SHORT COMMUNICATION

Status of the Vulnerable shrub *Astrotricha crassifolia* (Araliaceae) in Brisbane Water National Park, NSW: an update

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Abstract: A resurvey (previously surveyed 2003–04) of the northern metapopulation of the listed Vulnerable shrub *Astrotricha crassifolia* (family Araliaceae) near Gosford, New South Wales, revealed six additional small subpopulations nearby, bringing to nine the total number, all in Brisbane Water National Park. While the stem count of the previously measured sites remained largely the same, the discovery of further subpopulations has increased the total known stem number to 1211 stems, with an area of occupancy of only 385 m^2. The majority (nearly 80%) of these subpopulations are very small, directly adjacent to roads, and remain vulnerable to park management and maintenance practices.

Astrotricha crassifolia is surviving due to its successful rhizomatous growth, but may not be reproducing from seed. This paper recommends some changes to management to reduce potential threats.

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Introduction

Astrotricha crassifolia Blakely (family Araliaceae), an endemic New South Wales shrub (Benson & McDougall 1993), is listed as Vulnerable, both under the NSW *Threatened Species Conservation Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. It is only known to occur in two separate disjunct areas, a 'northern metapopulation' near Gosford, north of Sydney, and a 'southern metapopulation' near Sutherland, south of Sydney; in Gosford and Campbelltown local government areas respectively. The Gosford metapopulation occurs in Brisbane Water National Park (BWNP), near Warrah Trig between Pearl Beach and Patonga, in an area known as the Waratah Patch.

Astrotricha crassifolia is a narrow-leaved erect shrub to 2m (Pellow et al. 2009) with a conspicuous indumentum of stellate hairs on most parts of the plant except the upper surface of the mature leaf (M.J. Henwood & R.O. Makinson in Harden 2002). Plants appear to grow in light shade (Benson & McDougall 1993), quite densely, in a number of small, isolated patches. Flowers are insect-visited but pollination details are unknown. Although fruit are produced, there are no reports of the species producing viable seed; there has been no evidence of seed germination or seedling growth in over 20 years of intermittent observations (Bob Makinson, pers. comm. 17/11/ 2010). *Astrotricha crassifolia* responds to slashing and fire by resprouting from rhizomatous growth. The Waratah Patch was burnt during an extensive wildfire in 1990 with some sections again being burnt in 2001, 2002 (Beckers & Offord 2010).

The NSW Office of Environment and Heritage (OEH) has given high priority to surveying sites and documenting threat status of *Astrotricha crassifolia*. This study updates a 2003–04 census of three subpopulations in the Waratah Patch, Brisbane Water National Park (Beckers 2004), and reports on new subpopulations and ongoing threats.

Methods

The three previously surveyed subpopulations of *Astrotricha crassifolia* (*Acras1, Acras2* and *Acras3*) are in the Waratah Patch (lat 33° 32' S; long 151° 17'E), a ridgetop (altitude 190m) of deep sandy lateritic loam (Somersby soil landscape unit of Chapman & Murphy 1989), in Brisbane Water

Fig. 1. Aerial view of the Waratah Patch in Brisbane Water National Park showing subpopulations of *Astrotricha crassifolia* in 2004, and area of burns in 2001, 2002 and 2006.

National Park, between Pearl Beach and Patonga, about 80 km north of Sydney (Figure 1). Another two occurrences at the Waratah Patch, each consisting of a single plant, were not included in this study. In this survey, the term subpopulation has been used to describe discrete patches; however it is unclear whether or not the patches are of common clonal origin.

The three subpopulations (*Acras1*, *Acras2* and *Acras3*) surveyed in 2003–04, were relocated using a Garmin 12XL GPS (Figure 1). Plant species with rhizomatous root systems can be problematic to census because of interconnected ramets which may appear as individual plants or clumps above-ground. In some cases these may be extensive, and without excavation to determine whether they are separate plant clumps or joined, estimates of population size may be inaccurate (Payne 2002). In this case each stem, together with its immediately subtending portion of rhizome, constitutes a potential reproductive unit, and was therefore an appropriate measure of plant abundance. Each stem within a subpopulation was flagged, traced to the base, then measured and assigned to one of four height categories (shorter than 10cm, 10–30cm, 30–100cm and higher than 100 cm). An estimate of subpopulation size was determined by measuring the perimeter of the area bound by the flagged stems. Life history observations were recorded including presence of buds, fruit, and evidence of old or new flowers. Observed threats and disturbances were noted. A distance of approximately 2–5m beyond each patch was checked for any outlier plants and further subpopulations.

Following the census, an opportunistic field search was conducted of similar habitat adjacent to the Warrah Trig track to locate any further subpopulations of *Astrotricha crassifolia*, and any found were measured as previously described. Voucher specimens were collected and a list of associated plant species was compiled (Appendix 1). A detailed log of the hours taken to record each population was kept to provide estimates of time required to repeat the sampling in the future.

Table 1: Chronological burn and monitoring history of *Astrotricha crassifolia* subpopulations in the Waratah Patch, Brisbane Water National Park (to 2010 modified from Beckers 2004).

Date	***Acras* 1**	***Acras* 2**	***Acras* 3**
1990	Burnt	Burnt	Burnt
1998			Disturbed by optic fibre cable laying
Nov 2002	Burnt	Burnt	Burnt
Dec 2003		468 stems Mean height 0.3 m	99 stems Mean height 0.3 m No plants in disturbed ground
Sept 2004	43 stems Some >1m tall Flowering		
Mar 2010	86 stems 71%> 1m tall No flowering material observed.	510 stems 111> 1m tall 50% had spent flowering material.	111 stems 47% >1m tall No flowering material observed.

Results

An update on status of 2003–2004 census

In 2003–04, around 600 *Astrotricha crassifolia* stems were recorded in the Waratah Patch (Table 1). In 2010, 707 stems were recorded for the same subpopulations, an increase of less than 20%. In September 2004, *Acras1* had 43 stems (with some over 1m tall); in 2010, 86 stems were recorded, 71% of which were in excess of 1m tall. In December 2003, *Acras2* had 468 stems (averaging 30cm tall); in 2010, 510 stems were found, an increase of less than 10%, 111 of which were greater than 1m tall. About 50 % of these stems had spent flowers. In December 2003, *Acras3* had about 99 stems (averaging 30cm tall), and in March 2010, 111 stems (an increase of less than 10%) of which only 47% reached a height of 1m.

Table 2. Size of *Astrotricha crassifolia* subpopulations, Brisbane Water National Park, in 2010 ordered by area of occupancy.

Population	Perimeter (m)	Population Diameter (m)	Area of occupancy (m^2)	No. of stems	Stems / m^2
Acras2	43	13.7	147	510	3.4
Acras3	35	11.1	97	111	1.1
Acras1	30	9.5	72	86	1.2
Acras7	21	6.7	35	290	8.2
Acras8	15	4.8	18	76	4.2
Acras9	9	2.9	6	39	6
Acras4	7	2.2	4	33	8.4
Acras5	7	2.2	4	34	8.7
Acras6	4	1.3	1	32	25.1

Field search and population size 2010

In winter, 2010, a further six small discrete subpopulations were located on the sandy lateritic loam within 5m of the Warrah Trig track. Some of the additional subpopulations were found on the opposite side of the Warrah Trig track to the existing known subpopulations (Figure 2). Those on the east of the track had been burned in 2001 as opposed to the western side of the track which was burned in 2002 (Figure 1).

The nine *Astrotricha crassifolia* subpopulations in the Waratah Patch had a total of 1211 stems(Table 2), an increase of about 50% on the number known in 2003–04. This represents an increase in the known size of the population, not an increase in the population size since 2003–4 as the plants are evidently long-lived and are likely to have been present in 2003–04, but not known. Most subpopulations are characterised by similar-sized plants suggesting widespread population recovery following a similar trigger event, probably the fires of 2001 and 2002. With the exception of *Acras4* (0%), most subpopulations had a high percentage of stems greater than 1m tall (Figure 3) and all, except for *Acras4* had more than 76% of plants greater than 30cm tall. There were very few subpopulations with plants in the 0–10cm height category. *Acras4* is subject to repeated slashing, and included 91% of plants less than 30cm tall.

The maximum perimeter length (43m) for *Acras2*, the largest subpopulation, equates to a patch diameter of 13.7m, suggesting an area of occupancy of 147m^2 and stem density of 3.4 stems/m^2 (Table 2). Using these approximate diameters, stem densities for all patches calculated to between 1 and 25 stems per m^2 (Table 2). The total area of occupancy of the *Astrotricha crassifolia* metapopulation in the Gosford LGA is 385m^2, this figure being an aggregate of all subpopulations. (Surveying the subpopulations took about 32 hours.)

Fig. 2. Location of nine subpopulations of *Astrotricha crassifolia* recorded in 2010, Brisbane Water National Park.

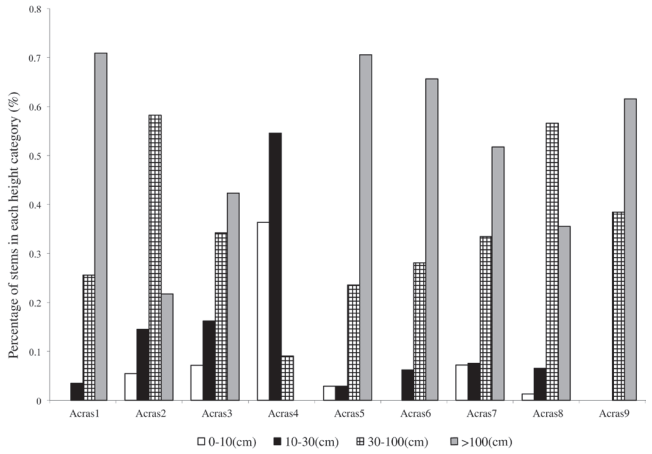

Fig. 3. Percentage of *Astrotricha crassifolia* stems in each height category in nine known subpopulations, Brisbane Water National Park, NSW.

Ecology

The vegetation community was generally low woodland to low open woodland dominated by trees of *Eucalyptus oblonga, Eucalyptus haemastoma, Corymbia gummifera.* The understorey at each subpopulation consistently included the Proteaceae shrubs *Banksia serrata, Conospermum longifolium*, *Grevillea buxifolia* subsp. *buxifolia*, *Isopogon anemonifolius, Lambertia formosa;* Fabaceae species included *Gompholobium grandiflorum*, *Phyllota phylicoides*, and Rutaceae species included *Boronia floribunda* and *Boronia ledifolia* (Appendix 1).

During late spring 2010, eight of the nine subpopulations flowered, except the slashed roadside population (*Acras4*) which was devoid of floral material. A native bee (identified by Anne Dollin (pers. comm. 2010) as a Reed Bee – Apidae *Exoneura* species) was observed on anthers of flowers in *Acras9* (Figure 4). Mass flowering of *Astrotricha crassifolia* appeared synchronised with *Conospermum longifolium* (Proteaceae) which shares a similar conspicuous paniculate inflorescence, and similar sized, white-coloured flowers to *Astrotricha crassifolia.* Stands of *Conospermum longifolium* were growing at similar heights to stands of *Astrotricha crassifolia* and were present in all of the nine subpopulations (Appendix 1).

All subpopulations (with the exception of slashed plants on the roadside) were observed flowering and producing fruit, and what appeared to be ripe fruit were observed on some plants (Figure 7). Later dissection of a small number of fruit revealed insect predation; no complete seed was observed and further research is required to determine whether viable seed is being produced.

The reproductive capacity of *Astrotricha crassifolia* may be influenced by vegetation density and light availability. Although the vegetation cover at each subpopulation was not measured, observations indicate that, consistent with Benson and McDougall (1993), *Astrotricha crassifolia* favours light shade. This study found that where the vegetation was particularly dense, the plant will extend robust branches more than 1m laterally through dense vegetation and leaf litter, in order to reach appropriate light intensity, often collapsing, forming an 'elbow' vertically towards the available light gap. However, where there was little competition for light and space the plant grew erect.

Resprouting from basal vegetative material, the recruitment strategy indicated in Benson & McDougall (1993), enabled *Astrotricha crassifolia* to recover from slashing for roadside maintenance. Very few stems were observed in the 0–10cm height category (Figure 3); what appeared to be seedlings in the leaf mulch were often found to be the vertical light-seeking shoots of collapsed branches.

Fig. 4. Native bee (*Exoneura* sp.) on flowers of *Astrotricha crassifolia* (Photo D. Warman).

Fire

All subpopulations have been subjected to wildfire. In the 2004 inspection of the area burnt in 2002, Beckers (2004) found regenerating plants of *Astrotricha crassifolia* flowering. Unplanned fires in the area have affected all subpopulations; all have been burnt twice since 1990. The subpopulations on the east of the Waratah Patch are included within an area proposed to be burnt in the near future in a prescribed burn aimed at protecting the built assets in Pearl Beach (see Discussion regarding *Astrotricha crassifolia* post-fire response to this burn).

Human-induced threats and disturbance

Some subpopulations have been affected by a range of human-related impacts (Table 3) and 80% of the subpopulations are beside roads where issues include dust

Fig. 5. *Astrotricha crassifolia* affected by vehicular damage along Warrah Trig Track. (Photo D. Warman).

from the unsealed Warrah Trig track, slashing, effects of runoff, and microclimatic changes due to sedimentation traps, edge effects and vehicular damage (Figure 5). The subpopulations directly adjacent to Warrah Trig track may have been fragmented during the original construction of the road, which may also have resulted in the loss of some plants. Illegal rubbish dumping occurs regularly in the area and during this survey 150 tyres were found dumped in the bushland adjacent to the road in very close proximity to occurrences of *Astrotricha crassifolia* (Figure 6).

The Waratah Patch is a very popular area to view Waratahs (*Telopea speciosissima*) and in peak Waratah flowering season, pedestrian tracks trample the vegetation. This has the potential to affect subpopulations *Acras1, Acras2* and *Acras3* which co-occur with Waratahs (Appendix 1).

Fig. 6. Tyres dumped along the Warrah Trig track in very close proximity to roadside *Astrotricha crassifolia* subpopulations (Photo D. Beckers).

Discussion

The southern metapopulation of *Astrotricha crassifolia* (Campbelltown LGA) extends over a 5 km range in three habitat types – Riparian scrub, Gully forest and Low woodland; plants exhibit robust erect growth to 2m (Elizabeth Norris, pers. comm. May 2010). The northern subpopulations (Gosford LGA) of this study are restricted to a small number of disjunct clumps over a 1 km area of Low woodland-Low open woodland on a sandy ridgetop. Why the northern meta population is restricted to a single habitat is not known but the historic records influenced our search effort to target ridgetop habitats; in light of the southern population records, future targeted searches should not necessarily be confined to plateaus, but include slopes and riparian areas.

The nine subpopulations of the northern metapopulation of *Astrotricha crassifolia* were small clumps with a combined area of occupation of only 385 m^2; nearly 80% of those subpopulations are small, disjunct and adjacent to roads. With six subpopulations in close proximity to the Warrah Trig track, and the track potentially dissecting them, long-term conservation poses a major challenge for management. Management of park infrastructure (the reproductive potential of at least one small subpopulation was directly reduced by roadside slashing during this survey period) and other impacts associated with park use (e.g. dust from the unsealed road, vehicular damage, foot trampling and dumped waste) have the potential to further increase the vulnerability of these subpopulations and reduce their distribution. Slashing equipment and vehicle movement are vectors of weed seed and propagule dispersal, particularly grass species (the invasion of native plant communities by exotic perennial grasses is listed as a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995*) and the

Table 3 : Human-induced disturbance events affecting individual *Astrotricha crassifolia* subpopulations (*Acras* 1–9), Brisbane Water National Park.

Disturbance event	*Astrotricha crassifolia* subpopulations								
	1	2	3	4	5	6	7	8	9
Potential fragmentation due to road alignment				•	•	•	•	•	•
Powerline easement and optical fibre maintenance			•						
Roadside maintenance, including slashing, sediment traps and road surface maintenance				•	•	•	•	•	•
Trampling by vehicle due to inappropriate access		•					•		
Trampling by recreational use – wildflower viewing	•	•							

exotic perennial grasses *Andropogon virginicus*, *Eragrostis curvula* and *Hyparrhenia hirta* already exist in comparable habitat in the park. The increased light radiation and moisture runoff along road edges may favour those weed species in competition with *Astrotricha crassifolia* plants.

To reduce their effect on some subpopulations, management practices could be altered. For example, clear identification of each roadside population may enable better planning of future infrastructure installation such as sedimentation traps. Machinery engaged for slashing and road-grading should incorporate hygiene practices in their preparation, prior to entering the track. Maintenance of existing sedimentation traps could be altered to consider reducing the effect on some subpopulations, while slashing in some areas may be avoided, or the slash height reduced or frequency reduced to allow flowering and fruit dispersal.

The NSW Office of Environment & Heritage website (OEH 2011 2) indicates inappropriate fire regimes are a threat to the species, though the NSW National Parks and Wildlife Fire Response Database (NSW NPWS 2002) indicates there are not enough data to inform an appropriate fire regime for the species. The 2004 Census and our current work have increased knowledge of the species response to fire. Park fire management needs to ensure an appropriate regime is maintained. Knowledge of this plant's response to fire is crucial given the significance of the Waratah Patch to local tourism (Beckers & Offord 2010) and to reduce competing priorities for Waratah and fuel management. As this paper goes to press we can document the plant's response to a hazard reduction burn (on 22/9/ 2011) on the eastern side of Warrah Trig track, in the vicinity of subpopulations (*Acras 6,7,8*). On 11/11/2011, no true seedlings were observed but *Astrotricha crassifolia* resprouts were emerging from the soil at the base of burnt stems (Figure 7).

Fig. 7. Response to hazard reduction burn, *Astrotricha crassifolia* resprouting in November 2011, Brisbane Water National Park (Photo D. Warman).

Fig. 8. Mature fruit of *Astrotricha crassifolia*, Brisbane Water National Park, 7 Dec 2010 (Photo D. Warman).

High frequency fire is considered a key threatening process to many plants, but Gross (2006) identifies that the literature on clonality, implies frequent fire may which favour clonal species. There may however be serious long-term implications in clonal plants with the loss of sexual reproduction e.g. clonality may induce a cascade of events leading to sexual extinction and finally complete genetic homogenization (Honnay et al. 2006), and susceptibility to pathogens and disease (Schmid 1994). However, despite the limitations, evidence of extraordinary ages of clones, e.g. *Eucalyptus recurva*, a mallee eucalypt may have survived up to 13,000 years without sexual reproduction (NPWS 2003), means that being a clone may provide an alternative survival strategy. While we cannot confirm clonality in *Astrotricha crassifolia*, its localised patches of stems and the absence of evidence of true seedlings warrants the question as to whether the subpopulations are in fact clones.

The state and national conservation significance of *Astrotricha crassifolia* suggests that further research is a priority. Using its habitat features from this survey, it would be appropriate to model the distribution of *Astrotricha crassifolia* to predict additional localities for targeted searching. Information on the southern metapopulation could be incorporated into future modelling and a comparison of population genetic structure of the two disjunct populations would be interesting.

Conclusion

The northern metapopulation of *Astrotricha crassifolia* remains vulnerable, in the short term, to human-induced impacts, and in the long term to a lack of understanding of its reproductive success and how fire affects its recruitment and survival. The following recommendations are made to reduce the threats:

- Limit infrastructure management activities alongside Patonga Road and Warrah Trig Road near *Astrotricha crassifolia* subpopulations during the spring flowering and summer fruiting period i.e. August to February;
- Incorporate hygiene practices into roadside management activities;
- Further identify the geographical limits of the northern metapopulation;
- Undertake post-fire monitoring of subpopulations to determine fire response, i.e. potential seed viability, germination, seedbank dormancy and longevity;
- Expansion of monitoring to include the other two subpopulations in BWNP (Figure 1);
- Ascertain the degree of clonality within and among *Astrotricha crassifolia* subpopulations using molecular techniques.

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Appendix 1.

Plant species recorded and voucher specimens collected from ***Astrotricha crassifolia*** subpopulations (Acras 1–9) along Warrah Trig Road, Brisbane Water National Park, during the 2010 census.

Species	Family	Observed present in
Acacia myrtifolia	Fabaceae	1–8
Acacia suaveolens	Fabaceae	1–3, 7–9
Actinotus minor	Apiaceae	1,2,4,5,9
Allocasuarina distyla	Casuarinaceae	9
Angophora hispida	Myrtaceae	6,7,8,9
Anisopogon avenaceous	Poaceae	1,2,3,5–9
Astrotricha crassifolia	Araliaceae	1–9
Baeckea diosmifolia	Myrtaceae	5,6
Banksia oblongifolia	Proteaceae	6,7,9
Banksia serrata	Proteaceae	1,2,3,5–9
Banksia spinulosa	Proteaceae	1,2,3,5
Billardiera scandens	Pittosporaceae	1,2,3,5
Boronia floribunda	Rutaceae	1,2,4,5,6
Boronia ledifolia	Rutaceae	7,8,9
Bossiaea heterophylla	Fabaceae	1–9
Bossiaea scolopendria	Fabaceae	4,5,6,7
Bossiaea stephensonii	Fabaceae	3
Caesia parviflora	Anthericaceae	1,4
Calytrix tetragona	Myrtaceae	3
Cassytha pubescens	Lauraceae	1,2,3,5,6
Chordifex dimorpha	Restionaceae	6
Comesperma ericinum	Polygalaceae	2,3
Conospermum longifolium subsp. *longifolium*	Proteaceae	1–9
Corymbia gummifera	Myrtaceae	1–9
Cyathochaeta diandra	Cyperaceae	1–9
Dampiera stricta	Goodeniaceae	1,2,3,5,6,8
Daviesia alata	Fabaceae	1,3
Dillwynia elegans	Fabaceae	4–9
Entolasia stricta	Poaceae	3–7
Epacris microphylla	Ericaceae	4
Eriostemon australasius	Rutaceae	8
Eucalyptus haemastoma	Myrtaceae	1–9
Eucalyptus oblonga	Myrtaceae	1,2,3,6,7,8
Gompholobium grandiflorum	Fabaceae	1–9
Gonocarpus teucrioides	Haloragaceae	7,8,9
Goodenia bellidifolia	Goodeniaceae	3,4,5,7,8,9
Grevillea buxifolia subsp. *buxifolia*	Proteaceae	1–9
Grevillea sericea	Proteaceae	1–4,6–9
Hakea dactyloides	Proteaceae	1,2,5,6,7
Hakea gibbosa	Proteaceae	4,5,9
Hibbertia cistiflora	Dilleniaceae	6,7,9
Hibbertia empetrifolia subsp. *empetrifolia*	Dilleniaceae	1–9
Hovea heterophylla	Fabaceae	2–5
Isopogon anenomifolius	Proteaceae	1–9
Lambertia formosa	Proteaceae	1–9
Leptomeria acida	Santalaceae	2
Leptospermum juniperinum	Myrtaceae	6
Leptospermum trinervium	Myrtaceae	1,2,3,5–9
Lepyrodia scariosa	Restionaceae	6
Leucopogon juniperinus	Ericaceae	1,2,4,5
Leucopogon microphyllus var. *microphyllus*	Ericaceae	1,2,4–7
Lindsaea linearis	Lindsaeaceae	1–6,8
Lomandra cylindrica	Lomandraceae	6
Lomandra glauca	Lomandraceae	1,3–9
Lomatia silaifolia	Proteaceae	1,4,5,7,8
Micrantheum ericoides	Picrodendraceae	4,6–9
Mirbelia rubioides	Fabaceae	6
Patersonia sericea	Iridaceae	1–9
Petrophile pulchella	Proteaceae	1–8
Philotheca reichenbachii	Rutaceae	1,5,6,9
Phyllanthus hirtellus	Phyllanthaceae	1–9
Phyllota phylicoides	Fabaceae	1–9
Pimelea linifolia subsp. *linifolia*	Thymeleaceae	5,6
Platysace linearifolia	Apiaceae	1–9
Poranthera ericoides	Euphorbiaceae	1,2,6–9
Pteridium esculentum	Dennstaedtiaceae	3
Pultenaea tuberculata	Fabaceae	1–9
Scaevola ramossisima	Goodeniaceae	1,2,3,5,8
Schizaea bifida	Schizaeaceae	1,5
Schoenus imberbis	Cyperaceae	6,8,9
Stackhousia viminea	Stackhousiaceae	3,6,8
Stylidium lineare	Stylidiaceae	6
Telopea speciosissima	Proteaceae	1,2,3
Tetratheca shiressii	Elaeocarpaceae	5,6,7
Thysanotus tuberosus subsp. *tuberosus*	Anthericaceae	1,3–6
Xanthorrhoea sp.	Xanthorrhoeaceae	1–9
Xylomelum pyriforme	Proteaceae	1,2,3
Xyris gracilis subsp. *gracilis*	Xyridaceae	6