Date of Publication:
October 2018

Cunninghamia

A journal of plant ecology for eastern Australia

The Royal Botanic Garden Sydney

ISSN 0727-9620 (print) • ISSN 2200-405X (Online)

Angophora subvelutina (Myrtaceae) on atypical diatreme habitat at Glenbrook : an addition to the eucalypt list for the Greater Blue Mountains World Heritage Area

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***Abstract*:** The Greater Blue Mountains World Heritage Area (GBMWHA), a natural area of about one million hectares immediately west of Sydney, Australia, is significant for its biodiversity, and particularly for its richness of eucalypt species (species of *Eucalyptus*, *Angophora* and *Corymbia* in the family Myrtaceae), numbered at 96 species in 2010. This paper describes the finding of a previously unlisted *Angophora* species in the GBMWHA, and makes a conservation assessment of the population. A population of the Broad-leaved Apple *Angophora subvelutina* F. Muell. occurs at Euroka Clearing south of Glenbrook just within the eastern edge of Blue Mountains National Park, one of the eight conservation reserves that make up the GBMWHA. The population numbers over 200 plants and there is evidence that the species has been present at the site since before European settlement. The population includes a mixture of age classes and is considered viable, although substantial intergradation is occurring with the closely related species *Angophora floribunda*. Elsewhere in the Sydney area, the species is relatively uncommon and has been extensively cleared from its relatively fertile habitats. The population in the GBMWHA noted here has conservation significance for its size and long history at the site, and for the unusual ecological conditions of the Euroka diatreme, which is an atypical habitat for the species.

***Cunninghamia* (2018) 18: 073-078**
doi:10.7751/cunninghamia.2018.18.004

Introduction

The Greater Blue Mountains was inscribed on the World Heritage List in 2000 for its outstanding natural values, a major component of which is the high number of eucalypt species and eucalypt-dominated communities (the term 'eucalypt' refers to the closely related genera *Eucalyptus, Angophora* and *Corymbia* of the family Myrtaceae). In 2000, 91 eucalypt species were known from the Greater Blue Mountains World Heritage Area (GBMWHA). A subsequent assessment of the eucalypts in the eight conservation reserves which make up the GBMWHA (Blue Mountains, Gardens of Stone, Kanangra-Boyd, Nattai, Thirlmere Lakes, Wollemi and Yengo National Parks and Jenolan Karst Conservation Reserve) listed 96 eucalypt species (Hager & Benson 2010).

The number of eucalypt species recognised in the area is likely to fluctuate given the somewhat equivocal nature of systematic description and changes in the state of scientific knowledge, particularly with the increased application of genetic research. For example, Rutherford et al. (2018), in a genetic study, suggested that at least one of the eight green-leaved ashes (*Eucalyptus cunninghamii*) in the GBMWHA (Hager & Benson 2010) showed distinct genetic variation between populations warranting recognition of a new undescribed species, while two other species (*Eucalyptus laophila* and *Eucalyptus stricta*) could not be distinguished from each other.

A different situation applies to the finding of a population of a well-accepted existing species, not previously formally recorded in the GBMWHA. Such species may be found in areas that have remained inadequately explored botanically or within lands that are subsequently added to the GBMWHA. The species may also be very rare in the GBMWHA, with only one or two obscure previous records that have gone unrecognised.

In 2017 Peter Smith noticed that *Angophora subvelutina* F.Muell. (Broad-leaved Apple) was not included in the list of GBMWHA eucalypts in the foyer of the World Heritage Exhibition at the Blue Mountains Cultural Centre, Katoomba. The species is also not included in the GBMWHA eucalypt list of Hager & Benson (2010). Peter and Judy Smith recalled that *Angophora subvelutina* occurred at Euroka Clearing, Glenbrook, just inside the eastern boundary of Blue Mountains National Park and hence the GBMWHA.

Here, we confirm the presence of a previously unlisted (Benson & Hager 2010) eucalypt species (*Angophora subvelutina*) in the GBMWHA. We describe and assess the *Angophora subvelutina* population at Euroka Clearing, Glenbrook, and consider the long term viability of this population.

Distribution of *Angophora subvelutina*

Angophora subvelutina was first described by Ferdinand Mueller in 1858. It is a tree that typically grows to about 20 m high with persistent, grey, fibrous-flaky bark and adult leaves which are relatively broad, more or less sessile, and cordate at the base.

Angophora subvelutina usually grows on deep alluvial soils and may be locally abundant. It occurs at scattered locations, mainly east of the Great Dividing Range, from south-eastern Queensland south to the Bega district in southern NSW. In NSW it has been recorded in the North Coast (NC), Northern Tablelands (NT), North Western Slopes (NWS), Central Coast (CC), Central Tablelands (CT), Central Western Slopes (CWS) and South Coast (SC) botanical subdivisions, south to the Araluen district (PlantNET NSW Flora Online 2018). Intergrades with the closely related species *Angophora floribunda* are known from the NWS, CC, CWS and SC, and also occur beyond the known distribution of *Angophora subvelutina* in the Bega district of the far SC, and in the North Western Plains (NWP) (PlantNET NSW Flora Online 2018).

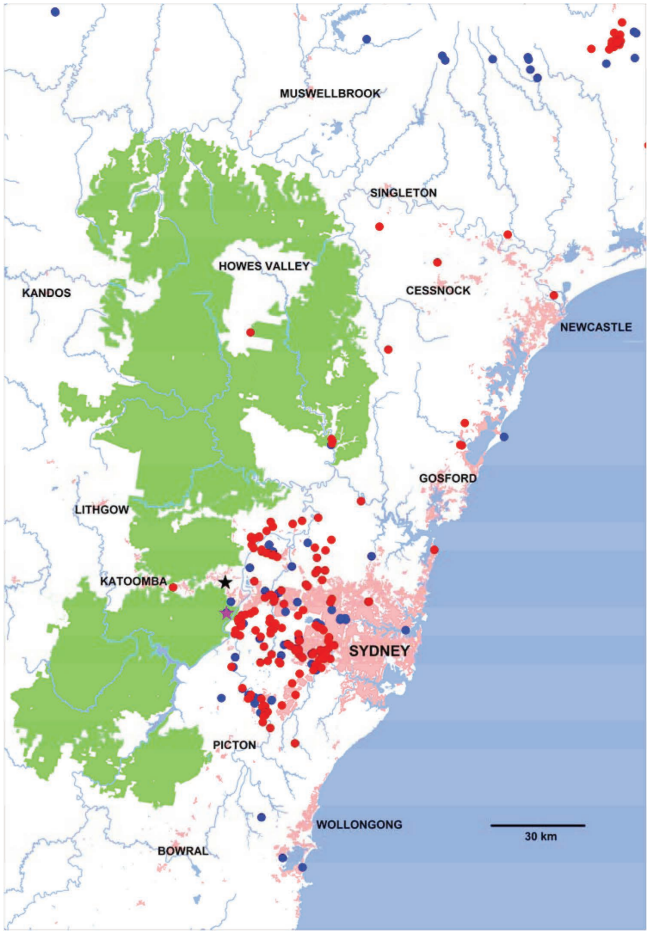

Fig. 1: Map of *Angophora subvelutina* records in the vicinity of the Greater Blue Mountains World Heritage Area. Records from Australasian Virtual Herbarium and NSW BioNet databases, extracted 27 July 2018. Red circles, records from 2000 or later; blue circles, records before 2000; purple star, Euroka Clearing; black star, Sun Valley. Records with inexact locations have not been mapped.

In the Sydney area, specimen records from the Australasian Virtual Herbarium (2018) and sightings records from the NSW BioNet Atlas (2018) indicate that *Angophora subvelutina* is mainly associated with river and creek systems on the Cumberland Plain (Fig. 1). It is found in floodplain forest and on creek banks on deep fertile alluvial soils, but may also

be associated with shale-derived soils with medium to high nutrient levels. In floodplain forest, associated tree species may include *Eucalyptus baueriana, Eucalyptus tereticornis, Eucalyptus amplifolia* and *Eucalyptus botryoides x saligna* (Benson & McDougall 1998). Most of its original habitat on the floodplains has now been cleared or severely degraded; James et al. (1999) regarded its regional conservation status in western Sydney as Vulnerable. *Angophora subvelutina* is a characteristic species of 'River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions', which is listed as an Endangered Ecological Community under the NSW *Biodiversity Conservation Act 2016* (NSW Scientific Committee 2011).

Study Area

Our study was undertaken at Euroka Clearing in Blue Mountains National Park, 2.5 km south of the township of Glenbrook. Euroka Clearing is a large semi-cleared area in a circular valley on a volcanic diatreme. Euroka Creek and its tributaries traverse the valley and drain to the Nepean River, some 800 m to the east. It is a popular camping area and is managed as such by NSW National Parks and Wildlife Service. Tree species in the remnant forest at Euroka Clearing include *Allocasuarina torulosa*, *Casuarina cunninghamiana*, *Angophora bakeri, Angophora floribunda*, *Angophora subvelutina*, *Corymbia eximia*, *Eucalyptus agglomerata*, *Eucalyptus beyeriana*, *Eucalyptus deanei*, *Eucalyptus eugenioides*, *Eucalyptus fibrosa*, *Eucalyptus punctata*, *Eucalyptus saligna*, *Eucalyptus tereticornis* and *Syncarpia glomulifera*. The vegetation on this diatreme is notable for the diversity of tree species and for its Cumberland Plain influences.

Methods

On 27 June 2017, Peter and Judy Smith collected a specimen (including adult leaves and fruiting capsules) of a tree at Euroka Clearing that they had identified as *Angophora subvelutina* (Broad-leaved Apple). The specimen tree (Fig. 2) was growing on the cleared slope on the eastern side of Euroka Creek, upstream of where the creek makes a right-angle bend. Its height was measured with a clinometer as 15 m on 8 February 2018 and it appeared healthy. The GPS coordinates of the tree were -33.799102, 150.618715 (GDA94 datum). The elevation of the tree was about 85 m asl (determined from a 10 m GIS contour layer). The specimen was given to the National Herbarium of NSW, Royal Botanic Gardens Sydney for identification.

On 8 February and 28 March 2018, Peter and Judy Smith carried out a series of field observations to provide an estimate of the size and age class structure of the *Angophora subvelutina* population at Euroka Clearing. It was soon noted that the population of *Angophora subvelutina* was intermixed with a population of *Angophora floribunda* and that a number of plants were intergrades between the two species. A random sample of 100 rough-barked *Angophora* plants was selected and each was identified to species (*Angophora subvelutina, Angophora floribunda* or intergrade) and classified as a tall tree, low tree (mature tree less than two-thirds the height of the tallest trees) or sapling. Intergrades were identified on leaf characters: leaves that were intermediate between the cordate, virtually sessile leaves of *Angophora subvelutina* and the cuneate, petiolate leaves of *Angophora floribunda*, or else leaves that were a mixture of the two leaf types. A rough estimate was made of the total number of rough-barked *Angophora* plants at Euroka Clearing.

On 27 July 2018, Peter Smith collated and mapped previous *Angophora subvelutina* records in and around the Greater Blue Mountains World Heritage Area. Records were obtained from the specimen database of the Australasian Virtual Herbarium (2018) and the sightings database of the NSW Bionet Atlas (2018).

Fig. 2: *Angophora subvelutina* tree (closest to camera) at Euroka Clearing, Blue Mountains National Park, from which a specimen has been lodged at the National Herbarium of NSW.

Results

The National Herbarium of NSW confirmed that the specimen collected at Euroka Clearing in June 2017 was indeed *Angophora subvelutina.*

The database searches revealed only a single previous record that definitely came from within the GBMWHA: a specimen at the National Herbarium of NSW that was collected at Euroka Clearing by T.M. Whaite in 1952. This specimen was from a "tree 20 ft [6 m], bark stiffly fibrous …. on breccia by creek". There is also a specimen at the N.C.W. Beadle Herbarium, University of New England, collected at "Glenbrook" by T.J. Hawkeswood in 1975, which may have come from Euroka Clearing.

Another record of interest is a 2005 sighting in the Bionet Atlas with coordinates (no description of the location but coordinate accuracy reported as within 30 m) that place it in the Putty Road corridor where it passes through Yengo National Park just north of the Putty Valley Road turnoff, near the head of Snakes Valley Creek. This record warrants further investigation but, if correct, then *Angophora subvelutina* likely occurs within the GBMWHA at this location.

There is also a cluster of four records (one undated specimen and three 2006 BioNet sightings) along the Macdonald River near St Albans, close to the boundary of Yengo National Park. However, the *Angophora subvelutina* population along the river may be restricted to the floodplain outside the GBMWHA.

Another sighting of *Angophora subvelutina* in the BioNet Atlas is from the railway corridor near Bullaburra station in 2011, close to Blue Mountains National Park. This is an unlikely location for the species and, if correct, is probably not a natural occurrence. There are also duplicate *Angophora subvelutina* specimens at the National Herbarium of NSW and the National Herbarium of Victoria that were collected at "Mt Victoria" by J.H. Maiden in 1901. This is another unlikely location for the species but is probably either an error or refers to the general Mt Victoria district rather than the immediate vicinity of the township itself (which is surrounded by Blue Mountains National Park). The specimen was possibly collected in the nearby Kanimbla Valley or Hartley Valley, outside the GBMWHA.

From our fieldwork in February and March 2018, we estimated that the combined population of *Angophora subvelutina*, *Angophora floribunda* and intergrades at Euroka Clearing numbered over 500 individuals, with most individuals found along or near Euroka Creek and its tributaries. The three entities were intermixed and we could see no obvious habitat differences between them.

Based on our sample of 100 plants, the rough-barked *Angophora* composition at Euroka Clearing consisted of 43% *Angophora subvelutina*, 32% *Angophora floribunda* and 25% intergrades (Table 1, Fig. 3). On this basis, we estimate the size of the *Angophora subvelutina* population at Euroka Clearing at over 215 plants. The *Angophora subvelutina* population was of mixed sizes and 19% of the population consisted of saplings of various ages. The population also included some very large old trees, and one notable example had a height of 37 m and a trunk diameter of 1.65 m (Fig. 4). There was pronounced intergradation between the *Angophora subvelutina* and *Angophora floribunda* populations, with about three intergrade plants to every five *Angophora subvelutina* plants.

Table 1: Rough-barked *Angophora* composition at Euroka Clearing in February-March 2018, based on a sample of 100 plants.

Species	Tall trees	Low trees	Saplings	Total
Angophora subvelutina	21	14	8	43
Angophora floribunda	17	13	2	32
Intergrades	13	5	7	25
Total	51	32	17	100

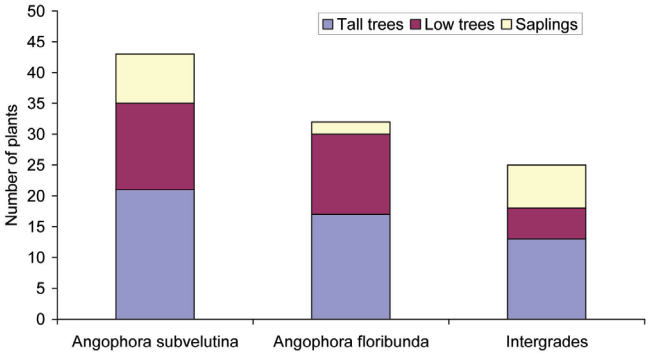

Fig. 3: Rough-barked *Angophora* composition at Euroka Clearing in February-March 2018, based on a sample of 100 plants.

Fig. 4: Large old *Angophora subvelutina* tree at Apple Tree Flat, Euroka Clearing, Blue Mountains National Park. The tree is about 37 m tall, with a diameter at breast height of about 1.65 m. It likely pre-dates European settlement.

Discussion

We have confirmed the presence of a population of *Angophora subvelutina* at Euroka Clearing, Glenbrook in Blue Mountains National Park and thus the Greater Blue Mountains World Heritage Area. The *Angophora subvelutina* population at Euroka Clearing numbers over 200 plants and has clearly been there for a long time. A specimen was collected from the site in 1952 and the population includes a number of trees which are likely to pre-date European settlement, such as the tree in Fig. 4. The long history of the species at the site, the size of the population in February and March 2018, and the range of age classes present, indicate that it is a viable population, despite substantial local hybridisation with another species at the site, *Angophora floribunda.*

This species should now be added to the formal list of eucalypts in the GBMWHA. *Angophora subvelutina* is a well known and accepted species. Its late addition to the GBMWHA eucalypt list highlights the fact that the GBMWHA, an area that is internationally renowned for its biodiversity, remains inadequately explored and documented botanically. Far too few botanists have been afforded the opportunity to work in this area.

The diatreme at Euroka Clearing is an unusual ecological site for *Angophora subvelutina*. It has a creek system but is not a floodplain. The Nepean River is nearby but runs through a gorge and has only a narrow floodplain in this vicinity. The slopes around the diatreme are on sandstone geology and there is a remnant shale cap on the surrounding ridge. The high nutrient soils of the diatreme, together with the influence of the surrounding sandstone and shale geology, appear to provide suitable conditions for both *Angophora subvelutina* and *Angophora floribunda*, as well as for an unusually large number of other eucalypt species that occur at the site. We have also observed *Angophora subvelutina* and *Angophora floribunda* growing together at Campbells Ford beside the Nepean River in Gulguer Nature Reserve east of the GBMWHA.

Angophora subvelutina also occurs on another large diatreme at Sun Valley, about 10 km north of Euroka Clearing, outside the GBMWHA (Fig. 1). Similarly to Euroka Clearing, both *Angophora subvelutina* and *Angophora floribunda* are present at Sun Valley, with evidence of intergradation between them (Andrew Orme, pers. comm.). The Sun Valley diatreme is a semi-rural area with many houses. The remnant forest on this diatreme, which is dominated by *Eucalyptus amplifolia* (Cabbage Gum), is listed as an Endangered Ecological Community, 'Sun Valley Cabbage Gum Forest in the Sydney Basin Bioregion', under the NSW *Biodiversity Conservation Act 2016* (NSW Scientific Committee 2001).

There is another, smaller diatreme, Machins Crater, about 5 km south-west of Euroka Clearing, within Blue Mountains National Park. Judy and Peter Smith inspected this diatreme on 12 September 2018. We found a single *Angophora floribunda* tree but no *Angophora subvelutina*. The diatreme supports relatively undisturbed forest dominated by *Eucalyptus deanei* (Mountain Blue Gum).

We conclude that the population of *Angophora subvelutina* at Euroka Clearing makes a valuable contribution to the biodiversity of the GBMWHA, as well as to conservation of the species in the general Sydney area. This is the only currently known population in the GBMWHA. Local populations in the Sydney area outside the GBMWHA are considered vulnerable as most floodplain forests have been cleared or severely degraded (Benson & McDougall 1998). We recommend that the Euroka Clearing population be monitored and managed to ensure its long-term viability. Although located within a national park that forms part of a World Heritage Area, the site where the population occurs is managed as a camping ground and day-use area, which may conflict with conservation management of *Angophora subvelutina*. Potential future threats to the population include climatic changes, inappropriate fire regime, lack of adequate regeneration, vegetation clearing, diseases such as the recently introduced Myrtle Rust, and genetic swamping through hybridisation with *Angophora floribunda*.

Acknowledgements

We gratefully acknowledge the assistance that we obtained during this study from Kristina McColl and Andrew Orme of the National Herbarium of NSW, Jacqueline Reid of NSW Office of Environment and Heritage, and local botanist Margaret Baker. Dr Peter Wilson of the National Herbarium of NSW confirmed the identification of the *Angophora subvelutina* specimen. Roger Lembit reviewed the manuscript and gave us helpful feedback. The Greater Blue Mountains World Heritage Advisory Committee was supportive of the study.

References

Australasian Virtual Herbarium (2018). Accessed 27 July 2018. https://avh.chah.org.au

Benson, D.H. (1992). The natural vegetation of the Penrith 1:100 000 map sheet. *Cunninghamia*, 2, 541-596.

Benson, D. & McDougall, L. (1998). Ecology of Sydney plant species Part 6: Dicotyledon family Myrtaceae. *Cunninghamia*, 5, 808-987.

Hager, T. & Benson, D. (2010). The eucalypts of the Greater Blue Mountains World Heritage Area: distribution, classification and habitats of the species of *Eucalyptus, Angophora* and *Corymbia* (family Myrtaceae) recorded in its eight conservation reserves. *Cunninghamia*, 11, 425-444.

James, T., McDougall, L. & Benson, D. (1999) *Rare Bushland Plants of Western Sydney*. Royal Botanic Gardens Sydney.

NSW BioNet Atlas (2018). Accessed 27 July 2018. http://www.bionet.nsw.gov.au

NSW Scientific Committee (2001). Final Determination to list the Sun Valley Cabbage Gum Forest in the Sydney Basin Bioregion as an Endangered Ecological Community on Part 3 of Schedule 1 of the Threatened Species Conservation Act, November 2001. Available from https://www.environment.nsw.gov.au/determinations/SunValleyCabbageGumForestSydneyEndComListing.htm

NSW Scientific Committee (2011). River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions – Determination to make a minor amendment to Part 3 of Schedule 1 of the Threatened Species Conservation Act, July 2011. Available from https://www.environment.nsw.gov.au/determinations/riverflat36a.htm

PlantNET NSW Flora Online (2018). Accessed 30 July 2018. http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Angophora~subvelutina

Rutherford, S., Rossetto, M., Bragg, J.G., McPherson, H., Benson, D., Bonser, P. & Wilson, P.G. (2018). Speciation in the presence of gene flow: population genomics of closely related and diverging *Eucalyptus* species. *Heredity,* 121, 126-141.

Manuscript accepted 1 October 2018