approach, vibration and engine noise (Higham and Shelton 2011). This study indicates that rate of vocalisation may provide a gauge to assess levels of disturbance to penguins at tourism sites. Tolerance is defined as 'intensity of disturbance that an individual ... tolerates without responding in a defined way' that is demonstrated through empirical observations at a given time across numerous individuals (Bejder *et al.* 2009). The significantly reduced rate of vocalisations by experienced penguins could represent a level of tolerance. Further research should be carried out to assess the applicability of vocalisations in avian species to assess human impact at nesting sites which are exposed to tourism.

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A limited vegetation survey of Cocoparra National Park and Cocoparra Nature Reserve

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Abstract
A vegetation survey of the Cocoparra National Park and Cocoparra Nature Reserve completed in 1992-96 was partially repeated during 2004 and 2005 with 26 of the original sites being re-surveyed. Cryptogams were collected in the 2004-05 surveys and some soil analyses were completed. Sites surveyed covered 14 of the 16 vegetation units in the area. Two hundred and eight vascular plants were recorded and included 43 introduced species. These numbers compared well with those of the earlier surveys; 41 species recorded in the 2004-05 survey were not recorded in the earlier survey and 48 species recorded in the 1992-96 survey were not found in the later survey. Twenty-three mosses, 13 liverworts and hornworts and 47 lichens were recorded in the 2004-05 survey. (*The Victorian Naturalist* **131** (5) 2014, 162-176)

Keywords
Cocoparra Ranges, vegetation survey, bryophytes, lichens

Introduction

The Cocoparra Ranges are part of a series of low ranges and rocky sandstone scarp ridges that lie along the eastern boundary of the south-western alluvial plains of New South Wales (Fig. 1). These outcrops are separated from each other and from the western foothills of the Dividing Range by alluvial valleys. Being less accessible and on poorer skeletal soils, they have retained a covering of natural vegetation in a landscape substantially modified by agricultural use.

Most of the Cocoparra Ranges between Griffith and Rankins Springs was declared as a Nature Reserve (CNR) in 1963, in the northern half, and as a National Park (CNP) in 1969, in

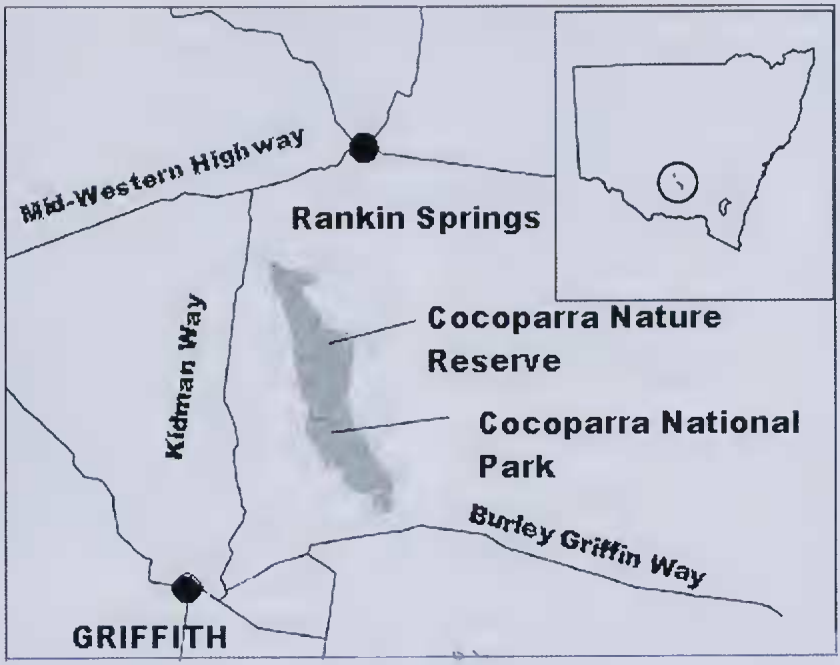

Fig. 1. Location of Cocoparra Nature Reserve and Cocoparra National Park in south-western NSW.

the southern half, to conserve a significant part of this landscape.

Prior to the 1990s, there was little information on the vegetation of the outcrops (Norris and Thomas 1991). A list of plant species was available for Cocoparra National Park (NPWS, Griffith Office, no date) and a vegetation map based on structural form, as interpreted from 1965 aerial photos of CNP and CNR, was drawn by John Brickhill in 1976. At the time, verification of the vegetation by field work was limited. A full survey of the two areas was undertaken in 1992–96 to verify the structural vegetation map, to classify the plant communities, and to obtain information relevant to pest species control programs (Whiting 1997).

During the 1992–96 survey, the average rainfall was c. 420 mm per year (Bureau of Meteorology, taken from Yenda for the period 1925 to present and Binya for the period 1876 to 2012. www.bom.gov.au). Subsequently, the climate changed to an El Niño pattern with continued drought years. Vegetation changed noticeably (pers. obs. over several visits) so a decision was made in 2004 to repeat the original survey and document any changes in vegetation. The survey was extended to include cryptogams and surface soil characteristics.

Cryptogams have been termed the 'Forgotten Flora' in Australia. The term is particularly justified in inland areas despite the fundamental role that soil crust organisms play in preventing soil erosion (Rogers and Lange 1972; Eldridge 1996; Eldridge and Tozer 1997; Eldridge *et al.* 2000). Lists of cryptogams, or even of the major component taxa, are rare, and more rarely published. Easily available distribution data are, therefore, woefully inadequate. Lepp and Curnow collected specimens in 1995 from four sites in the CNP for the Australian National Botanic Gardens Herbarium (now Australian National Herbarium), at Woolshed Flats, Woolshed Bluff, Jacks Creek and Mt. Caley (Curnow pers. comm. 2011). Elix collected a few specimens in the Rankins Springs area at the north end of the Cocoparra Ranges in 1990 (Chapple pers. comm. 2011). Eldridge collected in 1995 and 1996 at two sites in the CNP at Spring Hill and Jacks Creek (Eldridge pers comm. 2011) and McPherson, Cuddy and

Porter collected in 2002 from three sites at Mt Bingar in the CNP, on the west side of the CNP and in the adjacent Binya State Forest (Chapple pers. comm. 2011). *Hyperphyscia isidiata*, a lichen species new to Australia, recently was reported from two sites around Rankins Springs (Rogers 2011). Eldridge also has collected in the nearby Griffith area, the Murrumbidgee Irrigation Area and in Bunganbil State Forest in the Narrandera Ranges to the south of the Cocoparra Ranges. A systematic or comprehensive survey of cryptogams has never been undertaken for the Cocoparra National Park and Cocoparra Nature Reserve.

Methods

Location and surveying sites

The 1992–96 survey sites were not permanently marked. Positions of 35 sites surveyed in 1992–93 were recorded only as estimates on topographic maps. The 70 sites surveyed in 1996 were recorded as GPS readings; however, accuracy was never better than ±50 m with the technology then available. Relocation, therefore, relied on matching vegetation structure data within an area of 1 ha or greater. At a few sites, memory of distinctive features helped in the relocation.

Twenty-two of the 26 sites in the 2004–05 survey were within metres of the original sites of the 1992–95 survey, or at least in the general area. Four sites in the latter survey were considered either too disturbed or simply could not be located, so replacement sites were sampled within the same vegetation community as occurred in the earlier survey, although the vegetation was considered structurally different.

In the 2004–05 survey, sites were not permanently marked, but photographs were taken and a sketch map made of each to aid any future visits.

Vascular flora

As in the 1992–96 survey, each site constituted a 20 m × 20 m quadrat with the following data collected on both occasions: physical data—altitude; slope; aspect; topography; azimuth of horizon for eight compass points; drainage; rock outcropping; basic lithology; and evidence of fire: vegetation data—structural height with cover abundance (Braun-Blanquet scale) for dominant species; a species list with abundance; and estimate of maturity of canopy.

Cryptogam flora

Within each quadrat, samples of bryophytes and lichens were collected from nine c. 1 m^2 areas, four from near the corners, four from near the sides and one from near the centre of the quadrat. Collections of saxicolous lichens were restricted to those on pebbles or small stones. Except for a few readily identifiable taxa that were easily identified in the field, all specimens were identified at my work station at home using a stereo dissecting microscope (ISSCO SZM-3TL) and a compound microscope with a magnification up to 400x (ISSCO BM-Lab). Lichen substances were identified using spot tests for K, C, and Pd only (White and James 1985).

Many specimens of crustose lichens were either sterile or had immature ascospores and were not able to be identified. In addition, several of the taxa of this group do not have published keys for Australian species and the taxonomy is in a state of flux.

Identification and Nomenclature

Identification and nomenclature of vascular flora follows the *Flora of New South Wales* (Harden 1990–93).

Identification keys used for cryptogams were from *Flora Australia* (vols. 54, 55, 56A, 56B and 57 for lichens and vol. 51 for mosses) where appropriate. Otherwise, taxa were identified from published works (Scott and Stone 1976; Catcheside 1980; and Meagher and Fuhrer 2003 for mosses and liverworts, and Filson and Rogers 1979 for lichens). Nomenclature follows Streimann and Klazenga (2002) for mosses, McCarthy (2003) for liverworts and hornworts, and McCarthy (2003; including online amendments up to 2010) for lichens.

Soil tests

One surface soil sample was taken from each quadrat (except, inadvertently, one quadrat) and assessed for texture (after Northcote 1979), pH (Manutec Soil pH Test Kit), and colour (Munsell 2000).

Results

Relocating sites

Fourteen of the 16 vegetation units (Table 1) occurring in the area were sampled in this survey. A Grey Box Low Woodland (unit 1b) and the distinctive Broombush community (unit

5) were not examined, both occurring in more remote regions of the Nature Reserve and at higher altitudes. Only one site was examined in each of seven of the vegetation units, two sites within each of four units (2a, 4d, 6a and 6c), three sites within unit 4e, and four sites within each of units 2b and 6b. Sampling effort did not reflect distribution of vegetation units.

Number of vascular plant species recorded

From the 26 sites, 208 species and subspecies were recorded in the 2004–05 survey, including 43 introduced species (Table 2). These figures are comparable to the totals from the same sites in the previous survey (225 species with 37 introduced). This similarity is apparently coincidental, as 41 species recorded in the 2004–05 survey were not recorded in the same 26 sites in 1992–96, and 48 species were not recorded in the 2004–05 survey but were in the former survey. Such vegetation change was more notable when individual vegetation units were considered. For example, vegetation unit 1a had 50 species that were not recorded in the 1992–96 survey but were recorded in the later survey and 28 species that were not recorded in the 2004–05 survey were recorded in the 1992–96 survey. The four sites in vegetation unit 2b had 26, 26, 25, and 40 species respectively that were not recorded in the 1992–96 survey but were present in the later survey, and 8, 29, 28, and 26 species respectively that were not recorded in the 2004–05 survey but were present in the earlier survey. For these four sites, a species recorded in one survey often was absent in the other survey. For each site, the number of species recorded in both surveys was less than the number of species occurring in only one of the surveys.

Species occurring in only one of the surveys mostly were herbaceous or semi-shrub to small-shrub species that are annuals, biennials or ephemeral in growth habit. Some trends were discernible within some families. The species gained were predominantly by members of the Asteraceae. The Poaceae, Juncaceae and Cyperaceae lost a greater number of species over the time period between surveys than they gained (7, 3 and 4 species compared to 5, 1 and 0 species).

Cryptogams

Twenty-three species of mosses, 13 species of liverworts and hornworts and 47 species of lichens were recorded and identified at least to genus level from the 26 sites. The number of sites was insufficient to establish any clear patterns of distribution or preferences for particular vegetation units. The additional information gathered from opportunistic observations by the author between 1998 and 2002 also failed to elucidate any patterns. Instead, the impression was that occurrence has a greater dependence on microhabitats than any correlation with vascular flora communities.

Soil sampling

Most of the sites were of sandy loam or clayey sand, with other sites varying slightly from these two types (Table 1). Likewise, the pH of the soils mostly was in the range of 4.5 to 5.5 with only two sites as high as 6.0 (in vegetation unit 1a and one gully site in vegetation unit 6b). Soil colour was determined in the dry state. A sample was not collected from the site in vegetation unit 1b.

Discussion

Changes in the vascular flora

The canopy dominants *Eucalyptus populnea*, *E. dwyeri*, *Callitris glaucophylla* and *C. endlicheri* are all slow-growing species and well adapted to semi arid conditions. The assumption was made on trying to relocate the sites that there would be little change in mature trees. It is unclear whether the recorded changes in vegetation structure were due to the natural maturing–decaying–regeneration cycle, the adverse affect of the drought that occurred between surveys, or the heterogeneity of the vegetation units. Only regular observations of identifiable trees over a period of time covering drought and non-drought conditions could give the answers.

The taller shrubs *Acacia doratoxylon*, *Acacia homophylla*, *Acacia deanei* and *Allocasuarina verticillata* are considered to be dis-climax species in the region, with life spans of 30 to 50 years. They are all early dominants after disturbance such as bushfires. Generally, they have shown declines in cover abundance with some becoming absent in the 2004–05 survey. From this, and later observations by the author as the

Table 1. Summary of description of Vegetation Units.

Unit	Definitive characteristics	Soil description
1a	Low open Box woodlands of flat ridgetops, mostly *Eucalyptus populnea* and *Callitris glaucophylla* woodlands with an understorey of *Acacia deanei* and *Calytrix tetragona* located in the western parts of the Nature Reserve north from Woolshed Flats.	Sandy clay loam with pH 6.01 and a red-brown colour.
1b	Low open Box woodlands of the level ridgetops, mostly *Eucalyptus microcarpa* and *Callitris endlicheri* with a sparse understorey including *Acacia decora*.	No information.
2a	Open woodlands of level ridgetops with gravel surface, mostly *Eucalyptus populnea* and *Acacia homalophylla* with sparse understorey.	Clayey loam–sandy to sandy loam with pH 5.0 and a light brown to strong brown colour. Surface characteristically covered with buckshot gravel.
2b	Box woodlands of the alluvial aprons and river terraces, mostly *Eucalyptus populnea* and *Callitris glaucophylla* with an understorey of mostly *Chrysocephalum semipapposum*.	Clayey loam–sandy to clayey sand or sandy loam with pH 5.0 to 5.5 and a brown to red-brown colour.
2c	Box woodlands of alluvial aprons, mostly *Eucalyptus populnea* and *Callitris glaucophylla* with *Eremophila* or *Myoporum* in understorey located around Spring Hill Picnic Ground and eastwards.	Clayey sand with pH 5.5 and a brown colour.
3	Remnant Box woodlands largely cleared. Occasional remaining *Eucalyptus populnea* with regenerating *Acacia deanei*. Introduced grasses, *Echium plantagineum* and *Marrubium vulgare* frequent.	Clayey sand with pH 5.5 and a dark red-brown colour.
4a	Low grassy woodlands of the western slopes, mostly *Eucalyptus dwyeri, Callitris glaucophylla* and *Acacia doratoxylon*, understorey mainly *Thyridolepis mitchellii*. Located between Homestead and Store Creeks.	Clayey loam–sandy with pH 5.5 and a light yellow–brown colour.
4b	Low grassy woodlands, mostly *Eucalyptus dwyeri, Callitris glaucophylla* and *Acacia doratoxylon*; understorey of *Calytrix tetragona* in patches with *Leptospermum divaricatum* and *Lomandra patens* located on the western slopes north from Homestead Creek.	Sandy loam with pH 5.0 and a dark brown colour.
4c	Woodlands to low woodlands of upper sheltered slopes, with *Eucalyptus dwyeri, Callitris endlicheri* and *Acacia doratoxylon*; understorey sparse to moderately dense. *Amphipogon caricinnatus* common in northern parts.	Sandy loam with pH 4.5 and a brown colour.
4d	Low woodlands or low open woodlands mostly on steeper slopes in south and around Woolshed Creek, mostly *Eucalyptus dwyeri, Callitris endlicheri* or *C. glaucophylla*, and *Acacia doratoxylon*. Understorey moderately dense with only *Leptospermum divaricatum* in northern valleys.	Clayey sand with pH 4.5 to 5.0 and brown to dark brown in colour.
4e	Woodlands, low woodlands or low open woodlands of the slopes to open ridgetops, mainly with *Eucalyptus dwyeri* or *E. sideroxylon*, together with *Callitris endlicheri, Acacia doratoxylon, E. microcarpa* and *E. macrorhyncha*. Understorey dense with *Leptospermum divaricatum* and/or *Calytrix tetragona*. *Acacia paradoxa* often prominent.	Sandy clay-loam, a sandy loam or a clayey sand with pH 4.5 and brown to dark brown in colour.
5	Shrubland of *Melaleuca uncinata* with occasional *Allocasuarina verticillata* or *Allocasuarina havilandioranum* or dense with *Calytrix tetragona* and *Acacia paradoxa* on ridgetops or upper gullies.	No information.
6a	Woodlands of the upper sheltered slopes mainly of *Eucalyptus dwyeri, Callitris glaucophylla* and *Acacia doratoxylon*. *Acacia deanei* often as mid-storey. Understorey sparse (*Leptospermum divaricatum* and *Calytrix tetragona* absent). Located from Mt Elliot to Pleasant Valley.	Clayey sand with pH 4.5 and very dark brown in colour.
6b	Woodlands of sheltered gullies, mainly *Eucalyptus dwyeri* or *E. populnea* with *Callitris endlicheri* or *C. glaucophylla*, *Acacia deanei* or *Acacia doratoxylon*, *Eucalyptus blakelyi* or *E. melliodora*. Understorey sparse.	Clayey sand to sandy loam or loamy sand with pH 4.5 to 5.5 and either a brown to dark brown colour or yellow-red.
6c	Woodlands to open forests of steep slopes, south facing or under cliff faces, mainly *Eucalyptus dwyeri* with *Callitris endlicheri* and *Allocasuarina verticillata*. Understorey of mainly *Leptospermum divaricatum* scattered around rock outcrops.	Sandy loam with pH 4.5 to 5.0 and brown to dark brown in colour.

Table 1. cont'd.

Unit	Definitive characteristics	Soil description
6d	Woodlands of deep gullies or gorges mainly *Eucalyptus macrorhyncha* and *Callitris endlicheri* with *E. dwyeri* and *Acacia deanei*. Understorey moderately dense and mixed.	Sandy loam with pH 5.5 and a brown colour.

Table 2. List of species recorded from the 2004–05 survey. * indicates introduced species.

	Vegetation unit														
	1a	2a	2b	2c	3	4a	4b	4c	4d	4e	6a	6b	6c	6d	Number of veg. units
Number of quadrats surveyed (n=26)	1	2	4	1	1	1	1	1	2	3	2	4	2	1	14
Vascular plants															
Pteridophyta															
Aspleniaceae															
Pleurosorus rutifolius													x		1
Ophioglossaceae															
Ophioglossum lusitanicum		x	x												2
Sinopteridaceae															
Cheilanthes sieberi	x	x	x			x	x	x	x	x	x	x	x	x	12
Gymnospermae															
Cupressaceae															
Callitris endlicheri	x		x			x			x	x	x	x	x	x	9
Callitris glaucophylla	x	x	x	x	x		x	x				x			8
Monocotyledonae															
Anthericaceae															
Arthropodium minus	x	x	x		x		x	x			x	x	x		9
Dichopogon fimbriatus	x		x					x				x			4
Thysanotus patersonii		x				x	x		x	x			x	x	7
Tricoryne elatior	x					x									2
Asphodelaceae															
Bulbine bulbosa			x			x	x				x	x			5
Bulbine semibarbata	x	x	x	x	x			x	x		x	x	x		10
Colchicaceae															
Wurmbea dioica		x	x								x	x			4
Hypoxidaceae															
Hypoxis glabella		x	x									x	x		4
Juncaceae															
Juncus filicaulis												x			1
Lomandraceae															
Lomandra filiformis		x	x							x	x	x			5
Lomandra multiflora												x			1
Lomandra patens	x					x			x				x		4
Orchidaceae															
Caladenia caerula			x						x	x		x		x	5
Caladenia fuscata		x	x				x	x	x	x		x	x	x	9
Caladenia stellata							x								1
Caladenia tentaculata		x	x				x			x	x	x	x	x	8
Calochilus robertsonii													x		1
Diuris pardina						x	x		x	x		x	x	x	7
Microtis unifolia		x	x			x	x						x	x	6
Pterostylis mutica		x	x				x	x	x	x	x	x		x	9
Pterostylis nana		x	x				x			x		x	x	x	7
Pterostylis sp. aff. *biseta*									x						1
Thelymitra pauciflora	x					x							x	x	4
Poaceae															
**Aira cupaniana*											x				1
**Aira elegantissima*	x												x		2

Table 2. cont'd.

	Vegetation unit														
	1a	2a	2b	2c	3	4a	4b	4c	4d	4e	6a	6b	6c	6d	Number of veg. units
Amphipogon caricinus	x							x							2
**Avena fatua*			x												1
**Bromus rubens*	x														1
Danthonia eriantha	x	x	x			x						x			5
Elymus scaber											x				1
**Hordeum leporinum*	x												x		2
**Lolium perenne*	x											x			2
Monachather paradoxa						x									1
Poa sieberana	x							x		x		x	x		5
Polypogon monspeliensis	x														1
Stipa bigeniculata	x														1
Stipa densiflora		x							x	x	x	x	x		6
Stipa scabra	x		x	x	x	x		x		x	x	x	x		10
Thyridolepis mitchelliana	x					x	x	x			x	x			6
**Vulpia myuros*	x					x					x	x	x	x	6
Phormiaceae															
Dianella longifolia				x								x	x		3
Dianella revoluta										x		x	x		3
Stypandra glauca													x		1
Dicotyledonae															
Amaranthaceae															
Ptilotus spathulatus	x	x	x								x	x			5
Apiaceae															
Daucus glochidiatus	x	x	x		x		x	x	x	x	x	x	x	x	12
Hydrocotyle callicarpa			x							x		x		x	4
Hydrocotyle laxiflora			x									x			2
Platysace lanceolata										x			x		2
Trachymene cyanopetala		x	x				x	x	x		x	x	x		8
Trachymene ornata						x		x	x		x	x	x		6
Asteraceae															
Actinobole uliginosa		x	x		x		x	x							5
**Arctotheca calendula*	x	x	x	x	x						x	x	x		8
**Aster subulatus*					x										1
Brachycome gracilis			x												1
Brachycome lineariloba		x	x							x					3
Brachycome perpusilla													n		1
Bracteantha bracteata	x		x			x			x		x	x			6
Bracteantha viscosa									x	x			x		3
Calotis cuneifolia			x					x	x			x	x		5
Calotis hispidula	x	x	x				x	x	x		x	x			8
**Carthamus lanatus*	x														1
Cassinia laevis													x		1
Chrysocephalum apiculatum	x	x			x	x	x	x				x			7
Chrysocephalum semipapposum	x	x	x						x	x		x	x		7
**Cirsium vulgare*	x		x						x			x			4
Cotula australis			x		x										2
**Cotula bipinnata*												x			1
Cymbonotus preissianus			x	x								x			3
Gnaphalium sphaericum	x											x			2
**Hedypnois rhagadioloides*	x			x											2
Hyalosperma semisterile						x	x					x			2
**Hypochaeris glabra*	x	x	x		x				x	x	x	x	x	x	10
**Hypochaeris radicata*												x			1
Isoetopsis graminifolia	x	x	x			x	x	x			x				7
**Lactuca serriola*		x	x												2
**Leontodon taraxacoides*											x				1
Microseris lanceolata							x								1
Millotia myosotidifolia		x	x				x	x	x		x	x	x		8

Table 2. cont'd.

	Vegetation unit													
	1a	2a	2b	2c	3	4a	4b	4c	4d	4e	6a	6b	6c	6d	Number of veg. units
Minuria leptophylla		x													1
Myriocephalus rhizocephalus		x					x								2
Podolepis arachnoidea	x	x	x			x	x	x	x		x	x	x		10
Rhodanthe corymbiflora			x												1
Rhodanthe diffusa			x										x		2
Rhodanthe laevis		x	x				x	x	x	x	x	x		x	9
Rhodanthe pygmaea		x	x				x								3
Senecio glossanthus												x			1
Senecio hispidulus													x		1
Senecio quadridentatus									x				x		2
**Silybum marianum*					x										1
**Sonchus asper*													x		1
**Sonchus oleraceus*	x		x	x	x				x	x	x	x	x	x	10
Stuartina muelleri	x	x	x		x		x	x	x	x	x	x	x	x	12
Triptilodiscus pygmaeus	x	x	x					x	x		x	x	x		8
Vittadinia cuneata											x	x			2
Vittadinia dissecta			x									x			2
Vittadinia gracilis		x													1
Bignoniaceae															
Pandorea pandorana									x		x				2
Boraginaceae															
**Echium plantagineum*	x		x	x	x							x			5
Brassicaceae															
**Capsella bursapastoris*			x												1
Harmsiodoxa blennodioides		x	x		x							x			4
**Sisymbrium erysimoides*	x		x	x								x			4
**Sisymbrium irio*			x		x							x			3
Stenopetalum lineare			x												1
Campanulaceae															
Wahlenbergia communis	x		x		x										3
Wahlenbergia gracilenta	x		x						x						3
Wahlenbergia gracilis			x									x			2
Wahlenbergia stricta	x		x			x			x		x	x	x	x	8
Caryophyllaceae															
**Cerastium glomeratum*			x												1
**Silene nocturna*											x	x			2
**Stellaria media*			x		x										2
Casuarinaceae															
Allocasuarina verticillata						x	x					x	x		4
Chenopodiaceae															
Chenopodium desertorum subsp. *anidiophyllum*				x	x							x			3
Chenopodium desertorum subsp. *microphyllum*			x		x							x			3
Einadia hastata			x									x			2
Einadia nutans		x	x	x	x							x			5
Enchylaena tomentosa			x									x			2
Maireana enchylaenoides												x			1
Salsola kali					x										1
Sclerolaena diacantha												x			1
Clusiaceae															
Hypericum gramineum	x														1
Convolvulaceae															
Convolvulus erubescens	x														1
Crassulaceae															
Crassula colorata				x							x				2
Crassula decumbens											x				1
Crassula sieberiana	x	x	x		x		x	x	x	x		x	x		10

Table 2. cont'd.

	Vegetation unit														
	1a	2a	2b	2c	3	4a	4b	4c	4d	4e	6a	6b	6c	6d	Number of veg. units
Dilleniaceae															
Hibbertia sericea										x					1
Droseraceae															
Drosera peltata												x		x	2
Epacridaceae															
Astroloma humifusum		x	x							x		x			4
Melichrus urceolatus		x	x				x		x	x	x	x	x	x	9
Euphorbiaceae															
Phyllanthus fuernrohrii								x							1
Phyllanthus occidentale									x						1
Poranthera microphyllum								x							1
Fabaceae															
Glycine canescens	x														1
Glycine clandestine											x	x			2
Glycine tabacina	x														1
Indigofera australis							x				x	x			3
**Medicago minima*			x	x											2
**Medicago polymorpha*			x		x										2
**Medicago truncatula*	x														1
**Trifolium arvense*	x		x								x				3
**Trifolium campestre*	x														1
**Trifolium glomeratum*	x														1
**Trifolium subterraneum*			x	x											2
Fumariaceae															
**Fumaria capreolata*			x												1
**Fumaria muralis*		x	x									x			3
Geraniaceae															
Erodium crinitum	x	x	x	x	x	x		x	x		x	x			10
Geranium retrorsum												x			1
Goodeniaceae															
Dampiera lanceolata						x			x						2
Goodenia cycloptera		x										x			2
Goodenia fascicularis			x				x					x			3
Goodenia glabra						x	x	x							3
Goodenia pinnatifida												x			1
Goodenia pusilliflora	x	x	x			x									4
Scaevola spinescens	x														1
Velleia paradoxa								x				x			2
Haloragaceae															
Gonocarpus elatus		x	x			x	x	x	x	x	x	x	x	x	11
Lamiaceae															
**Marrubium vulgare*				x	x							x			3
Prostanthera nivea						x									1
Loganiaceae															
Mitrasacme paradoxa		x					x	x		x		x	x	x	7
Malvaceae															
Malva parviflora					x										1
Sida corrugata			x		x							x			3
Sida cunninghamii	x										x	x			3
Mimosaceae															
Acacia deanei			x		x							x			3
Acacia decora														x	1
Acacia doratoxylon						x	x	x	x	x	x		x		7
Acacia homalophylla		x													1
Acacia paradoxa			x									x			2
Myoporaceae															
Eremophila glabra	x														1

Table 2. cont'd.

	Vegetation unit													
	1a	2a	2b	2c	3	4a	4b	4c	4d	4e	6a	6b	6c	6d	Number of veg. units
Myrtaceae															
Calytrix tetragona										x				x	2
Eucalyptus blakelyi			x												1
Eucalyptus dwyeri		x	x			x	x	x	x	x	x	x	x		10
Eucalyptus macrorhyncha										x				x	2
Eucalyptus melliodora			x		x										2
Eucalyptus populnea	x	x	x	x								x			5
Eucalyptus sideroxylon			x							x		x			3
Leptospermum divaricatum								x	x	x		x	x	x	6
Melaleuca erubescens										x					1
Oxalidaceae															
Oxalis perennans		x	x	x	x	x	x	x	x	x	x	x	x		12
Oxalis radicosa				x		x		x	x		x	x	x		7
Pittosporaceae															
Bursaria spinosa													x		1
Pittosporum phylliraeoides			x												1
Polygonaceae															
Rumex brownii			x		x							x			3
Portulacaceae															
Calandrinia eremaea	x	x	x	x	x	x	x		x		x	x	x		11
Primulaceae															
**Anagallis arvensis*		x	x									x			3
Proteaceae															
Grevillea floribunda										x			x		2
Hakea tephrosperma		x		x											2
Persoonia curvifolia										x				x	2
Ranunculaceae															
Ranunculus pachycarpus			x											x	2
Ranunculus sessiliflorus			x		x							x	x		4
Rhamnaceae															
Pomaderris cocoparrana													x		1
Rosaceae															
**Aphanes australiana*			x									x			2
Rubiaceae															
Asperula conferta	x							x		x	x		x		5
**Galium aparine*			x		x							x			3
Galium gaudichaudii			x						x		x	x	x	x	6
Rutaceae															
Eriostemon brevifolius	x					x			x						3
Geijera parviflora	x														1
Phebalium obcordatum									x	x		x			3
Santalaceae															
Exocarpos cupressiformis		x							x						2
Sapindaceae															
Dodonaea viscosa subsp. *cuneata*												x			1
Scrophulariaceae															
Parentucellia latifolia	x														1
Solanaceae															
Nicotiana suaveolens												x			1
Solanum ferocissimum							x								1
Stackhousiaceae															
Stackhousia monogyna		x	x	x						x		x			5
Sterculiaceae															
Brachychiton populneus	x														1
Thymelaeaceae															
Pimelea linifolia	x					x						x	x		4

Table 2. cont'd.

	Vegetation unit														
	1a	2a	2b	2c	3	4a	4b	4c	4d	4e	6a	6b	6c	6d	Number of veg. units
Urticariaceae															
Parietaria debilis			x	x							x	x	x		5
Urtica urens			x		x										2
Violaceae															
Hybanthus monopetalus						x		x	x		x	x			5
Cryptogams															
Mosses															
Acaulon integrifolium			x	x					x	x				x	5
Barbula calycina	x	x	x		x	x	x	x	x	x	x	x			11
Bryum argentium			x						x						2
Campylopus clavatus		x	x				x	x	x	x		x	x	x	9
Campylopus introflexus		x	x			x			x	x			x	x	7
Ceratodon purpurescens	x	x	x		x					x	x	x	x		8
Didymodon torquatus		x	x	x											3
Eccremidium arcuatum	x	x	x		x		x			x	x	x	x		9
Eccremidium pulchellum	x	x	x			x	x	x				x			7
Entosthodon apophysatus	x	x	x			x	x		x		x	x	x	x	10
Entosthodon subnudus subsp. *gracilis*								x						x	2
Ephemerum cristatum			x									x			2
Fissidens taylori	x	x	x				x				x	x	x	x	8
Fissidens tenellus		x													1
Gemmabryum pachytheca	x	x	x		x	x	x	x		x		x			9
Gigaspermum repens	x	x	x			x					x				5
Grimmia laevigata		x			x				x	x	x		x		6
Pleuridium nervosum	x	x	x			x					x	x	x		7
Polytrichadelphus magellanicus												x	x	x	3
Rosulabryum billarderi											x	x	x		3
Rosulabryum campylothecium	x	x	x	x		x	x	x	x		x	x	x	x	12
Triquetrella papillata	x		x	x							x	x	x		6
Weissia controversa		x	x								x	x	x	x	6
Liverworts and Hornworts															
Asterella drummondii	x	x	x		x	x	x	x		x	x	x	x	x	12
Cephaloziella hirta	x	x	x				x				x	x	x	x	8
Fossombronia sp.	x	x	x		x	x	x	x		x	x	x	x	x	12
Gongylanthus scariosus	x	x	x			x	x						x		6
Lethocolea pansa	x	x	x			x				x		x	x	x	8
Phaeoceros laevis		x													1
Riccia bifurca		x	x									x			3
Riccia crinita	x	x	x				x								4
Riccia crystallina							x								1
Riccia lamellosa			x									x			2
Riccia nigrella	x		x		x							x			4
Riccia sorocarpa	x	x	x		x		x								5
Targionia hypophylla													x		1
Lichens															
Fruticose															
Cladia aggregata	x	x	x			x	x	x		x	x	x	x	x	11
Cladia corallazion	x						x	x		x			x	x	6
Cladonia cervicornis													x		1
Neophyllis microlemma									x			x			2
Siphula coriacea							x								1
Teloschistes sieberiana				x								x			2
Thysanothecium scutellum														x	1
Usnea scabrida subsp. *elegans*											x				1

Table 2. cont'd.

	Vegetation unit														
	1a	2a	2b	2c	3	4a	4b	4c	4d	4e	6a	6b	6c	6d	Number of veg. units
Squamulose															
Collema sp.		x													1
Endocarpon sp.	x	x	x		x						x				5
Placidium pilosellum	x														1
Toninia sp.	x	x	x		x							x			5
Crustose															
Acarospora sp.					x										1
Aspicilia contorta												x			1
Caloplaca sp.		x			x	x			x	x	x	x	x		8
Carbonea sp.			x												1
Diploschistes ocellatus	x	x													2
Diploschistes scruposus			x									x			2
Diploschistes sp.		x	x				x				x				4
Lecanora sp.									x						1
Micarea sp.		x						x			x				3
Rhizocarpon geographicum					x				x	x					3
Trapelia coarctata			x												1
Foliose															
Heterodea beaugleholei	x	x	x			x		x	x	x	x	x		x	10
Heterodea muelleri	x		x				x		x	x	x	x		x	8
Punctelia borreri				x							x				2
Punctelia subrudecta												x			1
Xanthoparmelia amphixantha	x														1
Xanthoparmelia barbatica	x	x									x				3
Xanthoparmelia bungendorensis											x				1
Xanthoparmelia elixii					x			x	x	x					4
Xanthoparmelia exillima					x		x				x				3
Xanthoparmelia flavescentireagens					x						x		x		3
Xanthoparmelia flindersiana		x													1
Xanthoparmelia glabrans	x	x				x		x		x	x		x	x	8
Xanthoparmelia incerta							x								1
Xanthoparmelia metastrigosa											x				1
Xanthoparmelia neorimalis	x									x				x	3
Xanthoparmelia pseudoamphixantha	x	x					x	x							4
Xanthoparmelia pseudohypoleia													x		1
Xanthoparmelia remanens								x							1
Xanthoparmelia subcrustacea		x					x			x					3
Xanthoparmelia substrigosa							x				x				2
Xanthoparmelia taractica							x	x		x			x		4
Xanthoparmelia tasmanica									x			x			2
Xanthoparmelia versicolor													x		1
Xanthoparmelia sp.		x													1

drought progressed, it can be seen that at least the older shrubs are susceptible to drought.

Allocasuarina verticillata may have benefited from reduced competition early in the progress of the drought but soon showed a lack of fruiting, then dieback. Since it is the main source of food for the threatened Glossy Black Cockatoo, there was considerable concern for the survival of the small population of this threatened species in this area.

Acacia deanei is the only wattle in the region with true (i.e. bipinnate) leaves. It was seen to decline overall and was clearly affected where it has had a major role in recolonising the cleared areas around the fringes of the Ranges.

Most of the medium-sized shrubs, such as *Acacia paradoxa*, *Persoonia curvifolia*, *Grevillea floribunda*, *Dodonaea* species and subspecies, also showed a general decline in cover abundance. It is possible that these shorter life-

spanned species suffered as much from an absence of viable recruitment as from death of the existing plants.

Acacia paradoxa was noted as very common around the Mount Binger Trig Point in 1993 and entirely dominant as the middle structural layer at site 23 (approximately 200 m SE of the Trig Point) such that the setting out of the quadrat was extremely difficult. In 2005 the bushes were recorded as dead. At the time, drought was thought to be the cause.

Pomaderris cocoparrana has a short but prolific flowering period. A dense stand is a striking sight in the bush, much like the massed flowering of some wattles. The 1996 survey of site 35, 'Oscars Gully', coincided with the flowering of the *Pomaderris* there and was a memorable sight. The sparsity of bushes found during the 2005 survey was very noticeable. *Pomaderris* was also a noticeable component of the shrub layer around the Bingar Trig Point but sadly hard to find in the latter part of the 2000–10 decade. Again the decline has been attributed to drought although, recently, *Pomaderris* has been suggested as being a bushfire-stimulated species (David Egan pers. comm. 2011).

Calytrix tetragona and *Leptospermum divaricatum* appear to be somewhat more resistant, although it was the easier movement through the *Leptospermum* scrubs that prompted the awareness that drought was causing a major change in the habitat. It is surmised that, initially, new growth and leaves were shed after the shortened growing season at the time the surveys took place, giving a later appearance of dieback.

The situation for the herbs and smaller shrubs is much more complicated. It is not known how populations change from year to year, regardless of changes in climate. Is there a cycle of different species rotating according to nutrient utilisation or can species exist in one site year in year out? As outlined above, a small shift in location of a quadrat can give different results due to the heterogeneity of the vegetation.

Relationship of vegetation units and soil characteristics

The paucity of data for each vegetation unit restricts the validity of the relationships that can be inferred, and the summary of soil characteristics for each vegetation unit as given in Table 1 is tentative and requires further investigation.

Cryptogams

Due to drought conditions and the early desiccation of the herbaceous flora, the combined survey was limited to 26 sites. This was insufficient to establish any clear patterns of distribution of the cryptogam flora. The additional information gathered from casual observations also failed to elucidate distribution patterns. Rather, the impression was that occurrence has a greater dependence on microhabitats rather than any correlation with vascular flora communities.

Table 3 lists the species recorded by Lepp and Curnow, Eldridge and Elix that are not recorded in this survey. The species recorded by Lepp and Curnow and also by Eldridge are listed as only by Lepp and Curnow because the list supplied by Eldridge included both sets without annotation.

Suggestions for further work

Although the survey was not able to show the effects of drought conclusively, it did highlight the need for further work to study the vegetation over a long period of time. Such work will require better site recognition via photographs or sketch maps of the sites where sites are not permanently marked. Survey intervals need to be shorter—ideally every 3 to 5 years. As droughts cannot be predicted reliably, a project may have to run for decades. Under current funding schemes, long-term projects have difficulties in being accepted. It would be useful if projected surveys could be done as part of a teaching course in ecology. Although participants would change from year to year, steps could be taken to maintain recording consistency. The outcomes of extended studies would be a greater understanding of the life cycles and ecology of species, particularly herbs and shrubs in semi-arid environments. This will be invaluable for restoration or rehabilitation work in the future.

Cryptogams are poorly reported from inland New South Wales, resulting in very incomplete distribution data. In the Cocoparra Ranges there is still need for further work, especially on crustose and other saxicolous lichens.

Table 3. Other cryptogams recorded in the Cocoparra Ranges.

Species	Source
Mosses	
Bartramia hampei	Lepp and Curnow
Bryum dichotomum	Eldridge
Campylopus bicolor	EW incidental observation between 2000 and 2003
Daltonia splachnoides	EW incidental observation between 2000 and 2003
Dawsonia longiseta	EW incidental observation between 2000 and 2003
Ditrichum difficile	EW incidental observation between 2000 and 2003
Entosthodon productus	Eldridge
Fabronia australis	EW incidental observation between 2000 and 2003
Fissidens curvatus	EW incidental observation between 2000 and 2003
Fissidens leptocladus	Eldridge
Fissidens linearis	Lepp and Curnow
Funaria hygrometrica	Eldridge
Goniomitrium acuminatum subsp. *enerve*	Eldridge
Grimmia pulvinata	EW incidental observation between 2000 and 2003
Hedwigia ciliata	Eldridge
Leptobryum pyriforme	Eldridge
Philonotis sp.	Lepp and Curnow
Polytrichum commune	EW incidental observation between 2000 and 2003
Ptychomitrium australe	Lepp and Curnow
Rosulabryum torquescens	EW incidental observation between 2000 and 2003
Stonea oleaginosa	Eldridge
Thuidium furfurosa	EW incidental observation between 2000 and 2003
Tortula atrovirens	Eldridge
Tortula pagorum	Eldridge
Tortula antarctica	EW incidental observation between 2000 and 2003
Tortula papillosa	Eldridge
Weissia brachycarpa	Eldridge
Weissia rutilans	Eldridge
Liverworts	
Anthoceros sp.	EW incidental observation between 2000 and 2003
Chiloscyphus semiteres	EW incidental observation between 2000 and 2003
Fossombronia wondraczekii	Lepp and Curnow
Frullania probosciphora	EW incidental observation between 2000 and 2003
Lophochloa squamatus	EW incidental observation between 2000 and 2003
Lunularia cruciata	Lepp and Curnow
Phaeoceros carolinianus	Eldridge
Plagiochasma rupestre	Eldridge
Riccardia bipinnatifida	Eldridge
Riccia albida	Eldridge
Riccia crozalsii	EW incidental observation between 2000 and 2003
Riccia spongiosula	EW incidental observation between 2000 and 2003
Riccia vesiculosa	EW incidental observation between 2000 and 2003
Lichens	
Fruticose	
Cladonia sp. aff. *fimbriata*	Eldridge
Cladonia macilenta	Eldridge
Foliose	
Austroparmelina conlabrosa	Elix
Flavoparmelia rutidota	Eldridge
Hyperphyscia isidiata	Elix
Hypogymnia sp.	Lepp and Curnow
Parmelia erumpens	Eldridge
Punctelia subalbicans	Eldridge
Punctelia subflava	EW incidental observation between 2000 and 2003
Xanthoparmelia alternata	EW incidental observation between 2000 and 2003
Xanthoparmelia bellatula	Eldridge
Xanthoparmelia digitiformis	Eldridge
Xanthoparmelia eilifii	Eldridge
Xanthoparmelia filarszkyana	EW incidental observation between 2000 and 2003

Table 3. cont'd.

Species	Source
Xanthoparmelia luteonata	Eldridge
Xanthoparmelia metaclystoides	EW incidental observation between 2000 and 2003
Xanthoparmelia multipartita	Eldridge
Xanthoparmelia pulla	EW incidental observation between 2000 and 2003
Xanthoparmelia reptans	EW incidental observation between 2000 and 2003
Xanthoparmelia subspodochroa	EW incidental observation between 2000 and 2003
Squamulose	
Collema coccophorum	Eldridge
Endocarpon pusillum	EW incidental observation between 2000 and 2003
Endocarpon simplicatum	EW incidental observation between 2000 and 2003
Crustose	
Buellia subcoronata	Eldridge
Caloplaca ferruginea	Lepp and Curnow
Candellariella vitellina	EW incidental observation between 2000 and 2003
Lecidea ochroleuca	Eldridge
Lecidea sp.	EW incidental observation between 2000 and 2003
Ochrolechia sp.	Lepp and Curnow
Peltula zahlbruckneri	Eldridge
Pyrenopsis sp.	EW incidental observation between 2000 and 2003

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