Vegetation on and around granite rock outcrops in the Wellington National Park

RUSSELL S. SMITH[1] AND LEIGH W. SAGE[2]

[1]Department of Conservation and Land Management, PO Box 1693, Bunbury WA 6230. russells@calm.wa.gov.au
[2]Department of Conservation and Land Management, 5 Dundebar Road, Wanneroo WA 6065. leighs@calm.wa.gov.au

SUMMARY

A survey of vascular plant species associated with granite outcrops in Wellington National Park near Bunbury in the south west of Western Australia was carried out in spring and summer 2002. One hundred and eight species, including 10 exotic taxa, were identified. The most frequently represented genera were Orchidaceae (8 species), Asteraceae (8), Apiaceae (6), Myrtaceae (6), and Poaceae (6). The outcrop vegetation formed a continuum dependant mainly on soil depth, ranging from lichen encrusting otherwise bare rock surfaces, through moss swards and herbfields to shrublands and heathlands on deeper soils. It contrasts with that of the surrounding forest both in regard to species composition and structure. This is mainly because of a higher proportion of obligate seeders due to lower fire frequencies, the high summer water stress levels and a wide variety of habitat types within a relatively small area. Not under immediate threat, plant pathogens such as *Phytophthora cinnamomi*, physical disturbance and climate change may pose threats in the near future.

INTRODUCTION

In the south west of Western Australia granite (or granitoid) rocks occur mainly on the Darling Plateau, an ancient erosion surface that averages 300 m above sea level. The Darling Scarp marks the eroded western edge of the Darling Plateau and rises about 200 m from the Swan Coastal Plain. The Collie River, one of the major streams draining the Darling Plateau, cuts through the Darling Scarp about 180 km south of the State capital, Perth. The granite rock outcrops surveyed for this project occur along the lower Collie River valley, below the Wellington Dam, and on the slopes of valleys leading to the Collie River. Altitude of the outcrops varies from about 60 m beside the river where it leaves the national park to 320 m on Mt Lennard. Most of the outcrops are composed of porphyritic granite (Wilde and Walker, 1982), with some smaller areas of granitic gneiss and quartz feldspar biotite gneiss. Occasional doleritic dykes occur. The outcrops protrude from lateritic soils at the upper levels and along the lower slopes there are minor areas of alluvial soils. The average annual rainfall is about 1200 mm, with a prominent winter peak.

Little is known about the vegetation of outcrops in the Wellington National Park or in the Jarrah Forest Bioregion (Thackway and Cresswell, 1995) generally and this survey was carried out partly to remedy that lack of knowledge. In addition knowledge of the rock outcrop vegetation will be important in conserving and managing these restricted communities within the park. The intention was to survey not just the herbfields associated with the skeletal soils on the outcrops, but also with the generally treeless vegetation on the shallow rocky soils on the margins of the outcrops.

The forms of the outcrops included the four types (dome, pavement, fugitive and tumulus) illustrated in York Main (1997) as well as another type that occurs along a stretch of the upper slopes on the northern edge of the Collie River Valley. This takes the form of a jumble of rocks, or tors, of varying shape and size interspersed with pockets of skeletal soils of varying depth, most of which are apparently too shallow for the growth of trees.

MATERIALS AND METHODS

In October 2002 five 100 m2 (10 m x 10 m) quadrats were placed on outcrops within the national park, situated so that they included some portion of their area as bare rock (Table I). In general the rock outcrop or lithic communities sampled in this survey were defined by the lack of trees, however occasionally in pockets of deeper soils small (< 5 m) individuals of *Corymbia calophylla* occurred. Three quadrats were sited on the north side of the Collie River and two on the south. All vascular plant species were identified within the quadrats and scored on a cover/abundance scale of 1–5. Additionally several other rock outcrops were visited and notes made of the dominant plant species. A follow-up visit was made to several of the outcrops in December 2002 to pick up late flowering species. Voucher specimens were collected and stored at the Department of Conservation and Land Management, Bunbury or deposited in the Western Australian Herbarium. Nomenclature follows the Paczowska and Chapman (2000) and current usage at the Western Australian Herbarium (Perth).

TABLE 1
Location and other characteristics of the Wellington National Park quadrats. (see Figure 1)

ATTRIBUTE NAME	WNP01 BOOMER RIDGE	WNP02 LOOKOUT TRACK	WNP03 MT LENNARD I	WNP04 MT LENNARD II	WNP05 SIKA TRACK
Altitude (m) a.s.l.	200	200	287	307	247
Latitude	33° 19' 56.4"	33° 22' 18.2"	33° 21' 43.9"	33° 21' 40.4"	33° 23' 32.0"
Longitude	115° 55' 37.0"	115° 56' 53.3"	115° 53' 22.8"	115° 53' 33.8"	115° 57' 49.1"
% bare rock	10	15	5	5	60
Aspect	north	south west	north east	north	south west

RESULTS

Flora

The number of vascular plant species within the 100 m2 quadrats ranged from 25 to 42, with a total of 108 species recorded including taxa found outside the quadrats, 10 of these being exotic (Appendix I). The most frequently represented families within the quadrats were Orchidaceae (8 species), Asteraceae (8), Apiaceae (6), Myrtaceae (6), and Poaceae (6).

The lithic vegetation associated with rock outcrops in Wellington National Park, and elsewhere in the Jarrah Forest bioregion, can be divided into three main communities determined by depth and development of soil. As determined by increasing depth of soil these are (1) the moss-lichen community with a few associated herbaceous annuals, (2) the herbfields of *Borya* species and various herbaceous annuals, and (3) the fringing heathlands and shrublands.

Vegetation and habitat

There was great variation in the vegetation associated with the outcrops, both in composition and structure. It ranged from patches of lichen on otherwise bare rock surfaces to moss swards where there was a minimal development of soil to herbfields which sometimes included mosses and were characterised by *Borya* species (resurrection plants), and geophytes such as *Stylidium* spp. (trigger plants) and *Drosera* spp. (sundews), and small annuals such as *Hydrocotyle* spp. (pennyworts), the small daisies *Podolepis lessonii* and *Podotheca gnaphalioides*, and the ubiquitous exotic grasses **Aira caryophyllea* and **Briza minor*. A robust from of *Stypandra glauca* (previously named *S. grandiflora*) was commonly found growing in narrow crevices in the rocks (cf. Ornduff, 1986, p. 16).

In deeper soil at the edges of the herbfields open heathland or shrubland (up to 1.5 m) usually dominated by *Verticordia plumosa* ssp. *plumosa* and *Grevillea bipinnatifida* was common. *Pimelea imbricata* ssp. *imbricata* and *Hypocalymma angustifolium* were also often present as well as a range of exotic and native herbaceous species. In places the shrubland is dominated by *Darwinia citriodora* with co-occurring shrub species such as *Daviesia hakeoides* ssp. *hakeoides* and *Hibbertia commutata*, particularly on the upper slopes of the north side of the Collie River valley where masses of tor-like boulders are interspersed with pockets of deeper soil.

DISCUSSION

Flora

Three Priority List[1] species were found during this survey, and the location of one species represented a significant range extension. The Priority 3 species (*Acacia oncinophylla* ssp. *oncinophylla*) usually associated with granite is quite common around outcrops on the lower slopes south of the river. *Calothamnus graniticus* ssp. *leptophyllus* (Priority 4) which was found on Mt Lennard during this survey had been collected from "Collie Weir" in 1946 but otherwise all specimens in the WA Herbarium are from Oakley Dam near Dwellingup. Apart from one collection on a disturbed roadside on the coastal plain near Dardanup the discovery of *Daviesia hakeoides* ssp. *hakeoides* within Wellington National Park represents a significant range extension for this species. The nearest known populations within conservation reserves are between Perth and Toodyay. A new population of the Priority 3 species *Synaphea hians* was found in one of the quadrats during this survey.

Vegetation and habitat

The major significance of the granite outcrop communities in the national park is the contrast they present with the surrounding forest in terms of structure and plant species composition – they share very few species with the surrounding jarrah-marri forest and have a high level of endemism (Hopper *et al.* 1997). The evolution of a distinct suite of plant species associated with rock outcrops no doubt is due to a number of factors; the diversity of microhabitats (alternately extremely dry and very wet), high light levels (Baskin and Baskin, 1988), and a relatively longer interval

[1] This lists flora that may be rare or threatened but for which there are insufficient survey data to accurately determine their status, as well as flora which is regarded as rare, but not currently threatened.

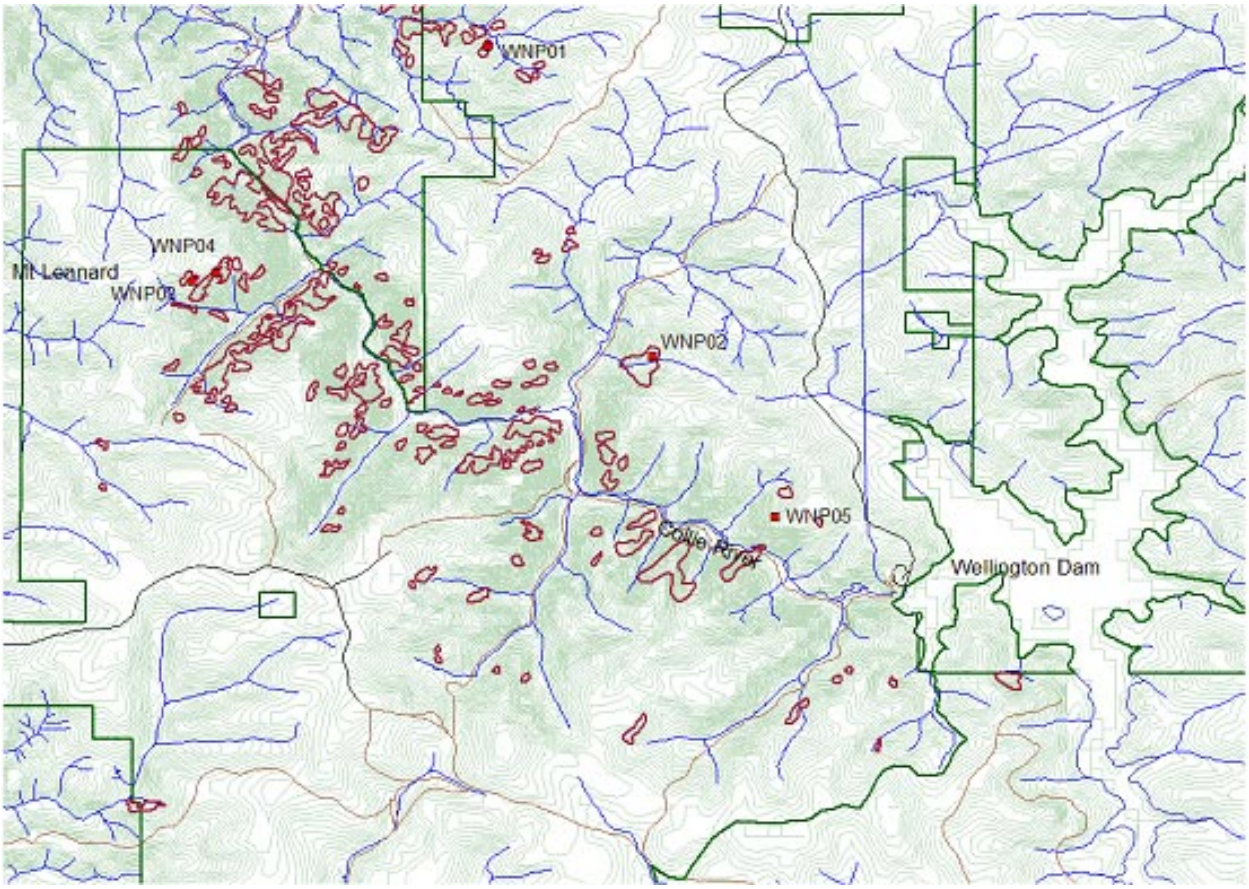

Figure 1. Map of part of Wellington National Park showing areas of rock outcrop and the location of 100 m² survey quadrats.

between fires than the surrounding vegetation (as indicated by higher proportions of obligate seeders; Hopper *et al.*, 1997; Clarke, 2002a, 2002b) being among the most important.

Insufficient information is available at this stage on the fire response characteristics of the Wellington National Park rock outcrop flora to be able to compare the proportion of obligate seeders with the rock outcrop vegetation surveyed by Clarke (2002b). Several of the dominant species of the Wellington National Park outcrop shrublands are seeders (*Darwinia citriodora, Daviesia hakeoides* ssp. *hakeoides, Calothamnus graniticus* ssp. *leptophyllus*) while several others are resprouters (e.g. *Dodonaea ceratocarpa, Hibbertia commutata, Hypocalymma angustifolium*).

There is little published data on the species composition of granite outcrop communities in the south west of Western Australia, and no attempt has been made to classify the communities. Hopper *et al.* (1997) listed 1320 vascular and cryptogram species represented in the Western Australian herbarium where the habitat description included the words "rock outcrop", although they noted that this was far from comprehensive. Ornduff (1986) surveyed the vascular flora of 10 rock outcrops in the south west of Western Australia, including several in the medium-high rainfall zone of the northern jarrah forest. However he did not identify and record the woody flora surrounding the moss swards and herbfields, nor the members of the Orchidaceae, which are a very important component of the outcrop flora in terms of endemism (Hopper *et al.* 1997).

Comprehensive accounts have been published of the vascular flora of three granite outcrops in medium to high rainfall areas of Western Australia. These allow a comparison of species composition with those of Wellington National Park (Smith 1962; Abbott 1982; Pigott and Sage 1997; Keighery *et al.* 2002). However, they are more than 150 km from the study area.

In addition as part of this project, a survey was made of a 6 ha portion of gneissic outcrop in Mullalyup Forest Block, 40 km south of the study area (Appendix II). This, together with a report on the flora of an outcrop in Serpentine National Park (Holmwood 1987), allow comparison with areas which are in a similar rainfall zone, and are geographically much closer.

A comparison of the number of vascular species these other sites had in common with the flora of the rock outcrops in Wellington National Park is shown in Table II. A partial list for Oakley Dam derived from records at the Western Australian Herbarium provides another source for comparison (Appendix III). It must be noted at this point that the species numbers used in Table 2 were derived using methods that are not strictly

TABLE 2

Comparison of vascular plant species occurrence associated with granite outcrops in Wellington National Park and at five other locations. [2] Includes both Lithic and Thicket (granite apron) complexes.

	WELLINGTON NATIONAL PARK (THIS STUDY)	MULLALYUP BLOCK (THIS STUDY)	SERPENTINE NATIONAL PARK (HOLMWOOD, 1987)	YILLIMINING ROCK[3] (PIGOTT AND SAGE, 1997)	PORONGURUP RANGE (SMITH, 1962; ABBOTT, 1982)	DRUMMOND RESERVE (KEIGHERY *ET AL*., 2002)
Rainfall (mm)	1200	1000	1140	450	700	470
Distance (km)		40	110	150	230	220
Number of vascular species	113	45	39	160	145	45
Number in common with WNP outcrops		24 (53%)	12 (31%)	28 (17%)	24 (17%)	13 (29%)

comparable. Those for the Porongurup Range, for instance, were derived from two surveys, the second extending over a period of six years (Abbott 1982) during which some species found during the earlier survey (Smith 1962) were not relocated.

Not unexpectedly the Mullalyup Block lithic communities had most species in common with those of Wellington National Park. The shrubland community in Wellington National Park and that at Mullalyup Block also have similar dominant species – *Darwinia citriodora, Grevillea bipinnatifida, Dodonaea ceratocarpa* and *Pimelea imbricata* are important in both. In addition the herbfield floras are quite similar, the fern *Cheilanthes sieberi* ssp. *sieberi, Stylidium calcaratum, Senecio quadridentatus* and the native grass *Neurachne alopecuroidea* being frequent. The shrubland at Oakley Dam is also quite similar with that in Wellington National Park with *D. citriodora, G. bipinnatifida* and

Figure 2. Surveying a quadrat at Mt Lennard (WNP04) with Andersonia aristata *in the foreground and* Verticordia plumosa *ssp.* plumosa *in the middle ground*

Calothamnus graniticus ssp. *leptophyllus* being amongst the dominant species. Somewhat surprisingly the flora on the granite outcrop in Serpentine National Park only 35 km north of the Oakley Dam site shares few shrub species with the Wellington National Park lithic communities, most of the plant species in common being exotic annuals and native herbaceous species. However on the evidence of the species list the Serpentine National Park survey may have been mainly confined to the rock outcrop *per se*, and does not include as many species in the slightly deeper soils at the margins as the Wellington National Park survey did.

Apart from *Darwinia citriodora* and *Hypocalymma angustifolium* the dominant species of the shrubland vegetation associated with granite outcrops in the Porongurup Range are different from those in the Wellington National Park. The species in common are predominantly those of the herbfields and the herbaceous component of the shrublands. The shrubland community associated with granite outcrops at the Drummond Nature Reserve (Keighery *et al.* 2002) 230 km to the north, where annual rainfall is less than half that in Wellington National Park, has only a single woody species (*Acacia pulchella*) in common with the latter area. Among the other species in common are the herbfield constituents *Borya sphaerocephala, Neurachne alopecuroidea, Hydrocotyle alata* and *Trachymene pilosa* as well as the exotic annuals **Hypochaeris glabra* and **Anagallis arvensis*. Likewise, the flora of the lithic and granite apron communities at Yilliminning Rock shares few shrub species with Wellington National Park. Notably however one of these is *Daviesia hakeoides* ssp. *hakeoides*, the Wellington National Park population of which represents a significant outlier.

Threats to the rock outcrop vegetation

Hopper *et al.* (1997) list the main threats to rock outcrop communities as being invasive weeds, feral animals, grazing, inappropriate fire regimes, clearing, loss of shrub layer, salinity and dieback disease. Eleven exotic plant species were found in the Wellington National Park rock outcrop vegetation – 12% of the total number of species. These were all small, mostly annual plants, with wind-dispersed seeds, most of which now have a cosmopolitan distribution and which appear to pose little further threat to the native species of the lithic communities. However rock outcrops appear to be more susceptible to weed invasion than most other plant communities in south-western Australia with relatively low levels of disturbance and there are situations where they have been invaded by less benign weeds (Pigott and Sage 1997; Pigott 1997). Monitoring for increases in weed invasion should take place within Wellington National Park where outcrops are readily accessible to the public, such as along Lennard Drive, the main access road along the lower Collie River Valley.

A related issue is disturbance by trampling which occurs when the general public has ready access to rock outcrops. If not controlled this can lead to loss of vegetative cover, erosion and increases in weed invasion. This is already apparent in some places along Lennard Drive.

The rock outcrops visited during this survey appear not to have been deleteriously affected by fire regimes. Prescribed burning has been carried out from time to time in the study area on the lateritic uplands either side of the lower Collie River Valley. The most recent prescribed burning within the Park was in spring 2001 in the area around Mt Lennard. This burnt less than 10% of the vegetation on the outcrops visited during this survey. Most of the vegetation on the fringes of the rock outcrops in this case appeared not to have burned primarily because of the protection afforded by areas of bare rock or sparse fuels. In addition, the moss sward is still damp in spring and less prone to burn in spring than during summer or autumn fires. It is possible that in the long-term a lack of fire could be a threat to the outcrop vegetation because many of the species have fire-stimulated germination.

A related issue is change of climatic conditions related to global warming. The diversity of microhabitats on the rock outcrops of south-western Australia appear to have acted as refugia for plants adapted by wet or dry conditions as the surrounding matrix waxed and waned climatically (Hopper *et al.* 1997). Rainfall amounts and patterns in the south-west have altered significantly over the last 30 years (IOCI 2002). There has been a 10–15% decrease in rainfall totals in the early winter months and a trend to fewer rain days and less rain in extreme days. In addition there has been a 0.7° increase in mean temperature over the last 50 years in the south-west (IOCI 2002). Both the increase in mean temperature and decline in winter and spring rainfall are expected to continue over the next 50 years.

A reduction in winter/spring rainfall amounts is likely to be accompanied by an increase in the area burnt by wildfires at a regional scale (Swetnam and Bettancourt, 1990). It is also likely to have an impact on the ease with which prescribed burning can be carried out safely. In recent years we have observed multiple drought-induced deaths of woody plants on the aprons of granite outcrops in the Jarrah Forest bioregion after particularly dry years. Reliant as they are on rainfall, rather than ground water, moss beds and associated herbfields may be amongst the first vegetation types to show the effects of the predicted climate change in south-western Australia.

CONCLUSIONS

The rock outcrop vegetation of Wellington National Park contrasts with that of the surrounding forest both in regard to species composition and structure, and also because it may have a higher proportion of obligate seeders. The high summer water stress levels of the outcrops, as well as the lower frequency of fires are probably the main contributors to this distinctiveness. Also, because of the wide variety of habitat types within

a relatively small area the rock outcrop vegetation has a higher diversity of composition and structure than equivalent areas of the forest matrix. The number of species observed during the survey compares well with others that examined rock outcrop vegetation in the south-west of Western Australia.

The rock outcrop vegetation does not appear to be presently under particular threat. The effect of the current regime of mainly spring fires and occasional autumn ones carried out at 8 – 10 year intervals over the last 40 years on the composition of outcrop vegetation is unknown. However, as noted already, the last prescribed fire in 2001 had little impact. While dieback disease, caused by the soil-borne pathogen *Phytophthora cinnamomi* is present in the national park there was no sign of deaths attributable to the disease during this survey.

Future risks to the outcrops include physical disturbance and opportunity for spread of plant disease that might come about through increased visitor use of the park. Climate change may cause unavoidable changes through reduced rainfall and increased evapotranspiration.

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APPENDIX I

Vascular plant species occurring (presence/absence) within 10m x 10 m quadrats placed on rock outcrops in Wellington National Park

FAMILY	SPECIES	WNP01	WNP02	WNP03	WNP04	WNP05
Adiantaceae	*Cheilanthes sieberi* ssp. *sieberi* Kunze	1	0	1	0	1
	*Chamaescilla corymbosa (R.Br.)*Benth.	0	0	1	1	0
	Thysanotus manglesianus Kunth.	1	0	0	0	0
	Thysanotus patersonii R.Br.	0	0	0	0	1
	Tricoryne sp.	0	1	0	0	0
Apiaceae	*Daucus carota* L.	1	0	0	0	0
	Hydrocotyle alata A.Rich.	0	0	0	0	0
	Hydrocotyle callicarpa Bunge in Lehm.	0	0	1	1	0
	Pentapeltis peltigera (Hook.)Bunge in Lehm.	1	0	0	0	0
	Trachymene pilosa Sm. in Rees	0	1	1	1	1
Asteraceae	*Angianthus sp.*	0	1	0	0	0
	Brachyscome iberidifolia Benth. in Endl., Fenzl, Benth.and Schott	0	1	0	0	0
	**Hypochaeris glabra* L.	1	1	1	1	1
	Podolepis lessonii (Cass.)Benth.	0	1	0	0	1
	Podotheca gnaphalioides Graham	0	0	1	0	0
	Senecio quadridentatus Labill.	0	0	0	0	1
	Senecio ramosissimus DC.	0	1	0	0	1
Boryaceae	*Borya scirpoidea* Lindl.	0	0	1	1	0
	Borya sphaerocephala R.Br.	0	1	0	1	0
Caryophyllaceae	*Cerastium glomeratum* Thuill.	1	0	0	0	0
Centrolepidaceae	*Aphelia cyperoides* R.Br.	0	1	0	1	0
	Centrolepis aristata (R.Br.)Roem.and Schult.	0	1	0	1	0
Colchicaceae	*Burchardia umbellata*	0	1	0	0	0
Crassulaceae	*Crassula sp.*	1	1	1	0	0
Cyperaceae	*Schoenus ?odontocarpus* F.Muell.	0	1	1	0	0
Dilleniaceae	*Hibbertia commutata* Steud. in Lehm.	0	0	1	0	1
	Hibbertia hypericoides (DC.)Benth.	0	0	0	1	1
Droseraceae	*Drosera ?bulbosa* Hook.	1	1	1	0	0
	Drosera macrantha ssp. macrantha Endl.	0	1	1	1	0
	Drosera menziesii ssp. menziesii DC.	0	1	1	1	1
Epacridaceae	*Andersonia aristata* Lindl.	0	0	0	3	0
	Andersonia caerulea R.Br.	0	0	0	1	0
	Leucopogon capitellatus DC.	1	0	3	1	0
Euphorbiaceae	*Phyllanthus calycinus* Labill.	0	0	1	1	0
Geraniaceae	*Pelargonium littorale* Huegel	0	0	1	0	1
Goodeniaceae	*Velleia trinervis* Labill.	0	0	0	1	0
Iridaceae	**Orthrosanthus laxus* (Endl.)Benth.	0	0	0	0	1
	**Romulea rosea* (L.)Eckl.	1	0	0	0	0
Lamiaceae	**Mentha sp.*	0	1	0	0	0
Lentibulariaceae	*Utricularia multifida* R.Br.	0	1	0	1	0
Myrtaceae	*Calothamnus graniticus ssp. leptophylla* Hawkeswood	0	0	3	0	0
	Darwinia citriodora (Endl.)Benth.	4	1	2	1	0
	Hypocalymma angustifolium (Endl.)Schauer	1	0	1	0	2
	Melaleuca scabra R.Br. in W.T.Aiton	0	0	0	1	0
	Verticordia plumosa var. plumosa (Desf.)Druce	0	4	3	4	1
Olacaceae	*Olax benthamiana* Miq. in Lehm.	0	0	0	1	0
Orchidaceae	*Caladenia attingens* Hopper and A.P. Br.	0	0	1	0	0
	Caladenia flava R.Br.	0	0	1	0	0
	Caladenia marginata Lindl.	0	0	1	1	0
	Elythranthera brunonis (Endl.)A.S.George	0	0	0	1	1
	Pterostylis barbata (Lindl.)Szlach.	0	0	1	1	0
	Spiculaea ciliata Lindl.	0	0	0	1	0
	Thelymitra antennifera (Lindl.)Hook.f.	0	1	0	1	0
	Thelymitra crinita Lindl.	0	0	1	0	0
Mimosaceae	*Acacia pulchella* R.Br. in W.T. Aiton	0	0	0	0	1
Papilionaceae	*Daviesia hakeoides ssp. hakeoides* Meisn.	2	0	0	0	0
	Gastrolobium spinosum Benth. in Lindl.	0	0	1	1	0
	Gompholobium marginatum R.Br. in W.T.Aiton	1	0	1	0	1
	**Trifolium sp.*	1	0	0	0	0

Appendix I (cont.)

FAMILY	SPECIES	WNP01	WNP02	WNP03	WNP04	WNP05
Philydraceae	*Philydrella pygmaea* (R.Br.)Caruel	0	1	1	1	0
Poaceae	**Aira caryophyllea* L.	1	1	1	1	1
	**Briza minor* L.	1	1	1	0	0
	Neurachne alopecuroidea R.Br.	0	0	1	1	1
	Poa sp.	0	0	0	1	0
	**Vulpia muralis* (Kunth)Nees	1	1	1	0	1
Primulaceae	**Anagallis arvensis* L.	1	0	1	0	1
Proteaceae	*Grevillea bipinnatifida* R.Br.	2	1	0	1	1
	Grevillea pilulifera (Lindl.)Druce	0	0	0	1	0
	Hakea lissocarpha R.Br.	2	0	0	0	1
	Synaphea hians A.S.George	0	0	0	1	0
Rhamnaceae	*Cryptandra arbutiflora var. tubulosa* Fenzl in Endl., Fenzl, Benth.and Schott	0	0	1	0	0
	Trymalium ledifolium Fenzl.	0	0	0	0	1
Rubiaceae	**Galium murale* (L.)All.	1	0	0	0	0
Rutaceae	*Diplolaena drummondii* (Benth.)Ostenf.	0	0	1	0	1
Sapindaceae	*Dodonaea ceratocarpa* Endl. in Endl., Fenzl, Benth. and Schott	0	1	0	0	0
Scrophulariaceae	* *Parentucellia latifolia* (L.)Caruel in Parl.	0	0	1	1	0
Stackhousiaceae	*Tripterococcus brunonis* Endl. in Endl., Fenzl, Benth. and Schott	0	0	0	0	1
Stylidiaceae	*Levenhookia sp.*	0	0	1	0	0
	Stylidium ?despectum R.Br.	0	1	0	0	0
	Stylidium brunonianum Benth.	0	0	1	0	1
	Stylidium calcaratum R.Br.	0	1	1	1	1
Thymelaeaceae	*Pimelea imbricata ssp. imbricata* R.Br.	0	1	0	0	2
	Pimelea imbricata ssp. piligera R.Br.	0	0	1	0	0
Xanthorrhoeaceae	*Xanthorrhoea preissii* Endl. in Lehm.	2	1	0	1	1
	Number of species in quadrat	**28**	**31**	**44**	**40**	**32**

Appendix I (cont.)

Rock outcrop associated[4] vascular plant species found outside the quadrats in Wellington National Park. Those derived from the Western Australian Herbarium database (Florabase) are identified by the herbarium Sheet Numbers, otherwise they were identified as part of this project.

FAMILY	SPECIES
Amaranthaceae	*Ptilotus manglesii* (Lindl.)F.Muell.
Apiaceae	*Actinotus leucocephalus* Benth. in Endl.,Fenzl,Benth.and Schott
Asteraceae	*Angianthus preissianus* (Steetz)Benth.
	Rhodanthe citrina (Benth.)Paul G.Wilson
	Stuartina sp.
Droseraceae	*Drosera stolonifera*, Endl.
Goodeniaceae	*Dampiera hederacea* R.Br.
	Dampiera linearis R.Br.
	Velleia macrophylla (Lindl.)Benth.
Lobeliaceae	*Isotoma hypocrateriformis* (R.Br.)Druce
Myrtaceae	*Baeckea camphorosmae* Endl. in Endl.,Fenzl,Benth.and Schott
	Corymbia calophylla (Lindl.)K.D.Hill and L.A.S.Johnson
	Melaleuca parviceps Lindl., 5957338
	Eucalyptus drummondii Benth., 5571383
Orchidaceae	*Diuris aff magnifica* D.L. Jones
Papilionaceae	*Acacia oncinophylla* Lindl. ssp. *oncinophylla*
	Acacia insolita E.Pritz, 5470064
Phormiaceae	*Stypandra glauca* R.Br.,
Pittosporaceae	*Marianthus bicolor* (Putt.)F.Muell.
Poaceae	*Austrodanthonia setacea* (R.Br.)H.P.Linder
	**Briza maxima* L.
Proteaceae	*Conospermum huegelii* Endl.
Rutaceae	*Boronia defoliata* F. Muell., 5484863
Sapindaceae	*Dodonaea ceratocarpa* Endl. in Endl.,Fenzl,Benth.and Schott
Sterculiaceae	*Thomasia macrocarpa* Endl. in Endl.and Fenzl,

[4] Found within the generally treeless zone associated with the shallow outcrop soils.

APPENDIX II

Vascular plant species associated with a rock outcrop in Mullalyup Block near Kirup.

LATITUDE: 33° 44' 47.5" LONGITUDE: 115° 51' 59.6" ALTITUDE: 170–190 M

GEOLOGY: AUGEN GNEISS WITH LOCAL FOLIATION ANNUAL RAINFALL: 1000 MM

FAMILY	SPECIES
Adiantaceae	*Cheilanthes sieberi* ssp. *sieberi* Kunze.
Anthericaceae	*Thysanotus patersonii* R.Br.
Apiaceae	*Daucus glochidiatus* (Labill.)Fisch.,C.A.Mey.and Ave-Lall. *Trachymene* sp.
Asteraceae	**Hypochaeris glabra* L. *Hyalosperma cotula* (Benth.)Paul G.Wilson *Podolepis gracilis* (Lehm.) Graham *Senecio quadridentatus* Labill.
Boryaceae	*Borya scirpoidea* Lindl.
Casuarinaceae	*Allocasuarina humilis* (Otto and F.Dietr.)L.A.S.Johnson
Colchicaceae	*Burchardia umbellata* R.Br.
Cyperaceae	*Lepidosperma tenue* Benth.
Epacridaceae	*Leucopogon corifolius* Endl.
Euphorbiaceae	*Phyllanthus calycinus* Lindl.
Gentianaceae	*Centaurium spicatum* (L.)Janch.
Goodeniaceae	*Scaevola* sp. *Dampiera* aff. *linearis* R.Br.
Haemodoraceae	*Anigozanthos ?flavidus* Redoute and DC.
Lamiaceae	*Hemigenia aff. incana* (Lindl.)Benth. in A.DC.
Lobeliaceae	*Isotoma hypocrateriformis* (R.Br.)Druce
Mimosaceae	*Acacia stenoptera* Benth.
Myrtaceae	*Baeckea camphorosmae* Endl. in Endl.,Fenzl,Benth.and Schott *Corymbia calophylla* (Lindl.)K.D.Hill and L.A.S.Johnson *Darwinia citriodora* (Endl.)Benth. *Hypocalymma angustifolium* Endl.(Schauer) *Verticordia plumosa* var. *plumosa* (Desf.)Druce
Orchidaceae	**Disa ?bracteata* Sw.
Papilionaceae	**Lotus angustissimus* Lindl. *Gastrolobium spinosum* Benth. in Lindl.
Phormiaceae	*Stypandra glauca* R.Br.
Poaceae	**Avena fatua* L. **Briza maxima* L **Bromus* sp. **Vulpia muralis* (Kunth)Nees *Austrostipa ?semibarbata* (R.Br.)S.W.L.Jacobs and J.Everett *Neurachne alopecuroidea* R.Br.
Proteaceae	*Grevillea bipinnatifida* R.Br. *Hakea lissocarpha* R.Br.
Rhamnaceae	*Trymalium ledifolium* Fenzl.
Sapindaceae	*Dodonaea ceratocarpa* Endl. in Endl.,Fenzl,Benth.and Schott
Scrophulariaceae	**Parentucellia viscosa* (L.)Caruel in Parl.
Stylidiaceae	*Stylidium calcaratum* R.Br. *Stylidium ciliatum* Lindl.
Thymelaeaceae	*Pimelea imbricata* ssp. *imbricata*, R.Br.

APPENDIX III

A provisional list of vascular plant species associated with granite outcrop at Oakley Dam near Dwellingup in the northern jarrah forest.

LATITUDE 32° 39' 22", LONGITUDE 115° 57' 53" ANNUAL RAINFALL: 1200 MM

FROM THE WAHERB DATABASE OF THE WESTERN AUSTRALIAN HERBARIUM.

VOUCHERED SPECIMENS

FAMILY	SPECIES
Myrtaceae	*Calothamnus graniticus* ssp. *leptophyllus* (Benth.)Hawkeswood
	Darwinia citriodora (Endl.)Benth.
	Verticordia huegelii Endl. var *huegelii*
	Verticordia pennigera Endl.
Pittosporaceae	*Billardiera parviflora* D.C. var. *guttata* E.M. Benn.
Solanaceae	*Anthocercis gracilis* Benth.

UNVOUCHERED SPECIES REPORTED AS BEING ASSOCIATED WITH THE ABOVE TAXA

Casuarinaceae	*Allocasuarina huegeliana* (Miq.) L.A.S.Johnson
Convolvulaceae	**Convolvulus angustissimus* R.Br. (*"C. erubescens*")
Lamiaceae	*Hemigenia incana* (Lindl.) Benth.
Mimosaceae	*Acacia lateriticola* Maslin
	Acacia pulchella R.Br. in W.T. Aiton
	Acacia urophylla Lindl.
Myrtaceae	*Corymbia calophylla* (Lindl.) K.D.Hill and L.A.S.Johnson
Proteaceae	*Dryandra nivea* (Labill.) R.Br.
	Dryandra praemorsa Meisn. *var. praemorsa*
	Grevillea bipinnatifida R.Br.
	Hakea lissocarpha R.Br.
	Hakea undulata R.Br.
Rhamnaceae	*Trymalium ledifolium* Fenzl.
	Trymalium spatulatum (Labill.) Ostenf.
Rubiaceae	*Opercularia apicilfora,* Juss
	Opercularia echinocephala Benth.
Xanthorrhoeaceae	*Xanthorrhoea preissii* Endl. in Lehm.
Zamiaceae	*Macrozamia riedlei* (Gaudich.) C.A.Gardner