

## The natural distribution and ecology of a Blue Mountains shrub, *Epacris browniae* (Ericaceae)

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**Abstract:** The recently described shrub *Epacris browniae* (family Ericaceae) an endemic Blue Mountains species, occurs on treeless, dry, rocky, Sydney Montane Heath, on Narrabeen and Hawkesbury Sandstone in the upper Blue Mountains, 100 km west of Sydney, New South Wales, (c. 33° 40' S; 150° 22' E) at altitudes above 800 m, and within the 1300 mm Average Annual Rainfall isohyet. Based on our surveys in the Blue Mountains (incorporating 46 locations), the Area of Occurrence of the species is estimated at 525 square km, within which the Area of Occupation is 25 hectares. The northern limit is Mt Wilson, southern limit, Mt Solitary, western limit appears to lie between Clarence and Narrow Neck (Katoomba) and eastern limit is Lawson Ridge.

The species grows either on flat terrain or on gentle southern or western slopes, sometimes blending into escarpment complex, on soils of moderate acidity (pH 6.5–6.8) and good drainage, associated most commonly with *Banksia ericifolia* and, in descending order of abundance, with *Leptospermum trinervium*, *Allocasuarina distyla*, *Kunzea capitata*, *Allocasuarina nana* and *Hakea dactyloides*.

*Epacris browniae* flowers in November and seeds ripen in March. Seeds are shiny, brown, minutely warty, about 0.6 mm long, and weigh 0.038 mg.

*Epacris browniae* does not resprout after fire. Average stem diameters at three sites with known single fire histories correlate strongly with likely maximum age and confirm that the species is a facultative reseeder with a potential lifespan of up to 50 years.

Despite its relatively narrow habitat and area of occupancy *Epacris browniae* is well conserved within National Parks in the Blue Mountains but its susceptibility to *Phytophthora*, an exotic pathogen in the Blue Mountains is unknown.

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## Introduction

The recently described species *Epacris browniae* (family Ericaceae), is an erect woody or stiffly robust shrub 0.5 to 2 m high (Coleby 2015). Major identifying characteristics are almost glabrous branchlets, leaves that are stiff, spreading and broadly trullate, with a blunt upturned apex and a concave lamina (Figure 1). Flower buds emerge singly from the leaf axils all down the stems of new growth: they flower basipetally, mainly in November (Figure 2).

The habitat for the species is treeless, dry, rocky, Sydney Montane Heath, scrub and escarpment complex (BMCC 2002), on either Narrabeen or Hawkesbury Sandstone in the upper Blue Mountains, 100 km west of Sydney, New South Wales. Limited data on the ecology were provided in Coleby (2015) and this paper enlarges on aspects of the habitat, range, rainfall and fire ecology of the species.

## Methods

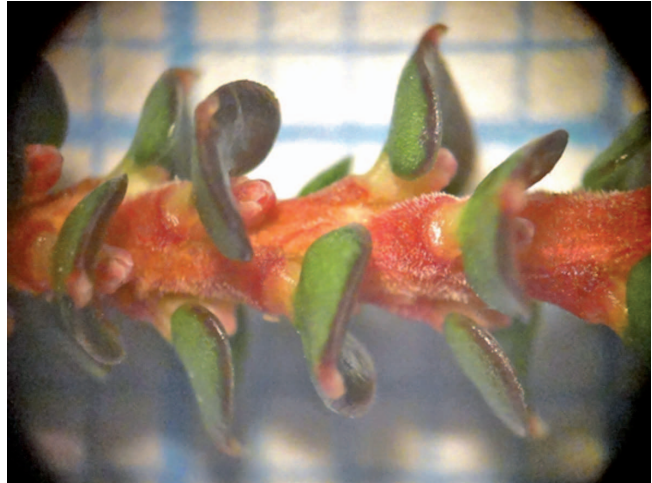
Sydney Montane Heath spans altitudes from 600 m to 1200 m, and has an open canopy of sclerophyll shrubs, 1–2 m tall, usually with emergent mallee eucalypts. There is often an open or patchy groundcover of sclerophyll sedges and herbs (Keith 2004). Using these habitat criteria, extensive searches for *Epacris browniae* populations were carried out in 2014 recording locations, map references, latitude/longitude, habits, habitats, plant associations and population abundance. Supplemented by data from 36 other sites discovered up to June 2015, the results were used to confirm the geographic range and distribution of the species, and associations with altitude, rainfall and geology.

The fire ecology of the species was given particular attention; it is a facultative reseed, killed by fire and potentially vulnerable to frequent burning regimes. The root system of an old plant that died during the investigations showed no sign of a lignotuber (Figure 4). It was found in an area that had not been burnt since the 1957 Leura fires and, assuming that it was part of the early post-fire recruitment, could have been up to 55 years old at the time of its death (in 2012). The diameter of the major woody stem was 30 mm. This fact suggested that if stem diameters at a site could be correlated with time since the last fire, a picture of the population dynamics of the species over periods of up to 50 years could be established.

Fire records on the Geographic Information System (GIS) of the NSW National Parks and Wildlife Service (NPWS) were examined. Older wildfire histories (before about 1960) are not necessarily accurate in terms of either spatial range or intensity, but wildfire histories in more recent decades are more reliable in terms of range. No indication of the intensity of wildfires is available.

A source of error in assessment of wildfire impact is the often patchy nature of a burn (Figure 3); some areas within the fire zone may be obliterated while, metres away, the adjoining terrain can be largely untouched. This feature can have a significant effect on the distribution of native plants. It may

be that the chance survival of some species in this situation allows both reseeders and resprouters to recolonise their terrain. In a few cases the GIS image for an area affected by wildfires of more than 2 per decade shows patchy later burns. Fire frequencies of more than 2 per decade may preclude adequate regrowth of either reseeders or resprouters.



**Figure 1:** *Epacris browniae*: almost glabrous branchlet, broad trullate spreading leaves with a blunt apex, robust petioles and axillary flower buds (Background scale is 1 mm).



**Figure 2:** *Epacris browniae*, basipetal inflorescence, November 2015.



**Figure 3:** Wildfire burn at Lincoln's Rock, Kings Tableland, Wentworth Falls, August 2015.



**Figure 4:** No sign of a lignotuber on old mature *Epacris browniae* plant.

Some 20 *Epacris browniae* sites were assessed for further study but most populations have experienced such complicated fire histories that assessments of age distributions could not be made. However, there were three sites where recent fire histories were straightforward (a fourth, Kings Table, was considered but rejected because of recent changes in human usage and management practices).

The three sites chosen for study were:

- **Flat Top summit, Mt Hay Road north of Leura** (33° 39' 21" S; 150° 22' 11.3" E), an area of several hectares of remnant Triassic Hawkesbury Sandstone last burnt in 2001-02. Some surrounding areas were burnt in 2002-03, but did not affect the summit. The age distribution of *Epacris browniae* on the summit of Flat Top could be up to 14 years.
- **Rocky Knoll on Bells Line of Road, 300 m west of Mt Charles** (33° 33' 14.5" S; 150° 22' 26.4" E), another remnant of Hawkesbury Sandstone. Its principal characteristic is its hardness. The western slope of the hard, smooth sandstone retains little or no soil, and the surface has been polished by wind and weather. This area was last burnt in 1993-94, and had not been previously burnt since 1979-80. Surroundings areas (such as Mt Charles itself) have been burnt at least once since 2000. The age distribution of *Epacris browniae* at Rocky Knoll could therefore span at least 20 years from 1994.
- **Sunset Rock on Kings Tableland (off Kedumba Road)**, (33° 45' 47.4" S; 150° 22' 19" E), a cliff-top site of Banks Wall Sandstone that experiences high orographic rainfall and has not been burnt for more than 50 years. It escaped burns in surrounding areas in 1964-65, 1977-78, 1988-89, 1999-2000, 2002-03, 2006-07 and 2015. The age distribution at this site could well be up to 50 years. There may be older survivors amongst the re-emergent population.

At least 48 plants in each population were sampled, but the nature of some habitats prevented a true random sampling. Instead an attempt was made to represent the size/age distribution of each population as accurately as possible. Each sample plant was measured for (a) height and (b) stem diameter 100 mm above ground level. Where multiple stems were present the sum of their diameters was recorded. For each location the average stem diameter (with standard deviation and standard error of the mean) was calculated.

## Results

### *Geographic Range*

Using the habitat criteria for targeted searches, populations of *Epacris browniae* were recorded at 46 locations in the upper Blue Mountains 100 km west of Sydney. The northern limit is Mt Wilson, and the southern limit is Mt Solitary. The western limit appears to lie between Clarence and Narrow Neck (Katoomba). The eastern limit appears to be Lawson Ridge. The Area of Occurrence was estimated at 525 square km (Figure 5) within which the Area of Occupation was 25 hectares.

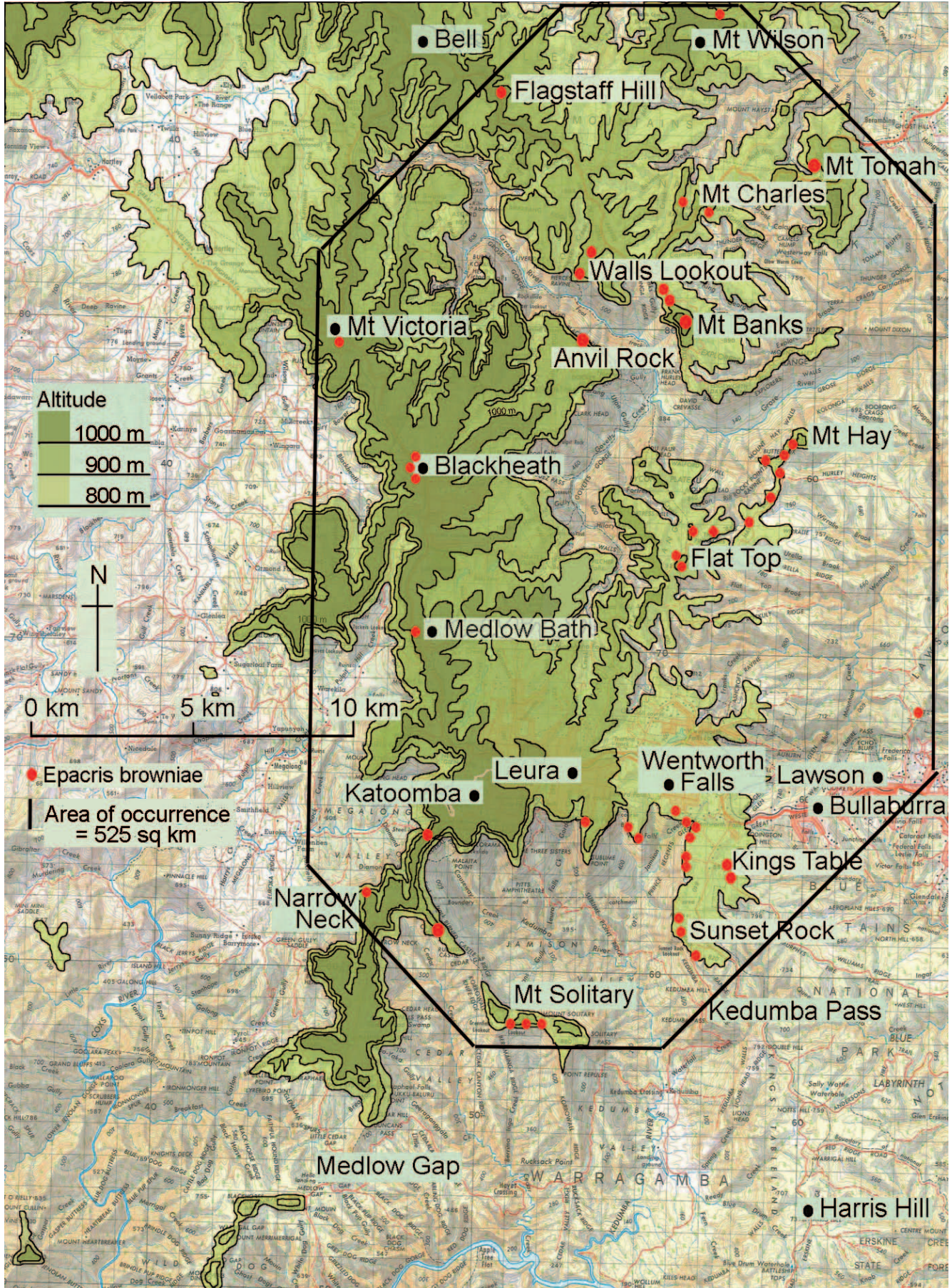
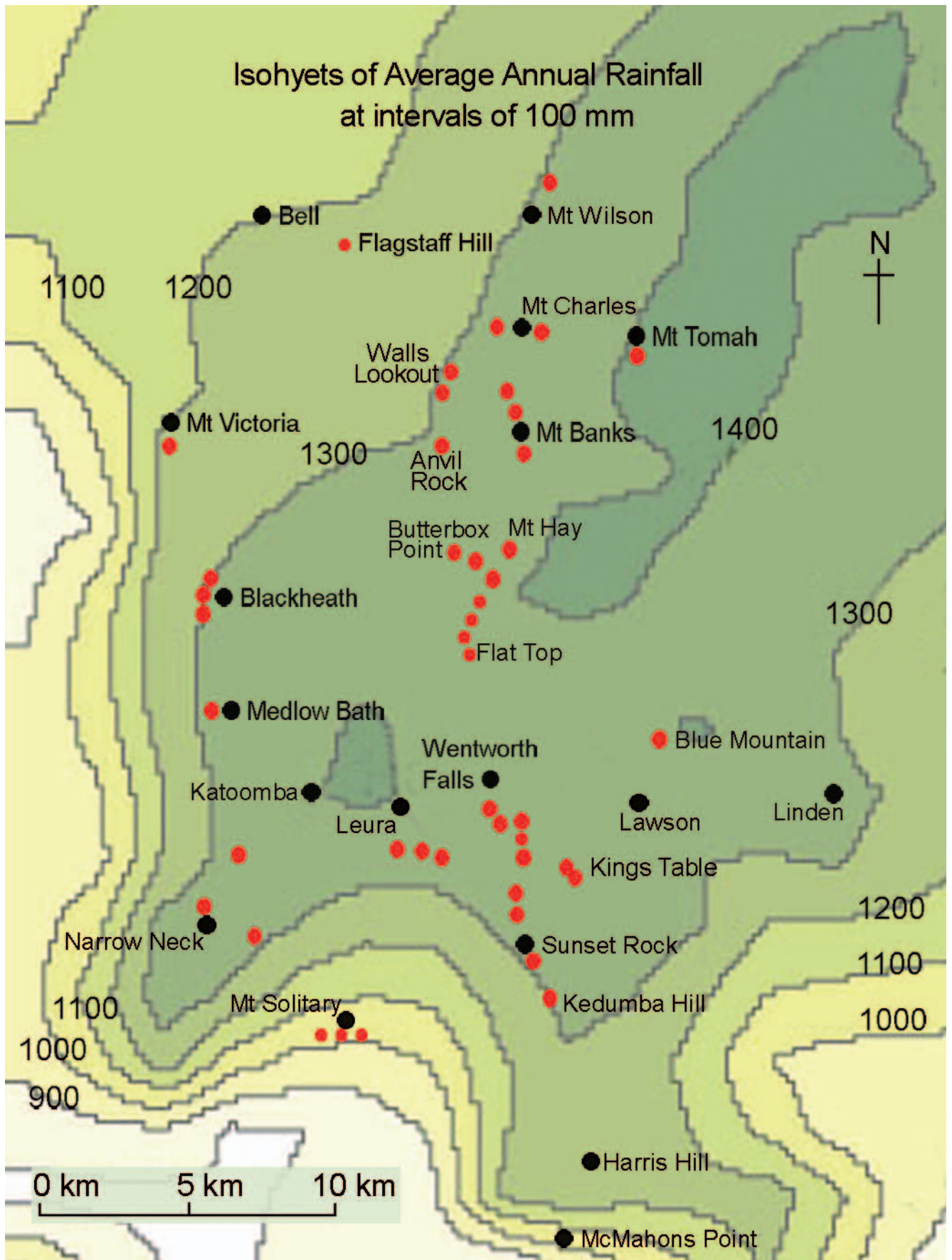


Figure 5: Occurrences (red dots ●) of *Epacris browniae* in the upper Blue Mountains, showing geographic correlation with altitude, and Area of Occurrence.



**Figure 6:** Occurrences (red dots ●) of *Epacris browniae* in the upper Blue Mountains, showing geographic correlation with average annual rainfall.

### Altitude

Occurrences of *Epacris browniae* correlate strongly with altitudes over 800 m (Figure 5) with populations recorded between elevations of 800 m and 1100 m. (A few small map areas northwest of Bell exceed 1100 m: they are not shown in Figure 5.) Further searches of suitable habitat may extend this geographic range, but the evidence indicates that the species is endemic to the upper Blue Mountains. North and east of Mt Wilson and Mt Tomah, in the Wollemi National Park, might also be suitable habitat. However, this remains unresolved because of rugged terrain and lack of access.

### Rainfall

Populations of *Epacris browniae* occupy habitat that receives relatively high rainfall and are almost wholly within the 1300 mm isohyet of average annual rainfall (Figure 6) derived from a larger sketch map (BoM 2015) based on Standard 30-year Climatology 1961–1990.

The inference that might be drawn from Figure 5 is that more *Epacris browniae* might be found in Blue Mountains National Park north and east of Lawson, where the average annual rainfall is still over 1300 mm. However, except for one outlying occurrence near the summit of Blue Mountain (725 m), none was found at these lower altitudes (approximately 600–700 m) during a search of Sydney Montane Heath along Queens Road, Binnowie Drive, and out to the lookout overlooking the junction of Mt Hay Creek and Wentworth Creek adjoining the Kolonga Labyrinth. This suggests that both altitude and high rainfall contribute to suitable habitat.

### Geology

The Blue Mountains is an uplifted, tilted and dissected peneplain stretching from low (150 m) elevation in the east near Penrith, to high (1100 m) in the west near Lithgow. The relatively soft Wianamatta Shales have all been eroded from the upper Blue Mountains, and the underlying Hawkesbury Sandstone survives in only a few patches, (such as at Rocky Knoll and at Flat Top). Populations of *Epacris browniae* occur either on the upper members of the Narrabeen Group or on the Hawkesbury Sandstone. The distribution does not encompass the adjacent basalt caps, as these have sufficiently fertile soils to support Tall Forest, a habitat where *Epacris browniae* does not grow.

*Epacris browniae* grows in Sydney Montane Heath either on flat terrain or on gentle southern or western slopes, sometimes blending into Escarpment Complex; its preference is for dry rocky outcrops. It copes well with open sunny sites and dense montane scrub alike. It favours thin, rocky soils of moderate acidity (pH 6.5–6.8) and good drainage. Soil types are predominantly clayey sands, varying from buff to russet to grey in colour, deriving from Triassic Narrabeen or Hawkesbury Sandstone. These sandstones give rise to free-draining, sandy, depauperate siliceous soils of low phosphorus and clay content, typically yellow podsols and earths, lithosols and colluvial scree (BMCC 1997).

One of the more extreme habitats for *Epacris browniae* is on the south-western flank of Rocky Knoll, near Mt Charles (Figure 7). Sparse open vegetation of stunted shrubs survives in cracks and fissures but, surprisingly, the most abundant species is *Epacris browniae* which not only thrives in this habitat, but outcompetes other common species such as *Banksia ericifolia*, *Hakea dactyloides* and *Leptospermum trinervium*. *Epacris browniae* at this site appears to benefit from association with mosses and lichens.



**Figure 7:** Rocky knoll site 300 m west of Mt Charles, last burnt about 20 years ago.

### Population sizes

Large populations of *Epacris browniae* inhabit the northern end of Kings Tableland, southeast from Wentworth Falls (especially on Kings Table (about 1 ha) and along Kedumba Walls). Accessible sites include Lincolns Rock (1 ha), Podgers Hill and Sunset Rock (1 ha). One plant was found on the cliff line, southwest of Kedumba Hill, but none has been found further south.

Large populations were also found north of Leura on the summit and the surrounds of Flat Top (5 ha) and the whole of the high plateau (10 ha), from the end of the Mt Hay Road, north to Mt Hay and west to Butterbox Point. Other major sites are at Mt Banks (0.2 ha), Walls Lookout, Mt Wilson, Mt Tomah and Rocky Knoll (1 ha) near Mt Charles.

Along Narrow Neck Plateau, south of Katoomba there is a significant but scattered population (0.1 ha) on and around the approaches to Castle Head and Castle Cliff trig (986 m elevation). This location is about 8 km from Katoomba railway station, and is on the edge of the 1300 mm isohyet. *Epacris browniae* was not found further south along Narrow Neck. Large populations were found in southern escarpment complex on the summit of Mt Solitary.

Large populations (0.2 ha) were found in Sydney Montane Heath north and south of Fort Rock in Blackheath, and in areas of high tourist traffic along Sir H Burrell Drive, and the track down to and including Fletchers Lookout in Wentworth Falls.

Small populations (1–10 plants), were found on clifftops at Moya Point and on the Scout Trail north from Inspiration Point in south Leura, on a small rocky outcrop at the end of Delmonte Avenue west of Medlow Bath, and on the summit of Flagstaff Hill near Bell. A single plant was found on the west of Sublime Point in south Leura.

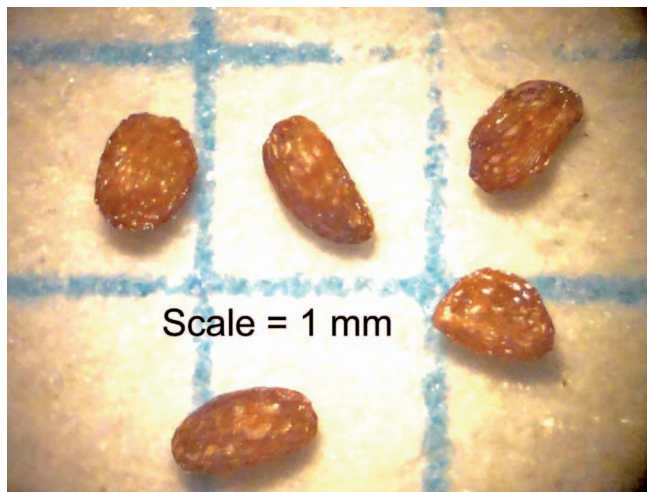
#### Associated species

*Epacris browniae* is associated most commonly with shrubs: *Banksia ericifolia* (95%) and, in descending order of importance, with *Leptospermum trinervium*, *Allocasuarina distyla*, *Kunzea capitata*, *Allocasuarina nana* and *Hakea dactyloides* (40%). Other associated shrub species include *Boronia floribunda*, *Epacris rigida*, *Conospermum taxifolium*, *Mirbelia rubioides* and *Dillwynia retorta*.

#### Reproduction

*Epacris browniae* flowers principally through November with seeds ripening in March. Like many other *Epacris* species, it has small brown seeds in papery capsules of relatively short persistence on the plant. Seeds are about 0.6 mm long, elliptical, hard, brown, shiny and minutely warty, and shaped like a miniature, half-inflated rugby football (Figure 8). Mean seed weight is 0.038 mg (pers. comm. Richard Johnstone, Seed Bank Officer, Australian Botanic Garden, Mt Annan). Howell (PlantNET) reports that seeds of a similar species, *Epacris microphylla*, weigh 0.03 mg.

Nothing is known about seed dispersal vectors for *Epacris browniae*, but local dispersal by gravity, wind and water are probably significant, possibly aided by small insects. Nothing is known about seed longevity, dormancy, germination requirements, time to first flowering and time to first fruiting, although some of these features may be resolved by observations on Kings Tableland, Wentworth Falls following the August 2015 fire (which burnt some 500 ha of bush, including populations at Lincolns Rock (Little Switzerland Road) and Podgers Hill (ANF)).

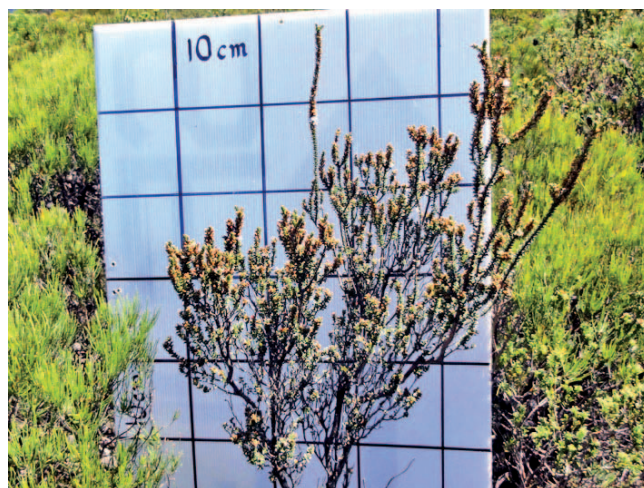


**Figure 8:** Seeds of *Epacris browniae*; mean seed weight is 0.038 mg.

#### Fire response

*Epacris browniae* does not spread vegetatively and since there is no lignotuber in young or mature plants it is unlikely to resprout after fire. For example there have not been any resprouting *Epacris browniae* plants at Podgers Hill: Figure 9a shows *Epacris browniae* before the fire of 1 August 2015, and Figure 9b shows the same site in December 2015, four months after the fire. The obvious regrowth is that of *Eucalyptus stricta*, and monocots. It is therefore considered a facultative seeder that relies on a long-term soil seedbank that survives fire.

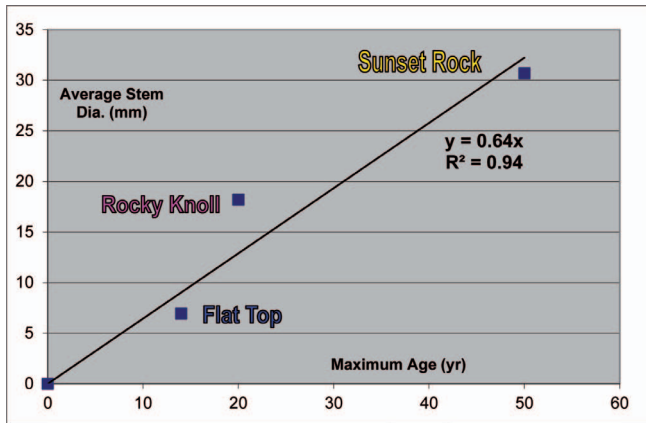
Some reseeder species may include a small percentage of plants that survive fire and resprout, especially where the rootstock is buried sufficiently deeply to avoid being burnt, or where the fire has been either low intensity or patchy (Burrows 1995, Auld 1996). A population of plants may exhibit some very old plants from before the last fire but there is no way of identifying this feature unless some burnt remains persist; none was found on any plants we measured.



**Figure 9a:** *Epacris browniae* at Podgers Hill, December 2013.



**Figure 9b:** The same view as Figure 13a at Podgers Hill, December 2015.



**Figure 10:** Average Stem Diameter vs. Maximum Age.

Assuming it is a facultative reseeder, the size distributions of stem diameters in three populations of *Epacris browniae* (Figure 10) indicate a correlation of average stem diameters with population age with a reasonable degree of confidence. Thus, one could measure the average stem diameter in a

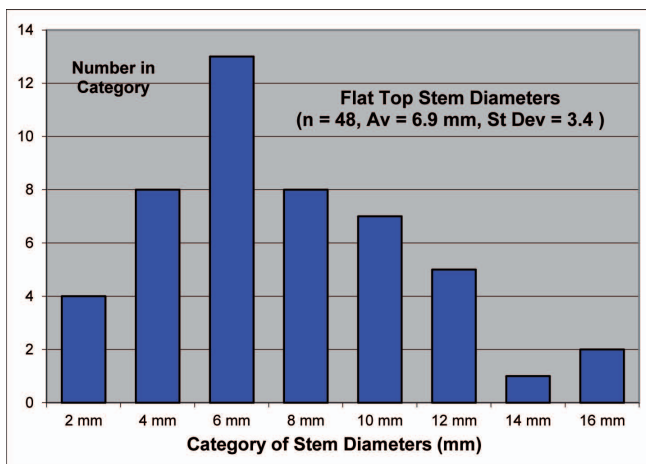
population of *Epacris browniae* and then deduce its likely maximum age. Our results indicate that plants can live to over 50 years. This approach might also be applicable to other perennial species.

*Longevity*

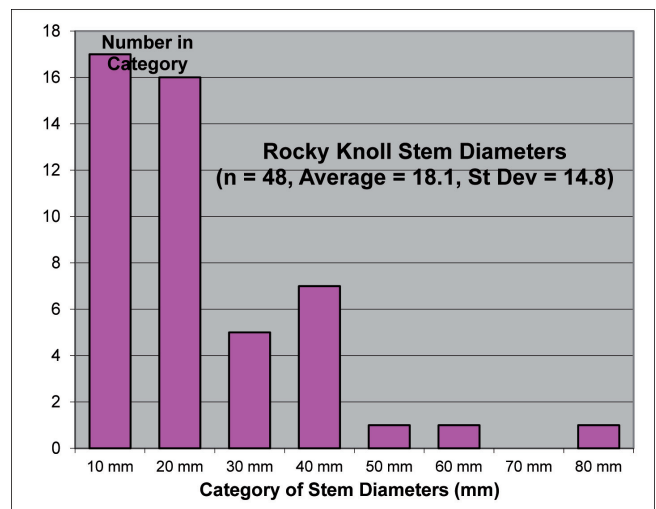
For each of the three sites with known single fire history, the numbers of plants were plotted against stem diameters measurements. In each case the average number in a given stem diameter category was calculated along with the standard deviation and the standard error of the mean (Table 1). No significant relationships were found for plant height, which can vary according to individual position and exposure. The stem diameter measurements are a more realistic guide to plant age and correlations with likely age are shown for Flat Top (Figure 11), Rocky Knoll (Figure 10) and Sunset Rock (Figure 13). Figure 12 shows the average stem diameter for each of the three populations against their likely maximum age. The slope of the plot is 0.64, and  $R^2 = 0.94$ .

**Table 1:** Statistical data for *Epacris browniae* from three sites; average stem diameter, standard deviation, standard error of mean, range of stem diameter, number of plants in each sample, and known maximum age based on last fire event.

	Av Stem Diameter (mm)	Standard Deviation of Average	Standard error of mean	Range of Stem Diameters	Number of Plants (n) in sample	Known Maximum age (yr)
Flat Top	6.94	3.4	0.5	2–15	48	14
Rocky Knoll	18.2	14.8	2.1	2–72	48	20
Sunset Rock	30.7	38.7	4.7	1.5–239	72	50

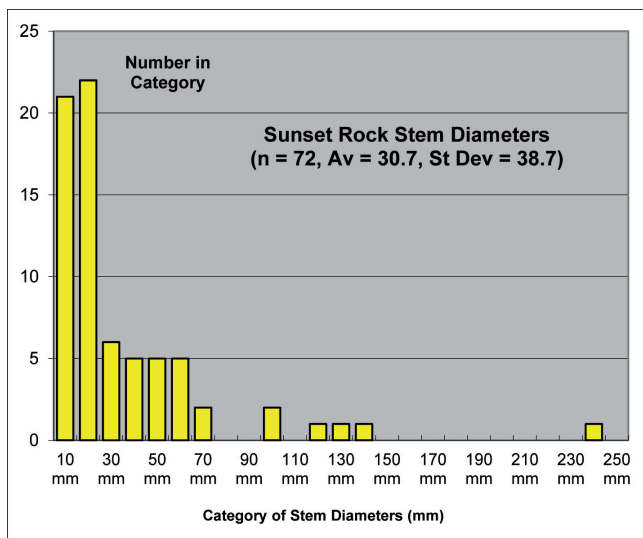


**Figure 11:** Histogram of Flat Top Stem Diameters.



**Figure 12:** Histogram of Rocky Knoll Stem Diameters.





**Figure 13:** Histogram of Sunset Rock Stem Diameters.

## Discussion

### *Habitat comparison with Epacris obtusifolia*

*Epacris browniae* does not grow in association with trees, nor in swamps, soaks, bogs, fens or any other wet places. In contrast *Epacris obtusifolia* grows over a far greater range of altitude and rainfall but predominantly in soils that remain wet for long periods. Such conditions occur in the upper Blue Mountains where there are high clay content soils within the 1300 mm isohyet of average annual rainfall. A localised example of the comparable habitat requirements of the two species is evident on the summit of Flat Top (929 m elevation) on the Mt Hay Road. Over several more or less flat treeless hectares, *Epacris browniae* and *Epacris obtusifolia* lie side by side in patches (metres in diameter), the former occupying slightly higher ground with better drainage, the latter preferring slight depressions with poorer drainage. Both species may also be found on the steep slopes of Flat Top, *Epacris browniae* where it does not get waterlogged, *Epacris obtusifolia* where it does. The two species flower together in early November, although at that time *Epacris obtusifolia* is coming to the end of its flowering period (normally September through October in the upper Blue Mountains).

### *Association with Epacris microphylla*

Along Little Switzerland Road (Wentworth Falls) *Epacris browniae* grows in tall Sydney Montane Heath alongside *Epacris microphylla* var *microphylla*, which occupies short Sydney Montane Heath. *Epacris microphylla* flowers mainly in September (although some nearby populations begin to flower in June). *Epacris browniae* flowers in November.

### *Association with Epacris rigida*

The closely-related *Epacris rigida* has a lignotuber and may be less dependent on seed for post-fire recruitment as

*Epacris browniae*. Both species are found together at Sunset Rock (Kings Tableland) and on the approaches to Mt Hay. *Epacris rigida* occurs alone on the steep smooth sandstone outcrop of Notts Hill (730 m) on Kings Tableland.

### *Comparison of geographic ranges of other Epacris species*

The natural geographic distribution of *Epacris browniae* is much smaller than that of *Epacris microphylla* var *microphylla*, a species within which it was formerly included. Whereas *Epacris browniae* is restricted to the upper Blue Mountains at altitudes above 800 m, *Epacris microphylla* var *microphylla* is widespread from coast to mountains, all along the eastern seaboard of NSW, and from Rockhampton in Queensland to the Victorian Alps and throughout Tasmania (PlantNET 2015, Australia's Virtual Herbarium 2015). *Epacris microphylla* var *microphylla* occupies swampy heath and drier coastal heath, two habitats that are inimical to *Epacris browniae*.

The geographic range of *Epacris browniae* is also much smaller than that of *Epacris brevifolia*, *Epacris gunnii*, *Epacris obtusifolia* and *Epacris pulchella*, all of which are found in the Blue Mountains, but extend to Queensland and (with the exception of *Epacris pulchella*), also extend to Victoria (AVH). Several other species of *Epacris* are commonly encountered in the Blue Mountains, of which *Epacris coriacea*, *Epacris rigida* and *Epacris purpurascens* var *onosmiflora* each have a distribution centred on Sydney and the Central Tablelands. Species such *Epacris muelleri* and *Epacris rhombifolia*, are much less common, though more widespread. *Epacris celata* is principally a species of the Victorian Alps and Kosciusko. All these species of *Epacris* (except for *Epacris obtusifolia* and *Epacris pulchella*) have flowers where the corolla tube is shorter than the sepals, and the lobes are as long as, or longer than the tube.

### *Conservation and management implications for Epacris browniae*

Despite its relatively narrow habitat and restricted area of occupancy *Epacris browniae* is well conserved within National Parks in the Blue Mountains; indeed because of the ruggedness of its habitat it is likely that most of its original presettlement (i.e. pre 1788) extent still remains. A general consideration however is that of possible change in both temperature and rainfall. As the rainfall isohyets of Figure 6 are relevant only for 1961-1990, subsequent changes (such as climate change) may invalidate conclusions concerning future rainfall patterns and effects upon the distribution of *Epacris browniae*.

Therefore although *Epacris browniae* is well conserved, the impact of frequent fire needs to be considered for some local populations. The other potential threat, particularly in the context of increasing temperatures and rainfall, is the spread of exotic pathogens such as *Phytophthora*; see for example Green (2016) for impacts on the shrub *Nematolepis ovatifolia* in Kosciusko National Park. The susceptibility of *Epacris browniae* is unknown.

## Conclusion

*Epacris browniae* is an upland species with habitat over 800 m elevation, average annual rainfall of over 1300 mm, good drainage, gentle southern or western slopes which may blend into Escarpment Complex. It inhabits the upper range of treeless Sydney Montane Heath. Soils are rocky, thin clayey sands derived from either Narrabeen or Hawkesbury Sandstones with pH 6.5–6.8. In these respects its habitat and range are more restrictive than those of its close relatives, *Epacris microphylla* var *microphylla* and *Epacris rigida*, and of its more distant relative *Epacris obtusifolia*.

Plants are robust, erect, woody or stiffly wiry, can tolerate exposure to wind and sun and are commonly 0.5 to 1.5 m high; in sheltered places (as in Escarpment Complex) old plants can attain 2 m and be up to 50 years old. It flowers mainly in November in the upper Blue Mountains, sets seed which ripens in March, and may be considered a facultative seeder.

## Acknowledgements

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