

Recent ecological observations on growth rates and seed production in *Isopogon prostratus* (Proteaceae), a little-known prostrate shrub from south-eastern NSW and Victoria

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Abstract: Observations on the longevity and ecology of *Isopogon prostratus* McGill. (Proteaceae) based on 1985 and 2009 field measures on Newnes Plateau, near Lithgow, and a seed germination trial are provided. Its survival strategy appears to be that of a stress-tolerator with long-term persistence at (relatively few) suitable sites, and it remains a relatively rare plant. It is conjectured that it is likely to have been a species of greater abundance in the drier, colder and generally treeless conditions of the Newnes Plateau 15–20 000 years ago, but, as conditions became warmer and wetter it has become reduced to isolated populations as taller shrubs outcompeted it for light.

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Introduction and Methods

Isopogon prostratus McGill.(Proteaceae) is a little-known prostrate shrub with natural sporadic, disjunct occurrences from Newnes Plateau near Lithgow at 1100 m elevation in the north, along the southern ranges and onto the coast at Eden and the Gippsland Plain in Victoria (Figure 1, 2). It is generally localised to small populations with little apparent reason for presence or absence except that occurrences are generally in heath on plateaus and ridges (Benson & McDougall 2000). The species is listed as endangered in Victoria (Department of Sustainability and Environment 2005).

The population at Newnes Plateau came to our attention in the 1978 during environmental surveys of the area. A localised population in Newnes State Forest near Bungleboori Picnic area (33° 24' S; 150° 12' E, elevation 1100 m) was found in an area partly cleared in preparation for pine planting (it was previously relatively undisturbed native woodland), and fenced off from the adjacent pine plantation.

In 1985, 58 plants (all that could be found) in the fenced area of about a hectare were tagged, and the maximum canopy spread of all individuals was measured. This measure included the distance to the end of the longest

branch. Branches spread radially and plants show no sign of vegetative spread such as layering or rooting along stems. In 2009 the site was revisited and individual plants relocated and their canopy spreads remeasured.



Fig 1. Inflorescence of *Isopogon prostratus* showing growing position at ground surface.

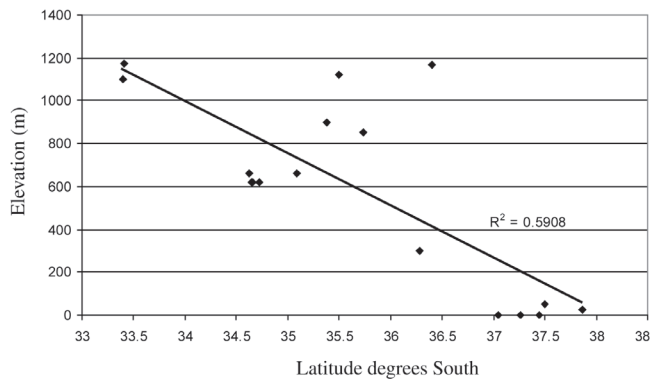


Fig 2. Relationship between elevation (m) and latitude for populations of *Isopogon prostratus*, based on herbarium collections.

In *Isopogon* the seeds are small one-seeded nuts held between persistent bracts that are tightly clustered in globular heads or cones. After fire the bracts open up releasing the nuts (Myerscough et al 2000). In 2009 cones were collected to test for seed viability. Cones along an individual branch from 10 plants were collected and dried to release the seeds. The maximum number of cones on any individual plant branch was 5. A total of 30 cones were collected and measured. Cones from 10 plants of *Isopogon anemonifolius* which commonly grows near *Isopogon prostratus*, were collected for comparison. Seed germination was carried out in a controlled environment cabinet set at 20° C with 12 hours light/dark.

Results

Since 1985 few additional individuals or populations of *Isopogon prostratus* have been recorded, either on Newnes Plateau, or over the species' general range.

In March 1985 the 58 marked and tagged individuals of the Newnes Plateau fenced population had canopy branch spreads ranging from 0.05–1.2 m (mean spread = 0.37 m se ± 0.04). In January 2009 spreads ranging from 0.2–3 m (mean = 0.94 m se ± 0.06).

It should be noted that during the January 2009 survey, only 3 of the original 58 metal tags attached to plants in 1985, were recovered. Remains of yellow plastic tape used in 1978 to mark plants were also found. Therefore, it is uncertain that the 58 plants inspected during the two survey periods (1985 and 2009) represent the same individuals, but it is likely that most of them are the same as all the observed plants had a substantial woody base or lignotuber, indicating longevity.

Based on canopy spread, the population size classes show a majority of small individuals (<0.25 m) in 1985, but by 2009 the majority fall within a larger class (0.76–1.0 m), with one individual up to 3 m across (Figure 3).

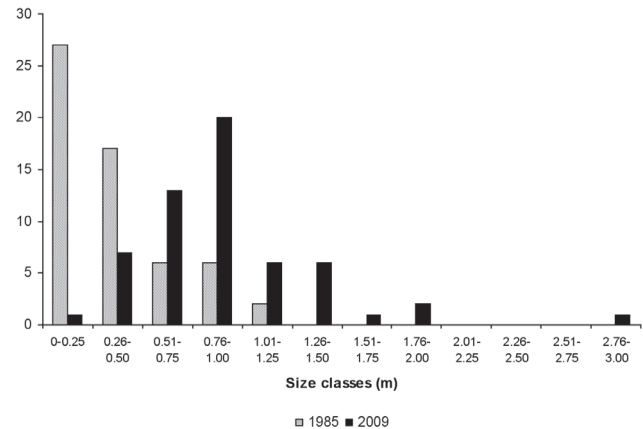


Fig 3. *Isopogon prostratus* size (canopy spread) classes in 1985 and 2009 for 58 plants in Newnes State Forest.

In 1978 the site had been roughly cleared and windrowed in preparation for pine planting, and existing plants may have been broken by scraping resulting in reduced canopy spreads. Small size does not necessarily indicate younger age. The site was described in 1978 as *the top end of sandy swamp in regenerating pine plantation with Eucalyptus dives and Eucalyptus radiata*. Since that time the fenced area has remained undisturbed except for the growth of the surrounding pine plantation, now 15 m in height, and the growth of native shrubs and grasses to 1 m high with a cover of 90% (mostly *Grevillea laurifolia*, *Phyllota squarrosa*, *Pteridium esculentum*, *Leptospermum polygalifolium*). Scattered trees of *Eucalyptus sieberi* and *Eucalyptus dives* to 10 m high are also present (Figure 4). There has been no fire or other disturbance over the 24 years since 1985 and probably over the 30 years since 1978.

Growth of *Isopogon* individuals takes place at the tips (10–20 cm) of long trailing branches (from 2–6 branches per plant) with flowering and fruiting cones produced periodically. In 2009 the majority of branches were buried in leaf litter and undergrowth. The tips however were found to have actively growing green leaves with some individuals flowering and fruiting this season despite relatively dry weather conditions. Individuals in full sun had more, but shorter branches, spreading radially whereas those under litter had fewer but much longer branches (generally only 1–2) as if spreading to reach more light.

The fruiting cones of *Isopogon prostratus* occur terminally on the current season's growth. The next vegetative growth flush occurs from just beneath the cone and forms an angular 'step' giving an indication of the number of growth seasons along a branch. The maximum number of these growth flushes observed was 12 so they do not necessarily represent annual growth. Older cones buried further back under the leaf litter had decomposed. The seeds are not released from the cone while still attached to the plant, but once cut from the plant, the cone opens readily and the hairy seeds fall out. They are likely to be released after fire as in *Isopogon*



Fig 4. *Isopogon prostratus* population site in Newnes State Forest in 2009.

anemonifolius (Bradstock & Myerscough, 1988). There is no obvious dispersal mechanism for the seed as it is located at ground level.

No evidence of juveniles or seedling recruitment of *Isopogon prostratus* was observed in the field. Bradstock (1991) found significant predation of seedlings of *Isopogon anemonifolius* in unburnt areas by unidentified animals, but this was not possible to determine at the Newnes site.

Comparison with Isopogon anemonifolius

Cones of *Isopogon prostratus* and the similar but erect shrub *Isopogon anemonifolius* were of similar size but *Isopogon prostratus* had nearly twice as many seeds per cone (41 ± 7) (Table 1).

Seed was produced from cones from a number of seasons/ growth flushes (up to 5) indicating pollination and seed set have been occurring, but seed release leading to germination has not been observed in the field. Under controlled conditions

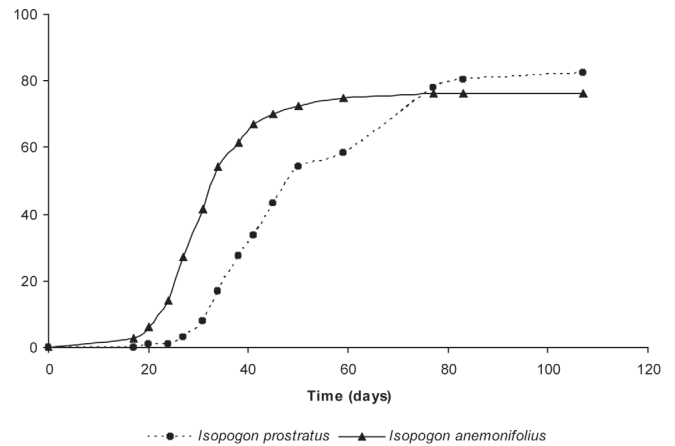


Fig 5. Seed germination of *Isopogon prostratus* and *Isopogon anemonifolius* over time in a controlled environment cabinet set at 20°C with 12 hours light/dark.



Fig 6. Seedling of *Isopogon prostratus* grown in glasshouse.

Table 1: Comparison of cone size and seed number for *Isopogon prostratus* and *Isopogon anemonifolius*

		<i>Isopogon prostratus</i>	<i>Isopogon anemonifolius</i>
Cone diameter (mm)	Maximum	27.4	25.1
	Minimum	13	17.2
	Mean (± s.e.)	19.6 (± 0.6)	20.1 (± 0.3)
	n	30	42
Seed number/ cone	Maximum	153	60
	Minimum	0	6
	Mean (± s.e.)	41 (± 7)	26 (± 2)

in the laboratory, seed germination for *Isopogon prostratus* began after 20 days and for *Isopogon anemonifolius*, after 17 days (Figures 5,6). Germination was quicker for *Isopogon anemonifolius* which finished by day 60, but *Isopogon prostratus* continued up to day 107. Both species achieved about 80% germination.

There was no difference in germination rates from different-aged cones collected from individual plants. Likewise there was no distinctive decline in seed viability for the different aged cones. In the field cones of *Isopogon prostratus* appear to decay more rapidly than those of *Isopogon anemonifolius*, as being on the soil surface, they are likely to be covered by litter and are more exposed to moisture and microbial activity.

Discussion

On the Newnes Plateau *Isopogon prostratus* is at its northern geographical limit and upper elevational limit. Individual plants are relatively long-lived with substantial lignotubers allowing them to survive an overstorey removal event (surface vegetation clearing) and to live at least 30 years under subsequent overstorey regrowth. The substantial lignotuber is likely to allow this regrowth to be repeated following disturbance e.g. in response to fire (though no burnt individuals have been observed) or other canopy destruction, giving a potential longevity of several to many times 30 years (perhaps 60–200 years). Mortality at this site is likely to occur as a result of physical disturbance of the lignotuber or disease.

The prostrate growth habit of *Isopogon prostratus* allows it to grow well in full sun or partial shade, while its long-lived lignotuber allows it to regenerate after physical disturbance (breaking, trampling) and fire. The germination trial indicates the Newnes population produces viable seed; therefore pollination and seed set are not limiting factors to its survival. Its poor dispersal ability presumably allows local occurrences to be maintained though no new individuals or evidence of seedling recruitment were evident in 2009, following several decades of general overstorey canopy growth, and absence of fire or disturbance. In terms of Grime's (2001) functional strategies the species is a Stress-tolerator. Its survival strategy is long term persistence at (relatively few) suitable sites, and as such, it remains a relatively rare plant.

Threatening processes for the long-term survival of *Isopogon prostratus* are direct destruction (through sand extraction, infrastructure and road construction) or physical damage of branches by trampling (through trailbikes, vehicles and vegetation clearing). Species of *Isopogon* in Western Australia and Victoria are susceptible to the root-rotting mould *Phytophthora cinnamomi*, and hence may be of concern for *Isopogon prostratus* if introduced to areas of known populations. Most of these threatening processes are likely to operate across its range.

Conjecture (for testing)

It is our conjecture that *Isopogon prostratus* is likely to have been a species of greater abundance in the drier, colder and generally treeless conditions of the Newnes Plateau at the time of the last glacial maximum 15–20 000 years ago (Hesse et al, 2003) (e.g. the hairy seed is more likely to have dispersed further by wind in drier open conditions), but has become reduced to isolated and disjunct populations as taller shrubs outcompeted it for light, as conditions became warmer and wetter. Its limited dispersal and current disjunct occurrences suggest it previously had a much more continuous distribution between Newnes Plateau and Victoria.

To test this, research on the tolerance limits of the species (maximum and minimum temperatures for growth, flowering, seedset, germination etc, moisture and light requirements) and levels of genetic variation is needed. Such work is likely to throw light on the dynamics of the species during the climatic changes of the last 20 000 years, and provide a sounder base for modelling likely future changes in vegetation patterns impacted by climate change.

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References

- Benson, D. & McDougall, L. (2000) Ecology of Sydney Plant Species Part 7b: Dicotyledon families Proteaceae to Rubiaceae. *Cunninghamia* 6(4): 1017–1202.
- Bradstock, R.A. (1991) The role of fire in establishment of seedlings of serotinous species from the Sydney region. *Australian Journal of Botany* 39: 347–356.
- Bradstock, R.A. & Myerscough, P.J. (1988) The survival and population response to frequent fires of two woody resprouters *Banksia serrata* and *Isopogon anemonifolius*. *Australian Journal of Botany* 36: 415–431.
- Department of Sustainability and Environment (2005) *Advisory List of Rare or Threatened Plants in Victoria–2005*. (Victorian Department of Sustainability and Environment: East Melbourne, Victoria).
- Grime, J.P. (2001) *Plant strategies, vegetation processes, and ecosystem properties* (John Wiley & Sons: Chichester)
- Hesse, P.P., Humphreys, G.S., Selkirk, P.M., Adamson, D.A., Gore, D.B., Nobes, D.C., Price, D.M., Schwenninger J.-L., Smith, B., Tulau, M. & Hemmings, F. (2003) Late Quaternary aeolian dunes on the presently humid Blue Mountains, Eastern Australia. *Quaternary International* 108: 13–32.
- Myerscough, P.J., Whelan, R.J. & Bradstock, R.A. (2000) Ecology of Proteaceae with special reference to the Sydney region. *Cunninghamia* 6(4): 951–1015.

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