Regeneration of remnant Blue Gum High Forest vegetation following the cessation of mowing

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Native plant species were recorded on a small mown remnant of Blue Gum High Forest in Observatory Park, Pennant Hills, in northwestern Sydney, in 1979 and 1988. In 1989 an area was set aside in the Park, in which mowing was stopped and bush regeneration commenced and is ongoing. Native species were recorded 5 times over the following 11 years, during which time the number of native species recorded rose from 47 to 126. The result demonstrates the potential for mown bushland sites containing native species to regenerate with appropriate treatment.

Introduction

Blue Gum High Forest (BGHF) is listed as an Endangered Ecological Community under the NSW *Threatened Species Conservation Act 1995* (*TSC Act*). BGHF once occurred along the high ridges of Sydney's North Shore on Wianamatta Shale derived soils in areas receiving more than 1100 mm rainfall per year (Benson & Howell 1990). It consisted of tall open-forest containing valuable timber, harvested from the time of early settlement. About 1% of the original area of the community currently exists in the form of a number of remnants (NSW Scientific Committee 1997). Smith and Smith (1990) recognised nineteen remnant sites in the Hornsby Shire Council area, totalling about 52 ha or approximately 0.15% of its bushland area (Hornsby Shire Council 1997–1998). Some sites are in private ownership while others are on public land. The Final Determination includes invasion by exotic plants and mowing among the list of threats to these remnants.

Observatory Park, a small area of Crown land in Pennant Hills, containing a remnant of BGHF has been managed as parkland for at least 35 years, and probably much longer, by Hornsby Shire Council. In 1989 Council stopped mowing the central portion of the Park and set it aside for bush regeneration. Except for recording species present every few years, no monitoring program was established.

The site

Observatory Park (formerly Red Hill Park) is a triangular island prominently situated at the junction of Pennant Hills and Beecroft Roads, Pennant Hills, in northwestern Sydney (33° 44' 40" S, 151° 3' 45" E). The Park's area has been reduced over the years to only 2.1 ha, chiefly by road widening, the latest in 1996.

Situated on deep Wianamatta Shale overlying Hawkesbury sandstone, the ground slopes very gently down from east to west. Its elevation is 180 m. The canopy trees are characteristic of Blue Gum High Forest, as are many of the shrubs and ground cover species. The canopy has always been tall open-forest consisting of mature eucalypts — *Eucalyptus pilularis* and *Eucalyptus paniculata* are the most common trees. *Eucalyptus pilularis* is concentrated on the lower western end and *Eucalyptus paniculata* subsp. *paniculata* on the higher, eastern end, with some *Eucalyptus saligna*. Three *Eucalyptus resinifera* subsp. *resinifera* trees, and one *Eucalyptus punctata* occur within the Park. The last *Syncarpia glomulifera* at the lowest point of the Park was felled for the most recent road widening.

History

In the early 1800s cattle were driven though the general area of Pennant Hills. Convict timbergetters came from Parramatta to cut timber from Pennant Hills. Hawkins (1994) suggests the Pennant Hills Sawing Establishment dates back to 1816 and an old map prior to 1831 (NSW Archives Office) shows a Government Sawing Establishment almost on the Park site. The tree cover was removed again in neighbouring Beecroft in the 1880s when the area was opened up for housing. An observatory housing an astrograph existed near the northern end of the Park from 1899 until the mid 1930s (Noble 1999). During the Second World War the Park was used as a staging camp for servicemen. More recently the Park has been used several times a year for fairs, the pedestrian and vehicular traffic resulting in compaction and erosion of the soil. Erosion washed the topsoil from the centre of the Park, exposing red clay.

During the 1970s, Shire residents approached Council concerning the poor state of the Park and its potential for natural regeneration. Robin Buchanan prepared the first known native plant species list in 1979 (Table 2). Growing Council interest is shown by the Park's inclusion in two consultants' reports (Perumal Murphy Wu 1982, and Smith & Smith 1990) which refer to Observatory Park and Ludovic Blackwood Sanctuary, immediately to the west of the Park. The earlier report recognised the Park's potential, the later one was more dismissive, only considering its condition at the time. In 1988 a resident, John Noble, enlisted the help of the author to make a species list. Forty-six native species were listed, mostly trees and plants that had escaped mowing at the base of the trees (Table 2). There was also an extensive ground cover of a small variety of *Lomandra filiformis* forming a 'lawn' in places. Mr Noble approached Council for permission to commence regeneration of the poorly-grassed central section of the site. This was granted.

Methods

In 1989 a central area of the Park of about 0.8 ha was protected from mowing by being marked out by bollards. Since that time weeds, mostly low herbs and grasses, dispersed by wind or birds, have been systematically removed, mostly by pulling and minimal digging. Leaf litter, branches and twigs fallen from the trees were spread over the site to reduce erosion and promote soil enrichment.

To demonstrate changes in plant species abundance that have taken place since the cessation of mowing in the protected area, all available species lists for the park have been collated. Because of the small size of the remnant a number of visitors have made species lists after walking through the site. Species lists were compiled by Robin Buchanan 1979, Jenifer Lewis 1988, Norman Lloyd (who collected grasses only) in 1990, Tein McDonald 1992, Pat Pike 1994, 1995, 1997, Pat Pike and Jenifer Lewis 1999 (Table 2).

Results

The total number of native species recorded for the Park between 1979 and 1999 is 126 — 2 ferns, 45 monocotyledon and 79 dicotyledon species (Table 2). Three species recorded by Buchanan in 1979 (*Adiantum aethiopicum*, *Pteridium esculentum*, and *Xanthorrhoea media*) had already gone prior to 1988. Only two terrestrial orchids have been recorded, though Mr Noble recalls a variety growing many years ago. Though new species were added at each survey, not all species remained visible at subsequent surveys as surveys were not carried out in the same season each year. For instance, in 1999, 105 species were listed of the 126 overall.

The high proportion of monocots, 36% of all species, includes 28 grass species. Fabaceae species account for 21 species or 27% of the dicotyledons — 12 Faboideae and 9 Mimosoideae. At the time of writing, in 2001, four more species have been observed since the last full survey in 1999 — *Notelaea longifolia* and *Acacia terminalis*, both young, and more recently, *Stipa densiflora* and the orchid *Microtis unifolia*. A sapling of *Eucalyptus resinifera* at the northern end of the regeneration area has flowered.

In the protected area from 1979 to 1988 prior to the cessation of mowing the number of species declined, especially among the dicotyledons. After the cessation of mowing in 1989 species numbers gradually increased (Table 1).

Table 1. Number of native species listed in the protected area 1979–1999

Year	1979	1988	1992	1994	1995	1997	1999
Ferns	2	-	-	-	-	-	-
Monocotyledons	12	12	28	30	35	36	36
Dicotyledons	40	34	45	49	48	60	69
Totals	54	46	73	79	83	96	105

In the protected area the almost bare ground has been replaced with a thick cover of ground plants including 28 grasses, 2 sedges, 4 *Lomandra* species, 14 climbers and 46 herbs. The shrub layer is comparatively sparse, with 24 species, some with only one or two individual plants. Of the shrubs, the family Fabaceae has 9 species of *Acacia* and four other shrubs, *Daviesia ulicifolia*, *Bossiaea obcordata, Platylobium formosum* and *Pultenaea retusa*, of which there are only one or two plants each. Dozens of single-stemmed eucalypt seedlings and saplings have emerged, ranging in size from 10 cm to 4 m. Of the acacias, *Acacia falcata* has germinated freely, and *Acacia parramattensis* and *Acacia longifolia* have produced several young plants. *Bursaria spinosa, Cassinia aculeata* and *Allocasuarina torulosa* are regenerating freely, and there are quite a few young *Polyscias sambucifolia* and *Breynia oblongifolia* plants, probably from rootsuckers.

About half of the species recorded in the renewed understorey are grasses, vines, acacias and legumes; this is consistent with previous studies (Buchanan 1989). Resprouters such as perennial grasses, vines and plants with lignotubers bear renewal buds below or near the ground, enabling them to survive some regular mowing. Another source of regeneration is seed stored in the soil, though long-term viability of seeds of different native species in the soil is not well documented (Benson & McDougall 1996). Seeds stored in the seedbank may respond to soil disturbance, occurring here from the hand removal of weeds and perhaps bringing seed closer to the surface and sunlight. In the recently extended area, now being regenerated, a dozen *Angophora costata* seedlings at the dicotyledon stage have appeared. Wind-borne species, such as *Vernonia cinerea* var. *cinerea*, *Senecio hispidulus* and *Clematis* may have crossed the road from the nearby Ludovic Blackwood Sanctuary.

Regrowth from the rootstock or from germination of seeds from the seed bank after the cessation of mowing would be expected to be providing seed itself in season, thus hastening the repopulation of the site.

Grass at the north-eastern and south-western ends of the Park is still being regularly mown. The mowing regime consists of monthly mowing from May to August, and fortnightly for the rest of the year. At the south-western end the tree canopy is the same as the regenerated area; intermingled with the mown grass are *Lomandra filiformis, Danthonia pilosa, Microlaena stipoides, Oplismenus aemulus, Pseuderanthemum variabile, Cotula australis, Dichondra repens, Desmodium varians*, and *Clematis glycinoides*. The north-eastern end is treeless and sunny; its mown grass harbours *Cyperus gracilis*, *Lomandra filiformis, Eragrostis leptostachya, Microlaena stipoides, Dichondra repens, Desmodium varians, Goodenia hederacea,* and *Veronica plebeia.* Some groundcover species appear to be untouched by the mower, but *Lomandra filiformis* leaves, *Clematis* and grass blades are damaged. *Microlaena* and *Eragrostis* are flowering (in June) despite the regular mowing.

Regeneration has been so successful that in the year 2000 the regeneration area was expanded by Council further into the southern part of the Park where grass cover is poor or where several native species survive within the mown grass. The regeneration area was also expanded closer to the eastern edge of the Park.

Discussion

In 1998, Blue Gum High Forest was listed under the *TSC Act* as an Endangered Ecological Community. Mature trees growing on Wianamatta Shale in Observatory Park indicate a BGHF community, including its canopy trees, are present in the Park. Understorey species that have appeared since the cessation of mowing also belong to the BGHF. The regenerated Park is a significant addition to the conservation of the BGHF endangered ecological community.

None of the individual species identified is listed under the NSW *TSC Act*, 1995, nor in the national lists of Briggs & Leigh 1996. At a regional level Benson & McDougall (1998) regard *Eucalyptus resinifera* subsp. *resinifera* as '*not well conserved, shale and shale-sandstone transition habitats now rare*' and *Eucalyptus paniculata* subsp. *paniculata* which

is one of BGHF characteristic species as 'conservation status unknown'. Three species, *Carex breviculmis, Hypoxis hygrometrica* and *Mentha satureioides* are of local significance because they have not been recorded in over 30 species lists for different parts of Hornsby Shire, including 15 by the author.

The existence of grassland under tall trees at Thompsons Corner, about 1.3 km to the west on Wianamatta Shale, is recorded from early settlement (Hornsby Shire Historical Society 1979). The large number of grass species is addressed in Hawkins (1994). He says, 'the forest land around Pennant Hills supported a good growth of native grasses that made suitable fodder for animals. The rich clay soils derived from the shale supported a good growth that was further encouraged by a high water table and a canopy of tall Eucalypts'. He lists 23 grass species for Pennant Hills, five less than recorded in the Park, 14 species being the same.

Care should be taken in assessing a degraded bushland site for regeneration potential as indicated by comparison of the two consultants' reports (Perumal Murphy Wu 1982 and Smith & Smith 1990) on the Park, which had been carried out for different purposes. The two earliest surveys carried out by Buchanan and Lewis revealed that species can sometimes be found on unpromising sites if care is taken to search for them.

In speculating about the long term outlook for BGHF at Observatory Park it seems that the resilience of the site, 'ability to recover after injury or damage', is fairly high as indicated by the increase in the number of species over 11 years. Factors which contribute to the site's resilience include existing flowering and fruiting plants in each structural layer capable of setting seed e.g. grasses survive mowing (similarly to grazing) to flower and set seed when mowing stops, as do herbs including *Lomandra* species, *Dianella* species and *Arthropodium milleflorum*. Around the base of the trees, herbs, shrubs and vines which themselves produce seed, escaped mowing. Examples of shrubs which have produced new plants include *Bursaria spinosa* and *Daviesia ulicifolia*. Though all the acacias have sufficient longevity to have been present before bush regeneration began (Benson & McDougall 1996), only three, *Acacia falcata, Acacia parramattensis* and *Acacia longifolia* have produced seedlings. All the trees except *Eucalyptus punctata* have produced single-stemmed saplings indicating regeneration from seed; their range of heights from several centimetres to 4 or 5 m indicates that recruitment has occurred at intervals. Resilience was also assisted by the number of low herbs which survive unscathed from the current grass mowing regime at either end of the Park.

Many degraded bushland sites do not regenerate after the removal of weeds. The resilience of this site may be attributed in part to protection, because of its physical isolation and ridgetop situation, from inputs such as dumped garden waste, extra water and nutrient from garden run-off, storm water, stream pollution etc., which encourage weeds that inhibit growth of many native species. No displacement of native plants had occurred by large weedy shrubs.

Fire has not occurred on the site since mowing commenced. A controlled burn may cause the germination, by heat or smoke, of dormant long-lived seeds in the seed-bank, the dormancy of which, must be broken by fire. A small fire over an area about 5 m^2 in September 2000 caused little regeneration and, of that, no new species have

appeared. Mowing is a partial substitute by removal of above ground growth but it is far too frequent to mimic a natural fire regime and triggering of germination by heat or smoke is lacking. It is worth noting that *Acacia falcata, Acacia parramattensis*, and *Acacia longifolia* are germinating without benefit of fire.

Dispersal of seed by ground level fauna is unlikely to occur because of the site's isolation from other bushland by residential housing and streets. However, seed dispersal by arboreal fauna, especially birds and fruit bats, can occur, and a brush-tailed possum's scat was seen once on the site. Birds and fruit bats can carry fleshy fruit and larger seeds such as *Polyscias sambucifolia, Breynia oblongifolia, Omalanthus populifolius* and *Pittosporum undulatum*, from nearby bushland. The closest bushland sites beyond the immediately adjacent Ludovic Blackwood Sanctuary, are Pennant Hills Park in Lane Cove River National Park, 1.25 km to the east at its nearest point, Berowra Valley Regional Park at just over 1 km to the northwest, and Beecroft Reserve, 1.5 km to the south. Several species of ants are active and may play a role in dispersing *Acacia* and other seeds within the site. It is possible that pollination is reduced because of a reduced range of pollinators.

The emergence of many eucalypt saplings is important to ensure continued replenishment of the canopy. Previously mowing prevented a stand of mixed-age trees from developing and all trees on the site were mature. The shrub layer is sparse but may increase as the vegetation matures. As a result of mowing some of the resprouters have not reproduced sexually for decades, nor have those from dormant seeds. In the short term it is likely that more shrubs will appear, but, because of the small size of the site, only small numbers of many species will appear.

Conclusions

Cessation of mowing combined with weed removal in Observatory Park has allowed almost trebling of native species from 46 to 126 over a period of 10 years. This result is similar to a three fold increase in native species, mainly herbs, subshrubs and climbers in the short term, observed in Gum Tree Reserve, Guildford, when mowing was reduced from 6 times a year to an interval of 6 months (James 1994). Cessation of mowing in Observatory Park for 11 years has allowed resprouters and obligate seeders to restore the structure of tall open forest at all levels. These results show the extent of recovery possible in bushland with good resilience when mowing ceases on a site previously mown for decades, providing encouragement for similar projects. If the popular 'quick fix' by planting and mulching had been carried out some native species present at the site may have disappeared from the site.

As James (1994) says, '*The implications of these results for the management of urban bushland areas by local councils warrants recognition. It is important that detailed documentation of such remnant bushland is undertaken and appropriate priorities and management practices adopted*.' In the case of Observatory Park a successful management practice has yielded excellent regeneration, which has been fully documented.

Table 2. Native plant species recorded in Observatory Park, Pennant Hills, 1979–1999

Authors of species lists: 1979 – R. Buchanan; 1988 – J. Lewis; 1990 – N. Lloyd (grasses only); 1992 – T. McDonald; 1994, 1995, 1997, 1999 – P. Pike.

	1979	1988	1990	1992	1994	1995	1997	1999
FERNS								
Adiantaceae								
Adiantum aethiopicum	+							
Dennstaedtiaceae								
Pteridium esculentum	+							
MONOCOTYLEDONS								
Anthericaceae								
Arthropodium milleflorum	+			+	+	+	+	+
Tricoryne simplex				+	+	+	+	
Cyperaceae								
Carex breviculmis								+
Cyperus gracilis								+
Hypoxidaceae								
Hypoxis hygrometrica								+
Juncaceae								
Juncus usitatus								+
Lomandraceae								
Lomandra filiformis		+		+	+	+	+	+
Lomandra gracilis	+	+		+	+			+
Lomandra longifolia		+		+	+	+	+	+
Lomandra multiflora		+		+	+	+	+	+
Luzuriagaceae								
Eustrephus latifolius	+	+		+	+	+	+	+
Orchidaceae								
Caladenia catenata				+	+	+	+	
Dipodium variegatum		+		+	+	+	+	+
Phormiaceae								
Dianella caerulea var. *producta*	+	+		+	+	+	+	+
Dianella longifolia						+	+	+
Dianella revoluta	+				+	+	+	+
Poaceae								
Agrostis avenacea						+	+	+
Aristida ramosa								+
Aristida vagans			L	+	+	+	+	+
Austrostipa nodosa						+	+	+
Austrostipa rudis subsp. *rudis*			L	+	+	+	+	
Bothriochloa macra			L	+	+	+	+	+
Cymbopogon refractus	+				+	+	+	+
Dichelachne micrantha								+
Dichelachne rara			L	+	+	+	+	
Digitaria parviflora								+
Digitaria ramularis			L	+	+	+	+	
Echinopogon caespitosus	+	+	L	+	+	+	+	+
Echinopogon ovatus				+	+	+	+	+
Entolasia marginata	+		L			+	+	+
Entolasia stricta		+		+	+	+	+	+
Eragrostis brownii						+	+	
Eragrostis leptostachya			L	+	+	+	+	+
Eragrostis sp.		+		+	+	+	+	
Imperata cylindrica	+	+		+	+	+	+	+
Microlaena stipoides			L	+	+	+	+	+
Notodanthonia pilosa			L	+	+	+	+	+
Notodanthonia racemosa			L	+	+	+	+	
Notodanthonia tenuior			L	+			+	+
Oplismenus aemulus	+							+
Panicum simile			L	+	+	+	+	+
Paspalidium distans				+	+	+	+	+
Poa affinis						+	+	
Themeda australis	+	+	L	+	+	+	+	+

	1979	1988	1990	1992	1994	1995	1997	1999
Smilacaceae								
Smilax glyciphylla					+	+	+	+
Xanthorrhoeaceae								
Xanthorrhoea media	+							
DICOTYLEDONS								
Acanthaceae								
Brunoniella australis	+							+
Pseuderanthemum variabile	+	+		+	+	+	+	+
Apiaceae								
Centella asiatica								+
Hydrocotyle peduncularis							+	+
Araliaceae								
Polyscias sambucifolius	+	+		+	+	+	+	+
Asteraceae								
Brachyscome angustifolia var. *angustifolia*	+	+		+	+	+	+	+
Cassinia aculeata	+	+		+	+	+	+	+
Euchiton involucratus								+
Helichrysum scorpioides	+	+		+	+	+	+	+
Lagenifera gracilis								+
Senecio hispidulus var. *hispidulus*								+
Solenogyne bellioides								+
Vernonia cinerea var. *cinerea*					+	+	+	+
Bignoniaceae								
Pandorea pandorana	+	+		+	+	+	+	+
Campanulaceae								
Wahlenbergia gracilis				+	+	+	+	+
Casuarinaceae								
Allocasuarina torulosa	+	+		+	+	+	+	+
Chenopodiaceae								
Einadia hastata							+	+
Clusiaceae								
Hypericum gramineum				+	+		+	+
Hypericum japonicum	+							
Convolvulaceae								
Dichondra repens	+	+		+	+	+	+	+
Polymeria calycina							+	
Dilleniaceae								
Hibbertia aspera	+			+	+	+	+	+
Epacridaceae								
Leucopogon juniperinus	+			+	+	+	+	+
Euphorbiaceae								
Breynia oblongifolia	+	+		+	+	+	+	+
Chamaesyce dallachyana								+
Omalanthus populifolius								+
Poranthera microphylla	+						+	+
Fabaceae								
Acacia binervia							+	+
Acacia decurrens	+	+		+	+	+	+	+
Acacia falcata		+		+	+	+	+	+
Acacia floribunda		+		+	+	+	+	+
Acacia implexa	+							+
Acacia linifolia		+		+	+	+	+	+
Acacia longifolia	+	+		+	+	+	+	+
Acacia parramattensis							+	+
Acacia terminalis								
Acacia ulicifolia							+	+
Bossiaea obcordata	+	+		+	+	+	+	+
Daviesia ulicifolia	+	+		+	+	+	+	+
Desmodium brachypodum								+
Desmodium rhytidophyllum	+	+		+	+	+	+	+
Desmodium varians	+						+	+
Glycine clandestina	+	+		+	+	+	+	+

	1979	1988	1990	1992	1994	1995	1997	1999
Glycine microphylla								+
Glycine tabacina				+	+	+	+	+
Hardenbergia violacea	+	+		+	+	+	+	+
Kennedia rubicunda	+			+			+	+
Platylobium formosum subsp. *parviflorum*	+	+		+	+	+	+	+
Pultenaea retusa					+	+	+	
Geraniaceae								
Geranium homeanum								+
Goodeniaceae								
Goodenia hederacea	+	+		+	+	+	+	+
Goodenia heterophylla		+			+	+	+	
Lamiaceae								
Mentha satureioides					+	+	+	+
Lobeliaceae								
Pratia purpurascens	+							+
Myrtaceae								
Angophora costata	+	+		+	+	+	+	+
Eucalyptus paniculata subsp. *paniculata*	+	+		+	+	+	+	+
Eucalyptus pilularis	+	+		+	+	+	+	+
Eucalyptus punctata				+	+	+	+	+
Eucalyptus resinifera subsp. *resinifera*	+	+		+	+	+	+	+
Eucalyptus saligna	+	+		+	+	+	+	+
Syncarpia glomulifera	+							
Oleaceae								
Notelaea longifolia								
Oxalidaceae								
Oxalis corniculata	+	+		+	+	+	+	
Oxalis exilis								+
Oxalis rubens							+	
Pittosporaceae								
Billardiera scandens	+	+		+	+	+	+	+
Bursaria spinosa	+			+	+	+	+	+
Pittosporum undulatum	+	+		+	+	+	+	+
Plantaginaceae								
Plantago debilis				+	+	+	+	+
Ranunculaceae								
Clematis aristata				+	+	+		+
Clematis glycinoides	+	+					+	+
Rubiaceae								
Galium binifolium				+	+	+	+	+
Opercularia diphylla				+	+	+	+	+
Opercularia varia								+
Pomax umbellata					+	+	+	
Santalaceae								
Exocarpos cupressiformis	+	+		+	+	+	+	+
Sapindaceae								
Dodonaea triquetra							+	+
Scrophulariaceae								
Veronica plebeia	+	+		+	+	+	+	
Ulmaceae								
Trema aspera								+
Verbenaceae								
Clerodendrum tomentosum		+		+	+	+	+	+
Violaceae								
Viola betonicifolia				+	+	+	+	
Totals:	**54**	**46**	**14**	**73**	**79**	**83**	**96**	**105**
Ferns	2	0		0	0	0	0	0
Monocotyledons	12	12	14	28	30	35	36	36
Dicotyledons	40	34		45	49	48	60	69
Grasses	6	5	14	18	18	23	24	21

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