

The distribution, abundance and conservation status of *Grevillea beadleana* (Proteaceae): an endangered species

J.S. Benson

Abstract

Benson, J.S. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1992. The distribution, abundance and conservation status of *Grevillea beadleana*: an endangered species. *Cunninghamia* 2(4): 503–521. The two known disjunct occurrences of *Grevillea beadleana* (Guy Fawkes Lat. 30° 07' S Long. 152° 19' E and Binghi Lat. 29° 12' S Long. 151° 45' E) on the Northern Tablelands of NSW are documented for their population structure, edaphic features and associated plant species. *Grevillea beadleana* grows on granitic substrates with >75% silica content; derived soils are low in Mg, Ca, P and N. The abundance in three size classes at both populations (classified as seedling, young adult and mature adult) reflect recent fire history and subsequent recruitment. Seedling growth is highly susceptible to repeated fire and the species may have become rare due to increases in fire frequency over recent times. Death due to water stress during droughts may also limit numbers. Future research should centre on seed production, storage, viability and germination. This will refine management objectives regarding the optimal fire intensity and frequency for maintaining viable populations. In the interim, fire should be excluded from recently burnt areas for at least 15 years. Reservation (or protecting by other means) of the land on which the largest population occurs, at Oaky Creek Binghi, is necessary for the adequate conservation of the species.

Introduction

Grevillea beadleana McGillivray (family Proteaceae) is an attractive reddish-flowered shrub, growing on granitic outcrops in two locations on the Northern Tablelands of New South Wales. It was first collected in 1897 by Captain Crawford of 'Moona Plains' 30 km east of Walcha but searches of the granitic outcrops in this area, where it is presumed to have been first collected by Captain Crawford, have so far failed to re-locate the species (R. Makinson, pers. comm.). In 1981 it was rediscovered by N. Fenton (and collected in the same year by A.G. Floyd) on the rim of the eastern side of the Guy Fawkes River gorge inside Guy Fawkes River National Park. In 1988, another population was discovered by G. Roberts in the eastern section of the Binghi wilderness region, north of Torrington. The Guy Fawkes and Binghi populations are 115 km apart, separated by the Guy Fawkes River gorge system and the high altitude section of the New England Tableland between Glen Innes and Tenterfield, (Figure 1).

Grevillea beadleana is assigned a conservation status code of 2RC- in the Australian rare or threatened plant list (Briggs and Leigh, 1988). This has since been altered and its current threat rating is 3ECi (J. Briggs pers. comm.). The 3 implies the species extends over a range exceeding 100 km; E implies it is considered to be endangered with a serious risk of becoming extinct over the next few decades and Ci implies that it has less than 1 000 individuals in conservation reserves.

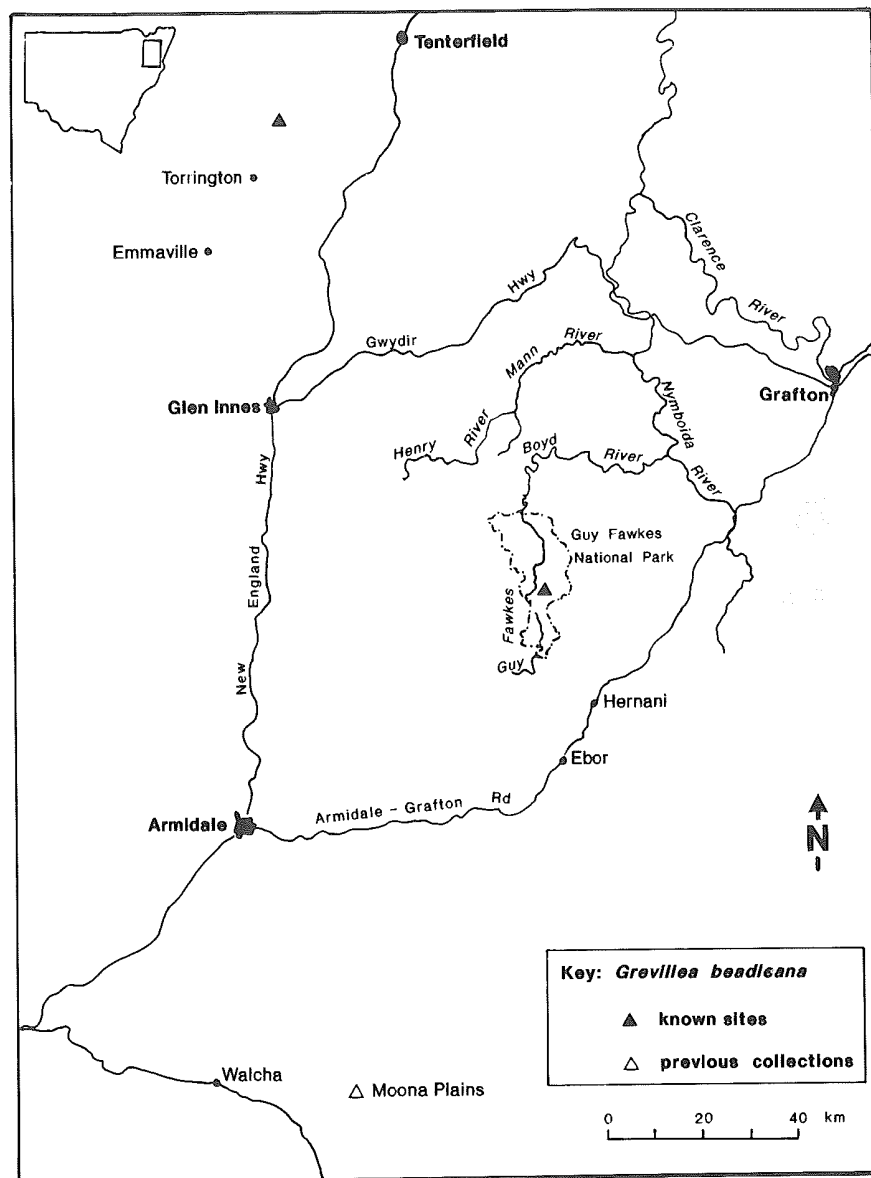


Figure 1. Recorded locations of *Grevillea beadleana*

Research of *Grevillea beadleana* has been limited to a field survey documenting its distribution, population size (including size classes as of 1991) and habitat (including associated plant species, soil and substrate).

While demographic studies are lacking, field survey data provide a basis for hypotheses about the causes of the species' rarity and current distribution.

Limited cultivation of the species has taken place at the Royal Botanic Gardens, Coffs Harbour Botanic Garden and a few private nurseries.



Figure 2. *Grevillea beadleana* is a robust shrub up to 2m high. The largest known population occurs along Oaky Creek, north of Torrington, on the western side of the Northern Tablelands.

Taxonomy

Grevillea beadleana is a spreading shrub up to 2 m high with divided, lobed, tomentose leaves 8–16 cm long and 5–10 cm wide (Figure 2). The reddish-purple flowers are aggregated in an erect 'toothbrush'-like terminal inflorescence (Figure 3). Flowering mainly occurs in late spring or summer but continues into early winter. The two-seeded fruits (follicles) are 10 mm x 6 mm coloured with brown to purple, longitudinal stripes. The seeds are about 5 mm long.

The first publication of the name *Grevillea beadleana* was in McGillivray (1986). This contains a minimal diagnosis. It is also described in Harden (1991). A full description of the species is included in a current revision of the genus *Grevillea* (McGillivray, in press).

McGillivray (in press) notes that the original collection from near Walcha in 1897 has broader and more sparingly divided primary leaf-lobes compared to the leaves of material collected at other sites but he still places it within the species *beadleana*.

Grevillea beadleana is placed in the 'toothbrush inflorescence' group of the genus *Grevillea*. Other related species in this group include *Grevillea willisii*, *G. caleyi* and *G. longifolia*, each of which is also listed as rare or threatened (Briggs & Leigh 1988).

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Figure 3. *Grevillea beadleana* mainly flowers in late spring and summer. It is placed in the 'toothbrush inflorescence' group of its genus.

Table 1. Herbarium collections of *Grevillea beadleana*..

Collector	Coll. No.	Lat./Long.	Place	Date	F
Capt. Crawford	Mel 75263		Moona Plains	1887	
A.G Floyd	AGF 1774		Guy Fawkes	15/10/1981	Y
J.B. Williams	NSW 151305	30° 00' S 152° 20' E	Guy Fawkes	13/06/1982	Y*
D.J. McGillivray	DJM 3993	30° 05' S 152° 19' E	Guy Fawkes	06/09/1982	Y
J.B. Williams	NE 48771A	30° 07' S 152° 19' E	Guy Fawkes	26/06/1988	
J.S. Benson	NSW 26879	29° 13' S 151° 45' E	Eastern Binghi	25/04/1989	Y

MEL - National Herbarium, Melbourne

NSW - National Herbarium, Sydney

NE - Herbarium of the University of New England

AGF, DJM - Personal collection number

F - specimen flowering

* - type collection



placed in the

e	F
0/1981	Y
6/1982	Y*
9/1982	Y
6/1988	
4/1989	Y

Methods

Using locality information from herbarium collections (Table 1), the known occurrences of *Grevillea beadleana* were visited. Nearby likely locations, chosen on the basis of aerial photographic interpretation and mapped geology, were also searched. These included Guy Fawkes Crags, 8 km north of the known location on the rim of the Guy Fawkes Gorge, and several granite knolls in the vicinity of Oaky Creek near Binghi. Floristic site data collected in the vicinity of Oaky Creek (Williams 1990) were reviewed.

The Binghi population occurs in two topographically distinct places - along Oaky Creek and on an unnamed knoll about 1 km to the west of the Creek. These subsets of the one population were sampled in April 1989 for associate species with six 20 x 20 m quadrats (five quadrats along the Creek and one on the knoll). During a second visit to the area in July 1991 the number of individuals of *Grevillea beadleana* on the knoll was counted, while estimates of the larger population along Oaky Creek were made using counts of the species in three 20 x 20 m quadrats. A count of the Guy Fawkes population was also made in July 1991.

Population counts were divided into three size classes with the view that these may have reflected several different aged cohorts arising from different germination events. Such events were most likely stimulated by fire but they could also have arisen during favourable climatic conditions. The size classes were: up to 40 cm (seedling), 40-80 cm (young adult) and greater than 80 cm high (mature seed-bearing adult). Other plant species in the quadrats were listed and assigned a cover rating using a modified Braun-Blanquet method.

Ten randomly collected sub-surface soil samples were taken from each of the populations at Guy Fawkes and Binghi (Oaky Creek). The samples from each site were mixed to gain an average sample for each site. This was tested for pH, electrical conductivity (EC), exchangeable cations of the elements calcium (Ca), magnesium (Mg) potassium (K), sodium (Na); nitrogen (N), sulphate (S), iron (Fe) and for exchangeable aluminium (Al) and phosphorus (P). Samples of rocks from the Guy Fawkes and Binghi sites were analysed for their mineralogy and major elements.

Measurements of slope, aspect and altitude were made at each site. Rainfall data from nearby stations were obtained from the Bureau of Meteorology.

Results

Grevillea beadleana is known from only two locations - Guy Fawkes and Binghi (Table 2). These two disjunct populations are described below.

Guy Fawkes

This occurrence is situated 45 km north of the town of Ebor, 3 km south-west of Chaelundi Mountain and 4 km south of Chaelundi Falls (Lat. 30° 05' S Long. 152° 19' E, altitude 950 m). It is accessible from the township of Hernani off the Grafton-Armidale Road via Marengo, Hardens and Misty Creek Roads.

The stand of *Grevillea beadleana* extends over an area of approximately 300 x 100 m (3 ha) downslope from the Escarpment Walking Track inside Guy Fawkes River National Park. Its habitat is a steeply sloping granitic bluff (Figure 4). The top section of the bluff adjoins an undulating plateau containing tableland species such

as *Eucalyptus caliginosa* (New England Stringybark); the lower section contains some coastal plants, for example *Eucalyptus maculata* (Spotted Gum). Very few individuals of *Grevillea beadleana* survive away from the rock outcrop, either upslope or downslope.

Population

A total of 266 plants of *Grevillea beadleana* were counted at this location in July 1991. Nearly half of the individuals were seedlings. These grew over an area where adult plants had been burnt and killed in 1988. There was a dominance of mature adults in the unburnt section of the site. This partial burning of the site led to the overall population at the site being evenly divided between mature adults and seedlings (Table 3). Few young adults were recorded.

It was observed that many seedlings had established downslope from adult plants killed in the recent fire. The average height of these post fire seedlings was 20 cm. Sections of the cliff that were not burnt contained a small number of seedlings which may indicate there is limited germination in the absence of fire.

Substrate and soil

The outcropping granitic rock forming the bluff is silica-rich (>75%) leucocratic, feldspathic granite (R. Barnes, Geological Survey, Armidale, pers. comm.). This rock is part of a complex of granitic outcrops mapped as the Chaelundi Granite that outcrops over most of the plateau and gorge rim in the Chaelundi Mountain area. Its chemical constituency is dominated by silica and aluminium (Table 4). Minuscule levels of phosphorous and magnesium are present in the substrate.

The sandy-loam, skeletal soil derived from this highly siliceous substrate is poor in nutrients typified by a very low calcium and magnesium content. It also contains low levels of phosphorus and nitrate. In contrast, high levels of aluminium and iron are present due to the acidic pH and base unsaturates (Table 5).

Rainfall

Based on data collected at the nearby 'Marengo' homestead on the eastern side of the gorge (853 m, data recorded 1964–1976) and the 'Ponderosa' homestead on the drier, western side of the gorge (data recorded 1964–1974), the annual rainfall is estimated

Table 2. Location, altitude, aspect, slope, geology, soil, landform and tenure of *Grevillea beadleana* locations

Location	Lat/Long	Alt(m)	Asp.	Slope	Geology	Soil	L/form	Tenure
Guy Fawkes	30° 05' 152° 19'	950	290	40	Chaelundi granite	sand	upper slope	Nat. Park
Binghi Oakly Ck	29° 12' 151° 45'*	650	0	10	Mole Ck granite	fine sand	creek bank**	Crown lease
Binghi knoll	29° 13' 151° 44'	840	270	15	Mole Ck granite	sand	hilltop +slope	Crown lease

* The lat/long along Oakly Creek is set in the middle of this population which extends for 1.5 km.

** *Grevillea beadleana* mainly occurs on the eastern (westward facing) side of Oakly Creek.



Figure 4. Protected from fire by its position on a granitic bluff, 266 plants of *Grevillea beadleana* were counted in 1991 on this granitic bluff on the rim of the Guy Fawkes River gorge inside Guy Fawkes River National Park. This is the only known conserved population.

to be approximately 1 000 mm (Figure 5). The rainfall is seasonal with three times as much falling in summer (November to February) than winter. Minimum rainfall is recorded in April, May and September.

Associated vegetation

Due to the predominance of rock outcrop the vegetation is woodland with a sparse shrub understorey. In the upper stratum *Eucalyptus campanulata* and the rare *Eucalyptus michaeliana* dominate with occasional small specimens of *Lophostemon confertus*. The middle stratum is dominated *Leptospermum novae-angliae*, *Allocasuarina littoralis*, *Grevillea beadleana* and *Notelaea microcarpa*. Scattered clumps of grasses, herbs and sedges make up the ground stratum with the most common plant species being *Gonocarpus teucroides*, *Lepidosperma laterale*, *Poa sieberiana*, *Stipa ramosissima*, *Pomax umbellata* and a species of *Aristida*. A list of plant species recorded from the site is included in Table 6.

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Table 3: Number of plants in size classes for *Grevillea beadleana* at its known locations (July 1991).

Location	Area (ha)	Population (% in brackets)			Dead*	Total alive
		<40 cm	40-80cm	>80cm		
Guy Fawkes	3	127(48)	48(18)	91(34)**	NA	266
Binghi* Oak Creek	15	67(2)	183(5)	3 410(93)	458	3 660
Binghi knoll	5	182(57)	25(8)	113(35)**	NA	320
Totals	23	376(9)	256(6)	3 614(85)		4 246

The Oak Creek population was estimated from counts in three quadrats. Guy Fawkes and Binghi knoll populations were counted.

* dead plants from non-fire sources: only estimated for the Oak Creek population.

** half of the population at these sites was burnt in 1988.

NA not assessed

Table 4. Major elements in rock samples

Element	Guy Fawkes (%)	Binghi (%)
SiO ₂	77.40	76.60
TiO ₂	.10	.13
Al ₂ O ₃	13.15	12.65
Fe ₂ O ₃	.17	1.33
MnO	.01	.03
MgO	.03	.08
CaO	.22	.13
Na ₂ O	4.00	3.25
K ₂ O	4.31	4.95
P ₂ O ₃	.02	.03
S	.00	.00
LOI	.48	.40
Total	99.89	99.58

Table 5. Properties of surface soil samples (0-10 cm)

Location	Soil properties										
	pH	Salinity (mS/cm)	Exchangeable cations				Ex Al*	Fe	S	N as (Nitrate)	P
			Na	K	Ca	Mg					
Guy Fawkes	4.0	0.06	35	172	244	118	45%	107	78	0.9	5.0
Binghi	4.3	0.04	21	138	506	96	25%	66	58	0.3	2.0

Exchangeable cations and other elements expressed in ppm with the exception of exchangeable aluminium (Ex Al) which is given as a percentage of exchangeable cations.

pH is based on soil suspension in CaCl₂ solution.

ns (July 1991).

Land-use history

Guy Fawkes River National Park was gazetted in 1972. Beforehand the area was vacant Crown land with licensed occupancies for grazing. Some of the forest above the gorge rim has been cleared in the past and has re-grown. The site where *Grevillea beadleana* occurs would have changed little since European settlement. It is included in an area that has been nominated as wilderness under the Wilderness Act 1987.

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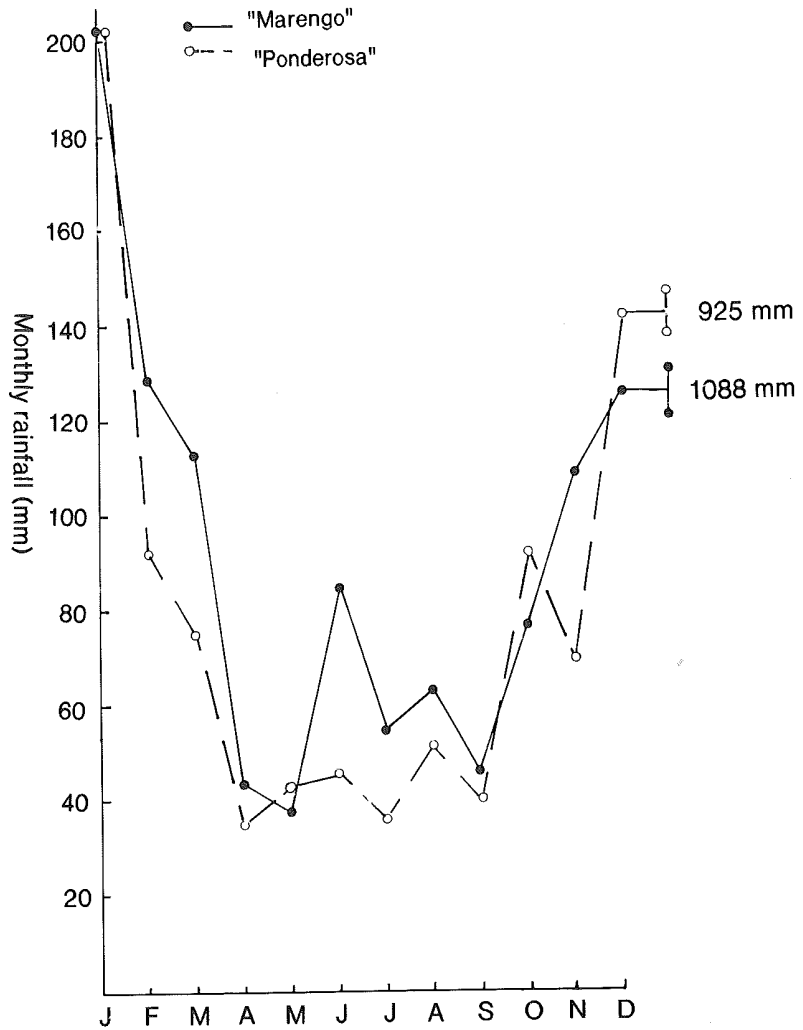


Figure 5. Mean rainfall for two stations in the vicinity of Guy Fawkes. Data supplied by the Bureau of Meteorology (1991).

Binghi

The Binghi population is distributed along a 1.5 km section of Oaky Creek (Lat. 29° 12' S, Long. 151° 45' E, altitude 950 m) and on a rocky knoll, 1 km to the west of Oaky Creek.

Unlike the situation at Guy Fawkes, where a steep bluff forms the habitat, the Binghi population occurs on undulating terrain, although there are some steep slopes adjoining the creek and the knoll. Most of the plants grow on a narrow strip of land within 100 metres of Oaky Creek. More plants are present on the eastern bank than the western bank. *Grevillea beadleana* grows on skeletal soil in crevices between granite outcrops which dominate the landscape.

Population

In July 1991, the population of *Grevillea beadleana* at Binghi was estimated to be approximately 4 000. Of this, 3 650 individuals were estimated to be distributed over 15 ha along Oaky Creek (Table 3) and 320 were counted over 5 ha on the knoll west of Oaky Creek.

The two subpopulations at Binghi have markedly different size class structures. More than half of the area of *Grevillea beadleana* on the knoll was burnt by a hot fire in 1988. This fire missed most of the plants along Oaky Creek. As a consequence, 57% of plants on the knoll were seedlings (Figure 7), in contrast with just 2% of the plants along the Creek. The Creek population is dominated by mature adults (93%).

Although there is no apparent physiographic difference between the creek banks of Oaky Creek, more plants were found on the eastern side compared to the western side. This distribution may be explained by the origin of fires in the west, possibly eliminating plants burnt before they could mature and set seed (see discussion below).

The two subpopulations at Binghi are growing in quite different topographical situations although they are only 500 m apart. It is possible that these subpopulations were once contiguous.

Despite searches of other knolls and creeks in the area by the author and others (Williams 1991) no other populations of *Grevillea beadleana* have so far been discovered.

Estimates taken for the Oaky Creek Binghi population reveal that 9% of the mature plants had died as a result of a drought in the early part of 1991. Many other individuals appeared to be suffering from water stress, indicating that this factor may be important in driving population fluctuations.

Substrate and soil

Mole Creek Granite is the major rock type in the area covering 40 000 ha. This granite is similar in its composition to the rock type at Guy Fawkes in having a >75% silica content, high aluminium levels and low levels of other elements (Table 4). However, it is relatively fine-grained compared with the Guy Fawkes granite and yields a fine loamy-sand soil. The soil is poor in nutrients illustrated by its low level of basic exchangeable cations - calcium and magnesium. Also, it is acidic, low in salts, nitrate and phosphorus but has a high exchangeable aluminium component (Table 5).

On flatter terrain away from the Creek, drainage is poor. The water table rises quickly to the surface after rain causing boggy conditions. *Grevillea beadleana* was rare here.

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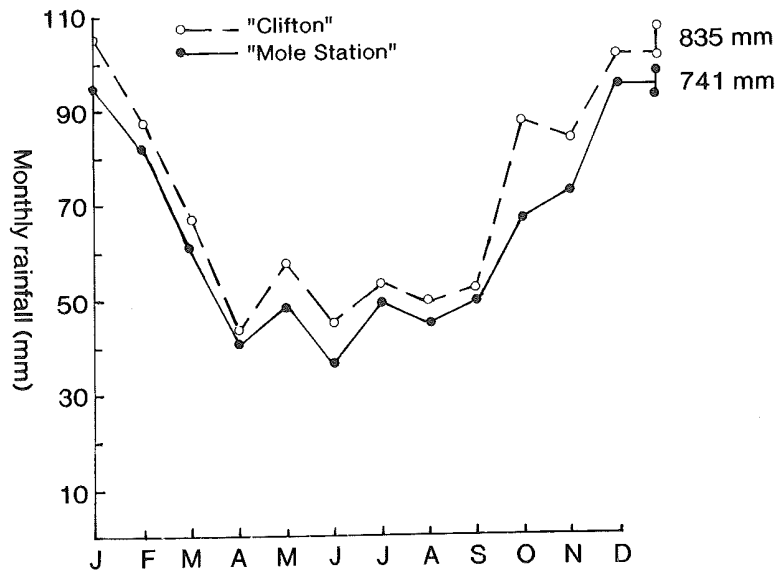


Figure 6. Mean rainfall for two stations in the vicinity of Oaky Creek, Binghi. Data supplied by the Bureau of Meteorology (1991).

Rainfall

Based on rainfall data recorded from nearby properties (Figure 6) the estimated annual rainfall in the Oaky Creek section of Binghi is approximately 800 mm (Bureau of Meteorology, 1991). 'Clifton' is located 20 km north of Oaky Creek at a similar altitude (670 m) (data recorded 1948-1990). 'Mole Station' is 10 km north of Oaky Creek at a lower elevation (440 m) (data recorded 1950-1990). The area is substantially drier than the Guy Fawkes site and probably has a higher evaporation rate due to higher average temperatures experienced at this lower altitude.

Associated vegetation

Vegetation structure is predominantly open-forest except along creek beds or on rock platforms where shrubs and forbs dominate. Common overstorey trees along Oaky Creek are *Eucalyptus prava*, *E. andrewsii*, *E. stannicola*, *Callitris enlicheri* and *Angophora floribunda*. On the knoll west of Oaky Creek *Eucalyptus andrewsii* is the dominant tree.

There is a diverse understorey flora with common shrub species including *Acacia granitica*, *Baeckea densifolia*, *Leptospermum brachyandrum*, *L. brevipes*, *Notelaea linearis*, *Mirbelia speciosa*, *Persoonia terminalis* subsp. *terminalis* and *Phebalium squamulosum*. Grasses, tussock forbs and sedges form a mid-dense ground cover. Common species include *Schoenus ericetorum*, *Xanthorrhoea glauca*, *Lepyrodia leptocaulis*, *Lomandra longifolia*, *Aristida armata*, *Cymbopogon obtectus* and *Eragrostis brownii*.

A combined plant species list from the *Grevillea beadleana* sites along Oaky Creek and on the adjacent knoll is given in Table 6.

Table 6. Plant species associated with *Grevillea beadleana*.

Species	Family	L	B	GF	Species	Family	L	B	GF
<i>Acacia</i> sp. aff. <i>falciformis</i>	Fab.	S	1		<i>Hibbertia acicularis</i>	Dilleni.	S	1	2
<i>Acacia fimbriata</i>	Fab.	S	1		<i>Hibbertia obtusifolia</i>	Dilleni.	S		3
<i>Acacia granitica</i>	Fab.	S	2		# <i>Hibbertia</i> sp. aff. <i>obtusifolia</i>	Dilleni.	S	2	
<i>Acacia penninervis</i>	Fab.	S	1		<i>Hibbertia riparia</i>	Dilleni.	S	1	
<i>Acacia pruinosa</i>	Fab.	S	1		<i>Hovea longifolia</i>	Fab.	S	1	
# <i>Acacia torringtonensis</i>	Fab.	S	2		<i>Hybanthus filiformis</i>	Viol.	F	1	
<i>Acacia viscidula</i>	Fab.	S	1		<i>Hypoxus hygrometrica</i>	Hypox.	F	2	
<i>Adiantum aethiopicum</i>	Adiant.	E	1		<i>Imperata cylindrica</i>	Po.	G	2	
<i>Allocasuarina littoralis</i>	Casuarin.	S	2	4	<i>Isopogon petiolaris</i>	Prote.	S	1	
<i>Alyxia ruscifolia</i>	Apocyn.	S		2	<i>Isotoma anethifolia</i>	Lobeli.	F	1	
<i>Aotus subglauca</i>	Fab.	S	1		<i>Jacksonia scoparia</i>	Fab.	S	1	3
<i>Angophora floribunda</i>	Myrt.	T	3		<i>Lepidosperma laterale</i>	Cyper.	G	1	4
<i>Aristida armata</i>	Po.	G	3		<i>Leptospermum arachnoides</i>	Myrt.	S	1	
<i>Aristida</i> sp.	Po.	G		4	<i>Leptospermum attenuatum</i>	Myrt.	S	1	
<i>Arundinella nepalensis</i>	Po.	G	2		<i>Leptospermum brachyandrum</i>	Myrt.	S	3	
<i>Astrotricha longifolia</i>	Arali.	S	1		<i>Leptospermum brevipes</i>	Myrt.	S	4	
<i>Billardiera scandens</i>	Pittospor.	C		1	<i>Leptospermum novae-angliae</i>	Myrt.	S		4
<i>Banksia integrifolia</i>	Prote.	T		1	<i>Leptospermum polygalifolium</i>	Myrt.	S	2	
<i>Baeckea densifolia</i>	Myrt.	S	3		<i>Lepyrodia leptocaulis</i>	Restion.	G	2	
<i>Boronia anethifolia</i>	Rut.	S		2	<i>Leucopogon attenuatus</i>	Epacrid.	S	1	
<i>Brachycome tenuiscapa</i>		S			<i>Leucopogon lanceolatus</i>	Epacrid.	S		1
var. <i>pubescens</i>					<i>Leucopogon muticus</i>	Epacrid.	S	2	
<i>Brachycome stuartii</i>	Aster.	F	2		<i>Liparis reflexa</i>	Orchid.	F		2
<i>Brachyoloma daphnoides</i>	Aster.	F	1		<i>Lobelia dentata</i>	Lobeli.	F	1	
<i>Breynia oblongifolia</i>	Epacrid.	S	1		<i>Logania albiflora</i>	Logani.	S	1	
<i>Callistemon</i>	Euphorbi.	S		1	<i>Lomandra confertifolia</i>				
sp. aff. <i>pallidis</i>					subsp. <i>pallida</i>				
<i>Callitris endlicheri</i>	Myrt.	S	1		<i>Lomandra longifolia</i>	Xanthorrhoe.	TF	1	
<i>Calotis dentex</i>	Cupress.	T	3		<i>Lomatia sialifolia</i>	Xanthorrhoe.	TF	2	3
<i>Cassinia quinquefaria</i>	Aster.	F	1		<i>Lophostemon confertus</i>	Prote.	S	1	
<i>Cassytha glabella</i>	Aster.	S	2		<i>Maytenus silvestris</i>	Myrt.	T		3
<i>Cheilanthes sieberi</i>	Laur.	C	1		<i>Melichrus urceolatus</i>	Celastra.	S	1	
<i>Correa reflexa</i>	Adiant.	E	2	2	<i>Mirabella speciosa</i>	Epacrid.	S	2	3
<i>Crassula pedicelosa</i>	Rut.	S	1		<i>Micranthemum hexandraum</i>	Fab.	S	2	
<i>Cryptandra scortechinii</i>	Crassul.	F	1		<i>Notalea linearis</i>	Euphorb.	S	1	
<i>Desmodium varians</i>	Rhamn.	S	1		<i>Notalea microcarpa</i>	Ole.	S	2	
<i>Dianella caerulea</i>	Fab.	C		1	<i>Olearia ramosissima</i>	Ole.	S	1	3
	Dianell	F		2		Aster.	S		

Species	Family	L	B	GF	Species	Family	L	B	GF
<i>Chellianthes sieberi</i>	Adiant.	E	2	2	<i>Mirbelia speciosa</i>	Fab.	S	2	
<i>Correa reflexa</i>	Rut.	S	1		<i>Micranthemum hexandraum</i>	Euphorb.	S	1	
<i>Crassula pedicellosa</i>	Crassul.	F	1	2	<i>Noteleaea linearis</i>	Ole.	S	2	
<i>Cryptandra scortechinii</i>	Rhamn.	S	1		<i>Noteleaea microcarpa</i>	Ole.	S	1	3
<i>Desmodium varians</i>	Fab.	C		1	<i>Olearia ramosissima</i>	Aster.	S	1	
<i>Dianella caerulea</i>	Dianell	F		2					

Species	Family	L	B	GF	Species	Family	L	B	GF
<i>Dianella laevis</i>	Dianell.	F	1		<i>Olearia viscosa</i>	Aster.	S		1
<i>Cymbopogon obtectus</i>	Po.	G	2		<i>Opercularia hispida</i>	Rubi.	F	1	1
<i>Cymbopogon refractus</i>	Po.	G	1	3	<i>Paterosonia sericea</i>	Irid.	F	1	
<i>Davallia pyxidata</i>	Davalli.	F		2	<i>Petrophile canescens</i>	Prote.	S	1	
<i>Daviesia umbellifera</i>	Fab.	S	1		<i>#Persoonia terminalis</i>	Prote.	S	2	
<i>Dendrobium speciosum</i> var. <i>hilli</i>	Orchid.	F		1	subsp. <i>terminalis</i>	Prote.	S		
<i>Dodonaea viscosa</i>	Sapind.	S	1		<i>Persoonia sp. aff. sericea</i>	Prote.	S	2	1
<i>Entolasia stricta</i>	Po.	G	3	3	<i>Phebalium squamulosum</i>	Rut.	S	2	
<i>Eragrostis brownii</i>	Po.	G	3		<i>Pimelea pauciflora</i>	Thymelae.	S	1	
<i>Eucalyptus andrewsii</i>	Myrt.	T	2		<i>Plectranthus graveolens</i>	Lami.	F		2
<i>Eucalyptus bridgesiana</i>	Myrt.	T	1		<i>Poa sieberiana</i>	Po.	G		3
<i>Eucalyptus campanulata</i>	Myrt.	T	1	5	<i>Polyscias sambucifolia</i>	Arali.	S		2
<i>Eucalyptus caleyi</i>	Myrt.	T	1		<i>Pomax umbellata</i>	Api.	F	1	3
<i>Eucalyptus dealbata</i>	Myrt.	T	3		<i>Pomaderris lanigera</i>	Rhamn.	S	1	1
<i>#Eucalyptus michaeliana</i>	Myrt.	T	1		<i>Pomaderris prunifolia</i>	Rhamn.	S	1	
<i>Eucalyptus microcorys</i>	Myrt.	T	1	4	<i>#Prostanthera staurophylla</i>	Lami.	S	1	
<i>Eucalyptus moluccana</i>	Myrt.	T	1	2	<i>Ptilantheium deustum</i>	Cyper.	G	2	
<i>Eucalyptus prava</i>	Myrt.	T	1		<i>Pultenaea foliosa</i>	Fab.	S	1	2
<i>Eucalyptus stannicola</i>	Myrt.	T	3		<i>Pyrrosia confluens</i>	Polypodi.	F		
<i>Exocaropus cupressiformis</i>	Myrt.	T	4	2	<i>Solanum cinereum</i>	Solan.	S	1	
<i>Ficus rubiginosa</i>	Santal.	S	1		<i>Schoenus ericetorum</i>	Cyper.	G	2	
<i>Geranium neglectum</i>	Mor.	T	1	1	<i>Stackhousia muricata</i>	Stackhousi.	F	1	
<i>Gahnia aspera</i>	Gerani.	F	2		<i>Stipa ramosissima</i>	Po.	G		3
<i>Glycine clandestina</i>	Cyper.	G	1		<i>Stylidium</i>	Stylidi.	F	1	2
<i>Goodenia hederacea</i>	Fab.	C	1		<i>Themeda australis</i>	Po.	G		3
<i>Goodenia rotundifolia</i>	Goodenia.	F	1		<i>Trema aspera</i>	Ulm.	S		1
<i>Gonocarpus teucrioides</i>	Goodeni.	F	1		<i>Wahlenbergia stricta</i>	Campanul.	F	1	
<i>#Grevillea beadleana</i>	Halorag.	F	2	4	<i>Xanthorrhoea glauca</i>	Xanthorrhoe.	TF	2	2
<i>Grevillea linearifolia</i>	Prote.	S	4	4	<i>Xyris gracilis</i>	Xyrid.	G	1	
<i>Hardenbergia violacea</i>	Prote.	S	2		<i>Zieria cyrtioides</i>	Rut.	S		1
	Fab.	C		2					

KEY

B = Oaky Creek, Binghi including the knoll west of the creek (average cover rating from six 20 x 20 quadrats).
GF = Guy Fawkes National Park - Chaelundi; cover rating assigned to species over the area of distribution of *Grevillea beadleana* i.e 300 m x 100 m.
L (life-form): T = tree; S = shrub; F = forb; TF = tussock; F = forb; E = fern; C = climber.
 # rare or threatened on national or regional basis.
 Cover ratings: 1 = <1%; 2 = 1-5%; 3 = 5-25%; 4 = 25-50% 5 = 50-75%; 6 = 75-100%.

Land-use history

Oaky Creek lies on the western side of the largest, naturally vegetated region on the Northern Tablelands of New South Wales - known as Binghi. The land tenure of the Binghi area is mainly Crown land and Crown lease and the main land uses are tin mining and rough grazing. It is one of the few areas on the western fall of the Great Dividing Range to have been classified as wilderness (Helman *et al.* 1976). Since the mid-1970s various proposals have been put forward to protect the natural features in the area. These have included establishing a national park, listing the area on the National Estate Register and declaring it as Wilderness (National Parks and Wildlife Service pers. comm., Australian Heritage Commission pers. comm, National Parks Association of NSW, 1976). The most recent report by the Department of Lands (1991) recommends that most of the Crown land in the Binghi area should be kept in Crown ownership and managed with the primary objective of maintaining its natural features. Such action would help prevent further clearing of native vegetation which is major threat to flora (including *Grevillea beadleana*).

Some abandoned tin mines are present in the area and there are traces of an old track running next to Oaky Creek - presumably related to mining earlier this century. Due to the rough topography, poor soils and the limited suitability of the vegetation as feed, grazing has been light.

Population biology

Field observations suggest that plants of *Grevillea beadleana* are usually killed outright when burnt. Lignotubers or similar root structures are absent and regeneration relies on the successful germination of seed and survival of seedlings. In a small number of cases, where the lower trunk has been protected from fire by rocks, suckering from the base of the trunk has been observed. It seems that given sufficient seed store the species will germinate well in the post-fire environment. There are no apparent limitations to pollination, although pollination vectors and mechanisms have not been studied.

Observations suggest that fruit do not persist on the plant but drop to the ground at maturity releasing their seeds. Large quantities of seed seem to be produced in both populations. The relatively heavy seed is unlikely to be dispersed far from its source.

The longevity of individual plants of *Grevillea beadleana* is unknown. A large specimen that was observed in 1981 at Guy Fawkes (J.B. Williams pers. comm.) was still alive in 1991 and must be at least 20 years old. It is likely that, left unburnt, individual specimens of *Grevillea beadleana* could live for several decades. In cultivation at Coffs Harbour Botanic Gardens plants grow quickly, flower in a year and produce viable seed within a maximum of three years (A. Floyd pers. comm.). Seeds remain viable in the soil for at least one year based on the time it took seedlings to emerge after the death of the only adult plant in the Coffs Harbour Botanic Gardens. This plant died after a prolonged wet period due to a fungal root infection (an incident that supports the view that *Grevillea beadleana* prefers better drained sites).

Care should be taken in extrapolating the Coffs Harbour observations to wild populations on the cooler tablelands where the growing season is shorter and habitat harsher than the coast. In its natural habitat the average height of seedlings two years after a fire was approximately 20 cm. From these observations it is estimated that, in its natural habitat, *Grevillea beadleana* may take up to five years to flower and seed.

Discussion

Along with many species in its genus, *Grevillea beadleana* favours well drained, acidic, low-nutrient soils - low in phosphorus, nitrate, calcium and magnesium but rich in silica and aluminium. Rainfall ranges from 800 mm to 1000 mm, altitudes from 950 to 650 m and aspect tends to be west to north-west.

The data confirm that *Grevillea beadleana* is a very restricted species. It also seems that given the limited number of collections, it was a restricted species at the time of European settlement. This supposition is based on a view that it is a highly attractive and distinctive plant - one which would not be easily overlooked by early collectors if it were widespread.

Though there is a potential large habitat for *Grevillea beadleana* in the Binghi area, recent botanical surveys covering lands around Torrington (Williams 1991) have failed to record it.

The rarity of *Grevillea beadleana* may be explained by historic and extant factors including changes in climate and detrimental fire regimes. From the historical perspective, *Grevillea beadleana* could now be surviving in climatic refugia. It may have been eliminated from other sites by extensive changes in climate over a long period of time and consequent competition with more adaptable species. This is supported by the fact that *Grevillea beadleana*, along with the also rare *Grevillea scortechinii*, are at the northern-most range of the *caleyi-longifolia-aspleniifolia* section of the 'toothbrush-inflorescence' group. Since there are related species in Western Australia it is possible that species in this group may have radiated from an ancient ancestor that lived perhaps as far back as 20–30 million years ago (R. Makinson pers. comm.). Also supporting this hypothesis is the apparent susceptibility of *Grevillea beadleana* to death from water stress during drought - a factor that may have eliminated the species from drier sites in the past.

If there has been a marked increased fire frequency in Australia (Singh *et al.* 1981) since human occupation, this may have had some impact on species which are sensitive to frequent fire. Most of the 'toothbrush-inflorescence' group of grevilleas may fall into this category. If so, this may form one explanation (yet to be tested) for the rarity of many of these species today. *Grevillea beadleana* presently survives only in relatively fire-protected positions - on rocky platforms, between boulders or near creeks. Most of the Oaky Creek population occurs on the eastern side of the creek - perhaps the creek forms a buffer from fires that most frequently originate to the west. Similarly, the granitic bluff at Guy Fawkes protects surviving plants from most fires.

Even though the Guy Fawkes population is within a national park this has not diminished frequent fire. These come from both the west, running uphill from the Guy Fawkes River valley to the rim of the gorge and from the adjoining plateau, trickling down over the edge of the gorge. The recent fire in 1988 originated on the plateau and burnt several kilometres of forest understorey to the north and the south (J.B. Williams pers. comm.). Most fires in the area are illegally lit, presumably to enhance grazing. A Travelling Stock Route (TSR) adjacent to the Guy Fawkes River in the heart of the Park adds to the difficulties in controlling illegal grazing and associated burning off (G. Roberts pers. comm.).

Of particular interest are the apparent parallels in ecology and threatened status of several species in this 'toothbrush-inflorescence' group. For example, populations of the threatened *Grevillea caleyi*, which grow on lateritic ridgetops in the northern suburbs of Sydney, are susceptible to frequent burns (Scott 1986, A. Auld pers. comm.). Research on *Grevillea caleyi* suggests that fire should be excluded for at least 10 years

to allow plants to mature, produce seed and build up a seedbank in the soil. Given that it seems to senesce after 30 years, occasional hot wildfire (say once every 20 years) may well be necessary for the successful survival of *Grevillea caleyi*. There is also some doubt about the effectiveness of a cool fire in promoting seed germination (A. Auld pers. comm.). The limited evidence on the ecology of *Grevillea beadleana* indicates that it may hold a similar reproductive strategy.

Fire, therefore, should not be viewed as incompatible with the existence of *Grevillea beadleana*. It would appear that it is vital to the regeneration of the species but is likely to be destructive if it occurs too frequently.

Other threats to the survival of *Grevillea beadleana* in the wild are habitat clearing, drought and grazing by sheep. In addition, its small population size at Guy Fawkes makes the species there vulnerable to the effects of inbreeding over the long term.

At Binghi there is the threat of physical disturbance of the habitat associated with the development of the leasehold land on which it grows. In 1989 some of the land on which *Grevillea beadleana* grows was illegally bulldozed by the lessee. Some plants of *Grevillea beadleana* were destroyed in the process and the disturbance resulted in localised soil erosion. Negotiations have since taken place between the lessee and relevant government authorities with a view to preventing further damage.

Another possible threat is grazing by goats. Several goat farms have been established on adjoining properties and if goats escape or were introduced into the naturally vegetated country, considerable damage could result (J.B. Williams pers. comm.). Any increase in grazing pressure, particularly on seedlings, could have an adverse impact on the populations of *Grevillea beadleana*.

Death of large numbers of individual plants during droughts is a possible important threat. Observations at Oak Creek in July 1991 (Table 3) at the beginning of a major drought indicate this cause of mortality may be significant during dry times.

Future research

Specific research and management tasks have been outlined and costed in Benson (1991). Suggested projects include:

Additional survey: the Moona Plains locality should be re-surveyed in case *Grevillea beadleana* still exists there. Also, further botanical surveys in the Binghi granite area may locate additional populations.

Population dynamics: observations in 1991 revealed that at both its population sites, relatively large post-fire cohorts of *Grevillea beadleana* seedlings have survived for two years (Figure 7). Therefore it could be assumed that there are no major limitations with flowering, pollination, seed maturation and germination. Dispersal of the heavy seed appears to be limited to near the parent plant. However, experiments based on the tagging of both adult and juvenile plants would help substantiate the growth rates of the species, mean ages for the production of flowers and seed, seedling survival rate, longevity of individuals and mortality rates and causes. Research could also be warranted into seed viability, dormancy and response to heat and dispersal. Ants may play a role here because the seed is bordered by a waxy substance; similar seeds in related species are known to be gathered by ants (R. Makinson pers. comm.). To gain a better understanding of the fire regimes required to maintain populations, experimental burns of patches containing mature plants could be undertaken. Measurements should be taken of post-fire recruitment against the variables of temperature of the burn and post fire climatic conditions.

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Figure 7. A two year old seedling. Parts of both the Guy Fawkes and Binghi populations of *Grevillea beadleana* were burnt in 1988. Adults are killed by fire and regeneration relies on seedlings.

Breeding systems: investigating the species' breeding system to establish its self compatibility and relative ratios of outcrossing to selfing would aid in indicating if inbreeding could be occurring in either or both of the populations.

Genetic variation: the presence of one large and one small population separated by 115 km allows for testing comparative differences in the genetic variability between the populations (R. Peakall pers. comm). The presence of any inbreeding in the smaller population could also be detected.

Conservation and management

Given that the species is endangered the main aim of management should be to maintain viable populations in the wild. This can best be achieved by preventing both populations from being burnt too often. It is inevitable that wildfire will burn each of the occurrences in the future, but every effort should be made to maintain a fire free period of at least 15 years (this suggested period is only an estimate at this stage pending the results of any future research into the species' fire ecology). The small population of *Grevillea beadleana* conserved in Guy Fawkes River National Park is in some ways the most threatened. It would seem that there needs to be better control on fires lit deliberately in the area including along the travelling stock route (TSR) in the valley. The removal of illegal livestock in the park, combined with the closure of the TSR could reduce some of the main incentives to start fires.

Protection of the large population of *Grevillea beadleana* at Oaky Creek, Binghi from inappropriate land use is a major management issue. This could be achieved either by acquisition of the land and its dedication as a nature reserve or by way of a secure covenant between the lessee and appropriate authority. Continuing destruction of nearby vegetation, construction of tracks and future recreational activities could adversely affect, indirectly or directly, this largest and most viable population of the species.

The protection of the habitat in the Oaky Creek valley would also benefit several other rare plant species - (*Prostanthera staurophylla*, *Hibbertia* sp. aff. *obtusifolia*, *Acacia torringtonensis*, *Acacia granitica* and *Persoonia terminalis* subsp. *terminalis*) and the *Eucalyptus prava*-*E. stannicola*-*E. andrewsii* plant association which is presently not represented in any conservation reserve.

If its population at Oaky Creek is conserved by way of a reserve or covenant and the appropriate authorities demonstrate they are able to control fire at both of its populations, then it would be justified to change the national threat status of *Grevillea beadleana* from endangered (E) to vulnerable (V).

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