Great Divide in the Macquarie River catchment on a watershed range between the Cudgegong and Turon Rivers in the Hill End subregion of the South Eastern Highlands IBRA. The Carcalgong subpopulation, within the roadside reserve and a small Travelling Stock Reserve, consists of about 1,600 stem clusters covering some 5.5 ha (calculated from Priday (2017) data) (Table 1). In his report, Priday confusingly states a total of 2,100 stem clusters were observed for the Carcalgong location, but also notes it is likely that at least as many, or potentially more than twice that number of stem clusters could occur in adjacent private lands not surveyed. The surveyed areas extended along Aarons Pass Road (westwards from near the Perke Rd intersection) for about 2.5 km towards Pyramul, and northwards along the perpendicular Perke Rd for approx. 0.75 km. These roadside easements vary in width from < 5 m up to 75 m either side of the formed road. Further survey of adjacent freehold lands is required to define the full extent of this subpopulation.

The Mullions Range SF subpopulation is unquestionably the largest, with very sporadic occurrences on at least some adjoining freehold land, notably to the south. The abandoned headquarters of the forest is 5.2 km west north-west of Mullion Creek and 21.2 km west north-west of Orange. The area straddles the boundary of the Central Tablelands and the Central Western Slopes Botanical Subdivisions (Fig. 2), in the Orange subregion of the South Eastern Highlands IBRA. The subpopulation occurs from 875-1000 m altitude, but mostly between 900-960 m. The highest point along Mullion Range is Mulyan Trig. (1015 m) on Mt Meehan (on freehold land). This subpopulation also occurs west of the Great Divide (in the Macquarie River catchment) in the northern Mullion Range which forms a watershed principally between Calula and Kerrs Creeks flowing to the west, Boshes, Isaacs and Oakey Creeks to the east, Curragurra Creek to the north and Mulyan Creek to the south.

Mullions Range SF covers 4,123 ha, of which 1,822 ha (41%) is under *Pinus radiata* plantation (M. Kong pers. comm. 2015) and the remainder, remnant native forest. It is estimated that almost 40,000 stem clusters/aggregates occur in the State Forest (Table 1), calculated from Priday (2017) and Forestry Corp. map data (2016) (Fig. 2). About 60% (24,400) of the clusters occur within the native forest remnants (Table 1), with an estimated total cluster area of 6.36 ha dispersed over a much larger area of about 1,000 ha.

Recent surveys of plantation areas revealed about 15,400 stem clusters (Table 1) along approx. 162 km of transects (calculated from Forestry Corp. map data (2016)); however the area of clusters was not assessed and not all plantation compartments were surveyed.

The subpopulation within Mullions Range SF is extensive, but comprised of many disparate, often widely separated colonies, both in the native vegetation remnants and in plantation forest landscapes (Fig. 2). The largest contiguous stand of *Acacia meiantha* in native remnants covers ca. 4 ha in the headwaters of Boshes Creek, adjacent to and north of the defunct Boshes Creek Park Picnic Area. Clearing and planting of pines commenced in the area as early as 1923 and ceased in 1982 (Pratten 1986). Many plantation areas have recently been, or are currently being clear-fell harvested and it is apparent from opportunistic regeneration in cleared areas that *Acacia meiantha* most likely originally extended throughout much of the cleared Mullions Range SF west of Long Point Road. Now occurrences in many areas are restricted to the edges of fire trails, batters, scattered remnant pockets and regenerating stocks.

Under the NSW *Plantations and Reafforestation Act (1999)* Threatened Species are defined as *Unique or Special Wildlife*. Plantation forest operations currently fall under the jurisdiction of the NSW Department of Primary Industries (DPI) who are charged with ensuring no adverse impacts on unique or special wildlife. To this end an inter-agency agreement of 'specified restrictions' has been implemented for management of *Acacia meiantha* within the Mullions Range SF plantation areas (DPI undated). Priority 'trial' areas have been assigned for pre- and post-harvest survey and procedures specified to minimise ground disturbance during harvesting and re-establishment operations, together with reporting to assess population responses to ameliorated forestry management. Future forestry operations of *Acacia meiantha* inhabited areas will be determined pending the outcomes from the trials.

Habitat

The three subpopulations occur on differing geologies, with no apparent commonality. The Clarence subpopulation is located on Sydney Basin Triassic Narrabeen Group high plateau chert sandstone (Table 1) with undifferentiated horizontal bedding (Bryan 1966). Soils are clays with occasional patches of sand (Coote 2016).

The other two western subpopulations are in the eastern parts of the Lachlan Fold Belt, but differ markedly from each other. The Carcalgong subpopulation occurs along a ridgeline with thin sandy loam soils formed on a remnant of the Permian Sydney Basin Shoalhaven Group of polymictic fine to coarse-grained conglomerate (Table 1) formed at the westernmost margin of the Sydney basin, a stratum lying conformably below the Narrabeen sandstones. It in turn overlies the Carboniferous Aarons Pass Biotite Granite nearby in the surrounding northern, eastern and southern landscape (Colqhoun et al. 2000) and to the west abuts other complexes of the Lachlan Fold Belt (Pemberton 1989; Pemberton et al. 1994).

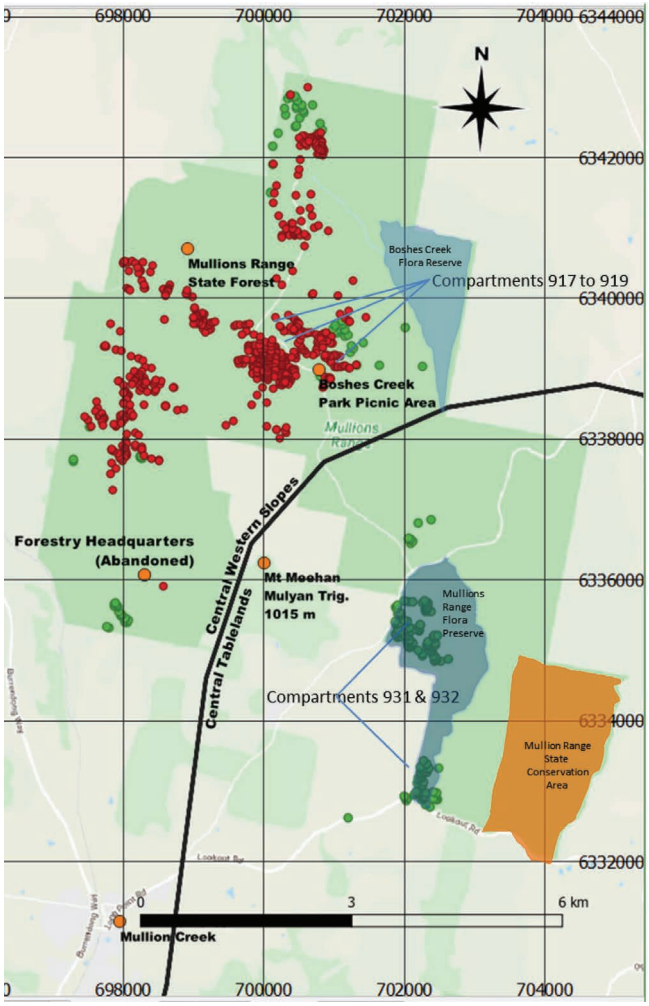

Figure 2. Distribution of *Acacia meiantha* within the Mullions Range State Forest. Red symbols depict survey data of Forestry Corp. (2016) in mainly plantation areas, green symbols depict data of Priday (2017) within native forest remnants.

The Mullion Creek population is seemingly confined to the Mullion Range Volcanics, Middle to Late Silurian rhyolite and dacite lavas and intraformational clastic rocks of the Mumbil Group (Hilyard 1981; Meakin et al. 1997). According to Anon. (2016), three soil landscapes of red-brown and yellow-brown sandy loams feature in the plantation areas of Mullions Range SF. *Acacia meiantha* is associated with the predominant Mookerawa Soil Landscape consisting mainly of red podzolic sandy loam of depths up to 25 cm (Kovak et al. 1990) and not with the Mullion Creek and Burrendong Soil Landscapes therein.

For Clarence, Tindale et al. (1992) indicate *Acacia meiantha* occurs in open eucalypt forest (*Eucalyptus dives* and *Eucalyptus sieberi*) and in an adjacent area of mainly shrubs, where the tree overstorey had been cleared near power lines. Coote (2016) attributes the ongoing disturbance of vegetation at the location for creating a contrived heath of a dense tall shrub layer which Priday (2017) records is dominated by *Leptospermum trinervium* with smaller numbers of *Leptospermum obovatum, Phyllota squarrosa, Banksia spinulosa* and *Isopogon anemonifolia*. The ground layer is dominated by sub-shrubs, particularly *Epacris microphylla* and *Mirbelia platyloboides* and less commonly *Persoonia*

chamaepitys and *Grevillea laurifolia* subsp. *caleyana*. At the time *Acacia meiantha* plants were mostly < 50 cm high throughout. Priday (2017) states the dominant trees included *Eucalyptus radiata* subsp. *radiata*, *Eucalyptus sieberi* and *Eucalyptus blaxlandii* and some with characteristics intermediate between *Eucalyptus radiata* subsp. *radiata* and *Eucalyptus dives*. This community falls under the broad assemblage of Newnes Plateau Woodland of Benson and Keith (1990). The nearest Plant Community Type (BioNet 2018) currently recognised is the Narrow-leaved Peppermint - Silvertop Ash - Mountain Grey Gum shrubby open forest of the upper Blue Mountains, Sydney Basin Bioregion PCT 967 (Table 1). The main associated substrata species present (Table 1) are a typical subset of the community.

The subpopulations at Carcalgong and Mullions Range SF occur in the same broad Southern Tablelands Dry Sclerophyll Forests vegetation class, however both dominant and substrata composition differ. At Carcalgong the dominant trees along the ridgelines are *Eucalyptus rossii, Eucalyptus sparsifolia* and *Eucalyptus lactea* [syn. *Eucalyptus praecox*] together with scattered *Eucalyptus goniocalyx* (Fig. 3). Dominants at Mullions Range SF include *Eucalyptus rossii, Eucalyptus mannifera, Eucalyptus dives* and *Eucalyptus macrorhyncha* (Tindale et al. 1992; Priday 2017) (Fig. 4). Within this broad classification, Priday (2017) mapped six communities in Mullions Range SF, based mainly on the presence or absence of *Eucalyptus rossii* and/or *Eucalyptus goniocalyx*, together with four riparian communities. Among these various communities reside subdominants of *Eucalyptus goniocalyx, Eucalyptus rubida* subsp. *rubida, Eucalyptus robertsonii* subsp. *hemispherica, Eucalyptus sparsifolia* and *Eucalyptus viminalis* (the author considers *Eucalyptus radiata* subsp. *radiata* shown on some Mullion Range maps (Priday 2017) was a misidentification of *Eucalyptus robertsonii* subsp. *hemispherica,* and *Eucalyptus dalrympleana* subsp. *dalrympleana* a misidentification of *Eucalyptus viminalis*).

Figure 3. Carcalgong - Southern Tablelands Dry Sclerophyll Forest habitat with dominant trees of *Eucalyptus rossii, Eucalyptus sparsifolia* and *Eucalyptus lactea.* Note dominance of *Acacia meiantha* in the shrub layer.

Figure 4. Mullions Range State Forest - Southern Tablelands Dry Sclerophyll Forest habitat with dominant trees of *Eucalyptus rossii, Eucalyptus mannifera, Eucalyptus dives and Eucalyptus macrorhyncha.* Note wilding *Pinus radiata* invasion.

Of the 10 communities in the Mullions Range SF mapped by Priday (2017), over 90% of the *Acacia meiantha* colonies showed a strong association with the single open forest community characterised by *Eucalyptus rossii, Eucalyptus macrorhyncha, Eucalyptus dives* and *Eucalyptus mannifera* subsp. *mannifera.* Within this community, Priday (2017) found *Acacia meiantha* in a range of topographic positions, aspects and soil depths, although apparently not in riparian communities. Contrary to Tindale et al. (1992), Priday (2017) reports *Acacia meiantha* also occurs among rocky outcrops.

In both the Carcalgong and Mullions Range SF *Acacia meiantha* is up to 2 m, among the tallest, and most common shrub where dense aggregates form. Associated shrubs at Carcalgong have a mixture of species typical of the Southern Tablelands Dry Sclerophyll Forests along with others such as *Acacia obtusifolia, Persoonia linearis, Podolobium ilicifolium, Acacia terminalis* and *Bossiaea obcordata* (Table 1) that show a greater affinity to Sydney Basin sandstone communities. Co-occurring species in Mullions Range SF also comprise some unusual species for the Southern Tablelands Dry Sclerophyll Forests such as *Bossiaea foliosa, Boronia microphylla, Tetratheca bauerifolia* and *Philotheca salsolifolia* subsp. *salsolifolia* (Table 1), which have their strongholds to the east and south of the area. Otherwise the two subpopulations share some similar shrub and ground-layer species. A notable groundlayer difference is the common occurrence of *Lomandra confertifolia* subsp. *pallida* at Carcalgong which is absent from Mullions Range SF areas where *Lomandra filiformis* subsp. *coriacea* occurs.

The sporadic distribution of *Acacia meiantha* in the Mullions Range SF is partly a result of clearing for plantation pine operations, but also reflects the disposition of preferred habitats for the species as is evident in the relatively undisturbed native forest remnants. Despite ostensibly similar habitat, the species is absent from the Cactus Gully and Isaacs Creek valleys (Kerrs Creek 1:25 000 Topographic Map) in the northeast of the forest. The most significant stands are in extant native forest remnants, Compartments

917 to 919 in the headwaters of Boshes Creek and to the south in Compartments 931 & 932 (Fig. 2) along Oakey Creek between Lookout and Long Point Roads, where the colonies are near continuous and in parts constitute the dominant shrub species over significant areas.

Ecology

Arguably the strongest feature aiding survival of the *Acacia meiantha* is its ability to reproduce clonally through underground suckering (Fig. 5). Accordingly, adult plants may comprise dense or diffuse clumps or clusters of stems arising from the roots of a single parent plant (Fig. 6). Consequently clonal colonies with many more ramets than genets in each occur, making it very difficult to estimate the number of mature individuals in an area. From the partial data recorded, cluster size ranged from 0.2 m^2 per stem at Clarence to 4.2 m^2 per stem in Mullions Range SF (Table 1). Based on incidental observation, this clonal growth is likely to facilitate resprouting after fire. However, there are no quantitative data on fire response, or the impact of fire intensity, fire intervals or frequency. The Clarence subpopulation was completely burnt during the extensive fires in December 2019, and observations in June 2020 indicated very limited resprouting by that time (D. Benson pers. comm. 2020) (Fig. 8). Further observations of suckering and regeneration following fire (Fig. 7) are required to provide ecological information critical to managing the species long term.

There have been no observations of natural seed germination or recruitment, and knowledge of seed set and seed longevity is lacking. Although flowering profusely, the Clarence subpopulation rarely sets seed (H. Drewe pers. comm. 2020). Has this subpopulation lost the ability to sexually reproduce, or are other environmental factors intervening? In contrast, both the other two subpopulations are fertile, although seed set, seed yield and quality appears to be dependent on seasonal conditions and parasitism (D. Benson and R. Johnstone pers. comm. 2016). Considering that flowering commences in mid-winter (July) and extends through to mid-spring (Oct.) (Kodela 2018; 2020), temporal factors may also be at play with respect to insect pollination; wattles are reputedly opportunistic pollinators, but mechanisms are unknown for this species. Likewise, given the clumping habit and often considerable distances between clusters and colonies, spatial factors are also likely to be involved in determining fertility.

Nothing is known of the genetic variation within or across the subpopulations. Tindale et al. (1992) and Kodela (2018) draw attention to the affinity of *Acacia meiantha* with the NSW coastal species *Acacia linifolia,* and with Southern Tablelands *Acacia boormanii.* Clearly there is scope for molecular analyses to illuminate these intra and inter-generic relationships.

Perplexing ecological questions remain as to why the species has such a confined presence in the physiographic landscape. Given the varying geologies, topographic and vegetation structures associated with the subpopulations there is no manifestly evident habitat-constraining impediment. Outwardly similar habitats remain inexplicably unpopulated in and around all three locations, especially in the Mullions Range SF.

Figure 5. Suckering ramets around the base of a parent plant of *Acacia meiantha.*

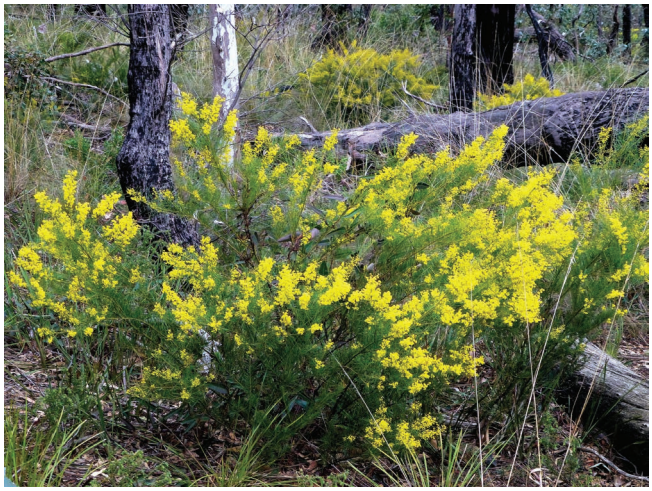

Figure 6. Multi-stemmed habit of *Acacia meiantha* due to suckering from the roots of a single parent plant, forming a cluster of ramets (Mullions Range State Forest).

Figure 7. Sucker regeneration of *Acacia meiantha* following cool hazard reduction burn (Mullions Range State Forest).

Figure 8. Clarence - Upper Blue Mountains Narrow-leaved Peppermint - Silvertop Ash - Mountain Grey Gum (*Eucalyptus radiata, E. sieberi*) shrubby open forest habitat with *Acacia meiantha* burnt in wildfire December 2019. Plants were resprouting in August 2020 (D Benson pers. comm.).

Conservation

Acacia meiantha has been listed as Endangered under both State and Commonwealth legislation on the basis of its restricted distribution and abundance, and vulnerability to ongoing threats. It occurs at a small number of locations (< 5), has small population size and is predicted to decline due to threats to the extent and quality of habitat. In making its Final Determination the NSW Scientific Committee (2015) estimated *Acacia meiantha* had an Extent of Occurrence (EOO) of 2,900 km^2 and an Area of Occupancy (AOO) of 68 km^2. Calculations by the author support the EEO, but found that the AOO to be slightly larger at 80 km^2. As recommended by the IUCN, AOO is estimated by overlaying 2 km by 2 km grid cells across the subpopulations and summing cells in which the species is present, in this case 20 cells. In this study the species had an actual *in situ* AOO of 1,960 ha [19.6 km^2] based on the sum of subpopulation polygons (Table 1). Clearly the IUCN (2019) method is conservative and allows for occurrences fringing known boundaries as for both the Carcalgong and Mullion Creek subpopulations where the species is known to occur on private lands outside of the surveyed boundaries.

In its Final Determination, the Scientific Committee (2015) concluded *Acacia meiantha* is facing a high risk of extinction in the near future, largely because of its geographically restricted distribution. Numerous threats specific to each of the subpopulations include present road and utility maintenance works at Clarence, roadworks at Carcalgong associated with the Crudine Ridge Windfarm Development (Eco Logical Australia 2019), and plantation forestry operations and wilding pine invasion at Mullion Creek. Plants within the footprint of road widening works at Carcalgong have been removed for on-going cultivation pending translocation back to the site (C. O'Dwyer pers. comm. 2020). Wildfire in December 2019 has severely impacted the Clarence subpopulation.

Acacia meiantha has recently been assigned to the site-managed stream of the NSW Saving our Species (SoS) program, which sets out in detail the management actions required at each of the subpopulation sites to secure it in the wild for at least 100 years (OEH 2020). A raft of threats and management recommendations is outlined to inform and mitigate impacts on the species including the development of fire frequency thresholds, the control of unfettered recreational vehicle movement in sensitive areas and control and removal of weed threats such as wilding pines. Other proactive recommendations include seed collection and *ex situ* seed banking, advising of private landowners to foster sympathetic conservation management and routine monitoring to detect temporal population trends and untoward damage at each of the subpopulations (OEH 2020; Dept. of Environment & Energy 2020). Once knowledge is available of the genetic diversity among and between subpopulations of *Acacia meiantha*, consideration could perhaps be given to establishing *ex situ* populations, by translocation to conservation lands.

Notwithstanding the SoS objectives, it remains a great concern that the species lacks conservation security. It does not occur on any conservation lands, other than in Dargans Creek Crown Land Reserve at Clarence where the small subpopulation is in a precarious and disturbed environment. Porteners (2000) and later Priday (2017) found no evidence of *Acacia meiantha* occurring in the Mullion Range State Conservation Area. Pratten (1986) submitted that the existing Boshes Creek Flora Reserve No. 23, occupying Compartment 915 of the Mullions Range SF, is unrepresentative of the diverse flora along the range and does not contain *Acacia meiantha* (Fig. 2) and Priday (2017) argues the Boshes Creek Flora Reserve supports unlikely vegetation community habitat for it. Pratten's (1986) case resulted in parts of Compartments 931 and 932 of Mullions Range SF east of Long Point Road being designated as Mullions Range Flora Preserve (Fig. 2); however Flora Preserve designation has no legal status from a conservation standpoint and no formal management plan for the Preserve exists.

Two possibilities for reservation of *Acacia meiantha* are available. One would involve an extension of the contiguous Mullion Range State Conservation Area to subsume the adjacent Mullions Range SF Compartments 931 and 932 east of Long Point Road. The second would involve either an extension of the Boshes Creek Flora Reserve to include Compartments 917 to 919, or the creation of a new conservation initiative for those compartments (Fig. 2). This option would also secure other regionally significant rare shrub and herb species (Table 2), and the threatened *Eucalyptus robertsonii* subsp. *hemisphaerica,* which has Vulnerable listing under both State and Commonwealth legislation and similarly lacks security within conservation land.

Table 2. Regionally significant flora occurring within the Mullions Range State Forest.

Species (family)	Occurrence, significance and status
Boronia nana var. *hyssopifolia* (Rutaceae)	Rare, disjunct; northern and western-most range limit
Bossiaea foliosa (Fabaceae)	Locally frequent, disjunct; northern and western-most range limit
Boronia microphylla (Rutaceae)	Locally frequent, disjunct; western-most range limit
Eucalyptus robertsonii subsp. *hemisphaerica* (Myrtaceae)	Uncommon; endemic to Central West NSW, Vulnerable, BC Act and EPBC Act
Persoonia chamaepeuce (Proteaceae)	Rare, disjunct; western-most range limit
Philotheca salsolifolia subsp. *salsolifolia* (Rutaceae)	Locally uncommon
Tetratheca bauerifolia (Elaeocarpaceae)	Locally uncommon, disjunct; northern and western-most range limit
Thelymitra circumsepta (Orchidaceae)	Rare, disjunct; western-most range limit

Conclusion

Acacia meiantha is confined to three locations within the Central West of NSW forming discrete subpopulations. Tantalising questions remain as to why this species is so restricted in the landscape when it occurs in contrasting geological and soil habitats and a range of vegetation communities. Taxonomically the species appears robust, but nothing is known of its genetic diversity either within or between subpopulations. The recruitment behaviour, reproductive biology and fire ecology of the species all remain data deficient.

The threatened species listing as Endangered under both State and Commonwealth legislation is warranted because it does not occur on any conservation lands, has restricted distribution and abundance and has vulnerability to ongoing threats. It occurs at three locations (< 5), has an estimated EOO of 2,900 km^2 (< 5,000 km^2) and an AOO of 80 km^2 (< 500 km^2) (figures in parentheses are IUCN (2019) thresholds) and has significant threats to the extent and quality of habitats. Additional opportunities exist for improving the conservation of the species over and above those outlined in the site-managed initiatives of the Saving our Species program.

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