

# The natural vegetation of the Wallerawang 1:100 000 map sheet

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## Abstract

Benson, D.H. & Keith, D.A.\* (*National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia* 2000) 1990. *The natural vegetation of the Wallerawang 1:100 000 map sheet*. *Cunninghamia* 2(2): 305–335. The composition and extent of the present natural vegetation on the Wallerawang 1:100 000 map sheet 8931 (lat. 30°00'–33°30'S, long. 150°00'–150°30'E) are described and mapped from aerial photography and field traverses. The structure, characteristic species, and associated environmental factors for 18 map units with 29 plant communities are described. These communities include small areas of eucalypt tall open-forest, extensive tracts of open-forest and woodland, and localised patches of sclerophyllous heath and shrub swamp.

The vegetation patterns are influenced by geology (mainly sedimentary and metasedimentary rocks), soil types (mainly low nutrient acid soils) and physiography (dissected sandstone plateaus and deep gorges), as well as modified by elevation (ranging from 400 m to almost 1200 m above sea level) and rainfall (ranging from 620 mm to 1220 mm per annum).

Significant plant communities and 23 rare species are listed. There is a need to conserve representative samples of plant communities on the western side of the map sheet and on the high elevation Newnes Plateau in particular, where proposals for extensive sand extraction threaten important woodlands, heaths and swamps. Particular concentrations of rare species occur on the Newnes Plateau, and in the Capertee Valley near Glen Davis. These areas may represent refugia during periods of climatic change.

## Introduction

Massive orange sandstone cliffs, spectacular 'pagoda' country, the dry woodlands of the Wolgan and Capertee valleys, and a history of often isolated and short-lived mining and industrial activity in a harsh natural environment, provide the background to the different plant communities in this map sheet area.

The Wallerawang 1:100 000 Vegetation Map Sheet (based on Wallerawang 1:100 000 Topographic Sheet 8931, Royal Australian Survey Corps) is bounded by latitudes 33°00'–33°30'S, and longitudes 150°00'–150°30'E. It is located in the Central Tablelands botanical subdivision of New South Wales except for part of the north-east corner which is in the Central Coast subdivision. It is about 100 km north-west of Sydney and is due north of the Katoomba sheet (Keith & Benson 1988).

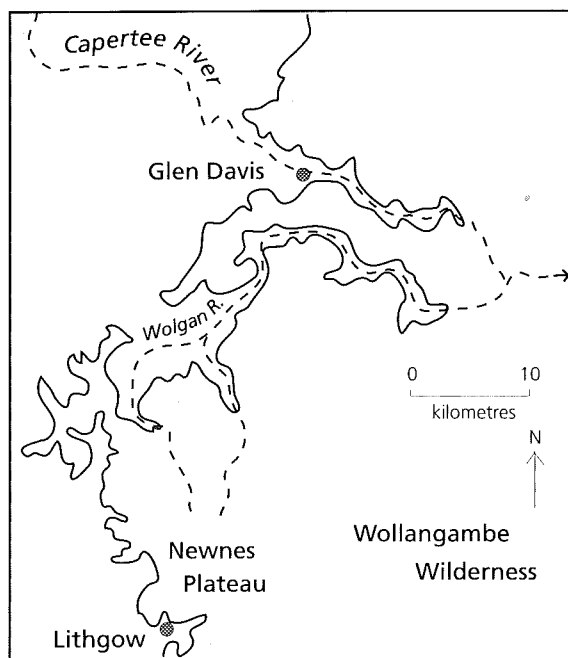
## Geology and geomorphology

The Wallerawang map sheet area lies on the western edge of the Sydney Basin,

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a major geological structural basin extending from Muswellbrook to Batemans Bay. The Great Dividing Range is on the western edge of the map sheet, and most of the sheet is within its eastern watershed. The major rivers are the Wollangambe, Wolgan and Capertee which flow eastward to join the Colo River and thence the Hawkesbury, and the Coxs River which flows to the south and ultimately eastward also to the Hawkesbury (Figure 1). The highest part of the map sheet, the Newnes Plateau (1100–1200 m) is a residual plateau of friable sandstones and shales of the Triassic Narrabeen Group (N.S.W. Department of Mines 1966). Evidence of remnant aeolian sand dunes has been recently observed (M. Tulau pers. comm.). Swamps have formed in the low relief headwater valleys of the Newnes Plateau, as a result of the high rainfall, low slope and impeded runoff. These swamp-filled valleys relate to NNE-SSW trending geological lineaments, and contrast markedly in orientation with the deeply incised easterly drainage patterns developed elsewhere throughout the Blue Mountains (Pecover 1984). Characteristic features of the Plateau margins are the 'pagoda' or beehive-shaped sandstone formations formed from the differential weathering of hardened layers of ironstone and softer sandstone strata.

Further east is an expansive dissected sandstone country, the 'Colo Wilderness' of Gold & Prineas (1978), a maze of ridges and gullies, of rocky outcrops and deep canyons cut from Narrabeen Group sandstones or the similarly appearing Triassic Hawkesbury Sandstones which cap them on the eastern fringe of the map sheet. Drainage is to the east. The southern half is known appropriately as the Wollangambe Wilderness. There are small Tertiary basalt flows capping the sandstone plateaus at Mount Irvine, Mount Cameron and Gaspers Mountain,



**Figure 1.** Major geographical features on the Wallerawang map sheet. Unbroken line indicates the western margin of main Triassic plateau.

and also on Mount Airly and Genowlan Mountain in the Capertee Valley.

West and north of the Newnes Plateau, the main rivers have cut through the sandstone to expose the softer Permian Illawarra Coal Measures and Shoalhaven Group below. The valleys of the Capertee and Wolgan Rivers are characterized by undulating floors between long talus slopes surmounted by spectacular sandstone cliffs. Isolated flat-topped mesas, Pantoneys Crown, Donkey Mountain, Mount Gundangaroo and Mount Airly, are impressive features within these valleys.

In Coco and Airly Creeks, in the north-west of the map sheet, deeper erosion of the valley floors has taken place. Here the underlying shales, siltstones, quartzites, tuffs and limestones of Devonian age are exposed. Similar Devonian metasediments, though lacking limestone, are exposed around Mount Walker (1137 m) west of Lithgow, and have eroded to leave very rugged country. Small areas of Carboniferous adamellite, granite and granodiorite (part of the Kanimbla Batholith) outcrop south-west of Wallerawang and west of Lithgow. A small diorite intrusion outcrops near Ben Bullen.

### Climate

The map sheet area includes some of the highest parts of the Blue Mountains and a section of the Great Dividing Range. Average maximum temperatures for January, the hottest month, are 25.4°C at Lithgow (920 m elevation), 23.5°C at Newnes State Forest (1024 m) and up to 27°C in the Capertee Valley (300 m). Average minimum temperatures for July, the coldest month, are 0.5°C at Lithgow and -1.0°C at Newnes State Forest. The lowest recorded minimum temperature for Lithgow has been -12.1°C in June (Bureau of Meteorology 1979).

Rainfall is highest over the Newnes Plateau and the high country in the south-eastern corner of the map sheet (Mount Wilson, just outside to the south receives 1228 mm p.a.), and decreases with decreasing elevation northward (Newnes State Forest 1047 mm p.a.) to less than 900 mm at the northern edge of the sheet. As a result of a rainshadow effect, there are lower rainfalls in the major valleys, the Capertee, the Wolgan and the Coxs. Lithgow, in the Coxs valley receives 888 mm per annum, and the lower elevation (320 m) Glen Alice in the Capertee valley further north receives only 621 mm. Seasonality is consistent throughout the area, with most rain falling between January and March; July and August are the driest months.

Light snow may fall at altitudes above about 1000 m, most frequently in July or August. Mount Victoria (1064 m), on the plateau just south of the map sheet averages ten snowfalls per year though Lithgow, below the escarpment, receives only three (Bureau of Meteorology 1979).

### Soils

Soils on the low-relief sandstone plateaus are mainly sandy, yellow, leached, gradational soils with ironstone gravels (Hamilton 1976). Grey-brown and yellow-brown uniform sands are found on areas of stronger relief. These soils are acidic and very infertile. In some of the headwater valleys on the Newnes Plateau and in the headwaters of Coxs River, below the escarpment, swampy,

organic, highly acidic sediments have accumulated. Soils on the steep Permian slopes are yellow leached gradational sandy loams; hard-setting, texture-contrast, sandy loams are found on flatter sites. Infertile, shallow, loamy, yellow, leached gradational soils are found on the Devonian sediments, while sandy loam red-brown gradational soils of moderate fertility relate to granite parent material (Hamilton 1976). Very fertile clay-loam, brown and red structured friable soils are found on the basalt caps.

### Land use

Lithgow and Wallerawang, both in the south-west corner of the map sheet, are the major towns; smaller settlements, Cullen Bullen, Ben Bullen and Glen Alice lie further north. With the exception of the Lithgow valley, the area is sparsely settled, and includes extensive State Forest and National Park areas.

Underground mining of the Permian/Illawarra Coal Measures for coal has been a major industry since the arrival of the western railway in 1869. New mines, along the western Newnes Plateau have been developed particularly for electricity generation. Lithgow developed as a mining and industrial town, and today is one of the largest on the Central Tablelands. A short-lived shale oil industry had its heyday in the early 1900s, ceasing in the 1940s. Ruins at Newnes and Glen Davis, and in particular the abandoned Newnes Railway stand testament to the major engineering feats needed to overcome the rugged terrain. The Newnes Railway also provides an interesting botanical link as the chief engineer during construction, Henry Deane, was also an enthusiastic amateur botanist who, amongst other things, collected the first specimens of *Boronia deanei*, presumably while surveying for the railway. After its abandonment the railway route provided access for naturalists into much otherwise inaccessible country including the Glowworm Tunnel.

Forestry operations at Capertee, Ben Bullen and Lidsdale State Forests, west of the escarpment, and Newnes State Forest on the Newnes Plateau, mainly provide hardwood pit-props for the coal mines from the native forests, and pine logs from *Pinus radiata* plantations first established in the 1930s.

The extensive deposits of deeply weathered friable sandstone on the Newnes Plateau have been suggested as a major source of industrial and construction sand for Sydney (Pecover 1984) and there are already major sand quarries at Clarence.

Nature conservation is a major landuse on the lower elevation sandstone country on the eastern half of the map sheet which includes parts of Wollemi and Blue Mountains National Parks.

## Vegetation

### Methods

Areas of vegetation with similar structural (Specht 1970) and floristic characteristics (dominant species) were grouped to form the map units on the basis of aerial photopatterns and available geological and landscape characteristics. Black and white 1975 aerial photographs from the New South Wales Department of Lands (approx. scale 1:40 000) were used. Only existing (i.e. in 1975)

natural vegetation is mapped, though comments on the original natural vegetation of some agricultural and urban areas are provided. An alpha-numeric code is used to identify individual map units. The numeric code represents the Specht structural form of the plant community and the alphabetic code represents the characteristic species. The codes used are consistent throughout the Sydney Region 1:100 000 Vegetation Map Series allowing map units to be cross referenced (Benson 1986, Keith & Benson 1988).

Compilation maps were prepared at 1:25 000 scale and subsequently reduced to 1:100 000 scale. Dyaline copies of the 1:25 000 compilation map sheets, Ben Bullen, Cullen Bullen, Gospers Mountain, Glen Alice, Lithgow, Mount Morgan, Rock Hill and Wollangambe may be obtained from the Director, Royal Botanic Gardens, Sydney.

The map units recognized are not all of equivalent rank. Limitations of scale and the difficulty of separating different species groupings with the same structural form make this impossible, except where very detailed ground traverses are done. Some units are essentially land units made up of several plant communities associated with a particular geological or physiographic type (e.g. map units 10a and 10h), whereas others are more clearly plant associations (sensu Beadle & Costin 1952) (e.g. map unit 9j). Generally the term 'plant community' is used for the basic vegetation unit. Where vegetation boundaries are relatively distinct, they are mapped with an unbroken line, while more diffuse boundaries are mapped with a broken line. For ease of reference, an attempt has been made to provide common names for communities, based loosely on habitat and composition.

General knowledge of the vegetation had been previously gained during the course of a number of localized surveys, but specific field checking was conducted mainly during the period 1978–1981. This included collection of lists of species from a number of 20 x 20 m sites. The reliability diagram on the map indicates where more detailed reconnaissance and site data collection was concentrated. As the patterns shown on the map are derived essentially from air photo interpretation and geological patterns, the map's overall pattern is not strongly biased by the degree of access available. Increased fieldwork in the more remote areas however would increase the accuracy of some of the map unit descriptions, as well as providing worthwhile data on localized features and species.

Information from unpublished reports of these local surveys has been included and the reports not cited individually unless they provide additional information. Reference has been made to existing plant community descriptions or species lists. Exhaustive species lists are not included here, though local species lists compiled at the National Herbarium are available (e.g. Bryant & Benson 1981; Keith 1988). A provisional list of species for the map sheet recorded during fieldwork is provided on the back of the map sheet. A list of species of particular conservation significance was prepared from herbarium records and fieldwork.

Botanical names used are those currently recognized at the National Herbarium of New South Wales. Recent nomenclatural changes include revisions of *Leptospermum* (Thompson 1989), *Banksia* (George 1981), *Tristania* (Wilson & Waterhouse 1982) and the separation of *Allocasuarina* from *Casuarina* (Johnson 1982).

The general vegetation of the Triassic sandstone has been described in

Pidgeon's (1937, 1938, 1940, 1941) vegetation study of the Central Coast of New South Wales. Broader views of the vegetation patterns are given in Beadle (1981) and Forster (1981).

A summary of the map units recognized here, their structural formation, main canopy species and geological substrate are given in Table 1. The vegetation map is located inside the back cover. This map and text replace an earlier draft map (Benson 1984).

### Descriptions of map units shown on the Wallerawang sheet

The map unit numbering system applies to the Sydney Region Vegetation Map Series. Missing numbers are used for plant communities not found on the Wallerawang sheet.

#### Map unit 6g - 'Moist Basalt Cap Forest'

Tall open-forest: *Eucalyptus viminalis* - *E. blaxlandii*

This unit is confined to the rich fertile soils on basalt-capped mountains receiving a reasonably high annual rainfall (>900 mm). These isolated peaks rise slightly higher than the surrounding sandstone plateaus. They include Mount Irvine, Mount Cameron, Green Hill and Gaspers Mountain and may be up to 1000 m high. The largest area of this vegetation is at Mount Wilson, just to the south of the map sheet, and described by Brough, McLuckie & Petrie (1924), Petrie (1925) and McLuckie & Petrie (1926). Their descriptions are relevant to vegetation on the basalt caps further north, though the smaller basalt-capped peaks such as Tambo Limb are less diverse. Typically on peaks with adequate rainfall (>900 mm) there is tall open-forest of *Eucalyptus viminalis* and *E. blaxlandii*, less commonly *E. fastigata*, some trees being up to 40 m high, with smaller trees of *Eucalyptus radiata* subsp. *radiata* and *Acacia melanoxyton* (Figure 2). The understorey has grasses, herbs and ferns, and small shrubs. Common ground layer species are *Pteridium esculentum*, *Viola hederacea*, *Dichondra repens*, *Geranium homeanum*, *Acaena novae-zelandiae*, *Hydrocotyle laxiflora* and *Polystichum proliferum*. Large clumps of *Libertia paniculata* are common and particularly prominent when flowering. Scattered clumps of shrubs, generally very prickly ones, are conspicuous; common species are *Coprosma quadrifida*, *Daviesia ulicifolia* and *Bursaria spinosa*.

On sheltered southern aspects and along watercourses, rainforest elements are present, though rarely as well developed as on Mount Wilson. Certainly the rich fern flora of Mount Wilson is not repeated elsewhere. On Mount Cameron, for instance, are trees of *Doryphora sassafras*, *Acacia melanoxyton* and *Hedycarya angustifolia*, the tree fern *Cyathea australis* and a dense understorey of moist forest species including *Coprosma quadrifida*, *Clematis glycinoides*, *Tylophora barbata* and *Eustrephus latifolius*. On the transition from the basalt soils to the surrounding sandstone, drier open-forest with *Eucalyptus cypellocarpa* and a dense shrub layer of *Bursaria spinosa* and *Daviesia ulicifolia* may be found.

The fertile soils on the basalt caps were eagerly sought by the early settlers for grazing and farming and many were totally or partially cleared. At the end of the nineteenth century they were linked by a network of often-steep bridle paths. Many of the most isolated ones have now been abandoned, or included within National Park allowing the vegetation to regrow.

Table 1. Map unit, common name, structure, main canopy species, geology, altitude and habitat of plant communities shown on Wallerawang 1:100 000 map sheet.

Map unit	Structure	Main canopy species	Geology	Altitude	Habitat
6g	'Moist Basalt Cap Forest' Tall open-forest	<i>Eucalyptus viminalis</i> <i>E. blaxlandii</i>	Tertiary basalt	>800m	Isolated residual caps eg. Mt Cameron
9i	'Blue Mountains Sandstone Plateau Forest' Open-forest	<i>Eucalyptus sieberi</i> <i>E. piperita</i>	Narrabeen Group	800-1150m	Sandstone plateaus and ridges
9j	'Montane Gully Forest' Open-forest	<i>Eucalyptus fastigata</i> <i>E. cypellocarpa</i> <i>E. dalrympleana</i>	Narrabeen Group	850-1150m	Gorges and sheltered gullies
10ag	'Sydney Sandstone Gully Forest' Open-forest	<i>Angophora costata</i> <i>Eucalyptus piperita</i> <i>E. agglomerata</i>	Narrabeen Group Hawkesbury Sandstone	<800m	Valleys and lower slopes
10ar	'Sydney Sandstone Ridgetop Woodland' Woodland  Open-forest	<i>Eucalyptus gummifera</i> <i>E. oblonga</i> <i>E. sclerophylla</i> <i>E. beyeri</i> <i>E. punctata</i>	Narrabeen Group Hawkesbury Sandstone	<800m	Plateaus and ridges at lower altitudes
10f	'Newnes Plateau Woodland' Woodland	<i>Eucalyptus sieberi</i> <i>E. oreades</i> <i>E. dives</i>	Narrabeen Group	>1050m	High altitude plateau Newnes State Forest
10g	'Scribbly Gum-Stringybark Woodland' Woodland	<i>Eucalyptus rossii</i>  <i>E. oblonga</i>	Narrabeen Group	>800m	Sandstone plateaus and ridges with lower rainfall than 9i
10h	'Tablelands Grassy Woodland Complex' Woodland  Woodland Open-forest  Woodland	<i>Eucalyptus rossii</i> <i>E. macrorhyncha</i>  <i>E. mannifera</i> <i>E. dives</i> <i>E. dalrympleana</i>  <i>E. pauciflora</i> <i>E. rubida</i>	Permian Illawarra Group	>800m	Hilly country, dry aspects  Undulating to hilly country Alluvium in valleys Valleys with frost hollows

Map unit	Structure	Main canopy species	Geology	Altitude	Habitat
10i	<b>'Talus-slope Woodland'</b> Woodland	<i>Eucalyptus rossii</i> <i>E. macrorhyncha</i> <i>E. polyanthemos</i> <i>E. fibrosa</i>	Permian Illawarra Group	200- 900m	Talus of major valleys, exposed sites
	Open-forest	<i>E. cypellocarpa</i> <i>E. eugenioides</i> <i>E. punctata</i> <i>E. melliodora</i>			
10j	<b>'Capertee Valley Woodland'</b> Woodland	<i>Eucalyptus melliodora</i> <i>E. blakelyi</i> ± <i>E. albens</i> ± <i>E. crebra</i>	Permian Shoalhaven Group	300- 700m	Possibly limestone influenced
	Woodland	<i>Eucalyptus fibrosa</i> <i>E. crebra</i> ± <i>E. rossii</i> ± <i>E. oblonga</i>			
10k	<b>'White Box Woodland'</b> Woodland	<i>Eucalyptus albens</i> <i>Brachychiton populneus</i>	Devonian shale, siltstone quartzite, tuff, limestone	400- 600m	Gorges of Airly, Coco and Genowlan Creeks
	Woodland	<i>Angophora floribunda</i> <i>E. melliodora</i>			
10m	<b>'Mt Walker Complex'</b> Woodland	<i>Eucalyptus dives</i> <i>E. mannifera</i> <i>E. bridgesiana</i> <i>E. rossii</i>	Devonian Lambie Group; quartzites, sandstones, siltstones, claystones	>600m	Rugged country around Mount Walker
10n	<b>'Dry Basalt Cap Woodland'</b> Woodland	<i>E. polyanthemos</i> <i>E. macrorhyncha</i>	Tertiary basalt	>1000m	Residual caps on sandstone mesas and plateaus
11a	<b>'Open Mottled Gum Woodland'</b> Open-woodland	<i>Eucalyptus mannifera</i> <i>E. dives</i> <i>E. pauciflora</i> ± <i>E. radiata</i>	Narrabeen Group	>900m	Poorly-drained creeks and shallow valleys, often surrounding shrub-swamps



Map unit	Structure	Main canopy species	Geology	Altitude	Habitat	
20a	Closed-heath	<i>Leptospermum grandifolium</i> <i>Baeckea linifolia</i> <i>Grevillea acanthifolia</i>	Narrabeen Group alluvium	>1000m	Shrub-swamps in narrow headwater valleys	
	Sedgeland	<i>Gymnoschoenus sphaerocephalus</i> <i>Xyris ustulata</i>				
20b	Closed-heath	<i>Leptospermum obovatum</i> <i>L. continentale</i>	Alluvium	>600m	Valleys and headwaters of creeks	
	Sedgeland	<i>Carex</i> spp.				
21c	Open-heath	<i>Allocasuarina nana</i> <i>Banksia ericifolia</i> <i>Leptospermum attenuatum</i> <i>Phyllota squarrosa</i>	Narrabeen Group	>850m	Exposed sites on shallow sandy soils	
21d	Open-heath	<i>Allocasuarina nana</i> <i>Leptospermum arachnoides</i> <i>Lepidosperma viscidum</i>	Narrabeen Group	>750m	Exposed sites on rock outcrops with shallow soils	
	Open-scrub	<i>Eucalyptus</i> sp. nov. MOKII				Associated with extensive rocky platforms and 'pagoda' rock formations
	Woodland	<i>E. rossii</i> <i>E. piperita</i>				Small sheltered gullies

C Cleared Native vegetation has been largely removed for agricultural, industrial or urban development but remnant vegetation of varying sizes and condition may remain.

### Map unit 9i - 'Blue Mountains Sandstone Plateau Forest'

Open-forest: *Eucalyptus sieberi* - *E. piperita*

This vegetation is characteristic of the Upper Blue Mountains, from Wentworth Falls to Bell and on much of the eastern Newnes Plateau. Varying structurally from open-forest to woodland, it predominates on the sandstone plateaus and ridges between 800 and 1050 m elevation with a rainfall between 900 and 1400 mm p.a. Soils are grey and yellow-brown uniform sands, very

acid, well-drained and chemically very infertile (Hamilton 1976).

The dominant trees are *Eucalyptus sieberi* and *E. piperita* subsp. *piperita*, often with *E. radiata* subsp. *radiata* (Figure 3). *Eucalyptus mannifera* subsp. *gullickii* is common on poorly-drained sites and *E. sclerophylla* on exposed sites. Both may form pure stands in these respective conditions. Stringybarks, *E. blaxlandii* and *E. oblonga*, may be present – *E. blaxlandii* on the most sheltered sites at higher elevations, and *E. oblonga* on more exposed sites.

The understorey is dominated by shrubs 1 to 2 m high. Many of the species are widespread on sandstone around Sydney, while others are restricted to the higher elevations. Common species are *Lomatia silaifolia*, *Platysace linearifolia*, *Acacia terminalis*, *Amperea xiphoclada*, *Persoonia laurina* and *Hakea dactyloides*. Typical high altitude species include *Acacia dorothea*, *Daviesia latifolia*, *Banksia spinulosa* var. *cunninghamii*, *Phyllota squarrosa*, *Persoonia myrtilloides* and *Boronia microphylla*. *Telopea speciosissima* may be locally common on deeper soils, while *Lomandra glauca* and *Patersonia glabrata* are common groundcover species.

#### Map unit 9j – ‘Montane Gully Forest’

Open-forest: *Eucalyptus fastigata* – *E. cypellocarpa* – *E. dalrympleana*

Open-forest of *Eucalyptus fastigata* and *E. dalrympleana* subsp. *dalrympleana* is found at high elevations (above 850 m) on escarpment slopes around Lithgow. It is found in narrow gorges and canyons at the edges of the sandstone



Figure 2. ‘Moist Basalt Cap Forest’ (map unit 6g) with *Eucalyptus viminalis* and an understorey of *Pteridium esculentum* and herbs at Mount Cameron.

plateaus, and at the heads of major drainage systems such as the Wolgan and Carne Creek. These are all sheltered sites and the soils, although of only low to moderate fertility, are moist, well-drained and deep, enriched by colluvial material from the sandstone escarpments above. Tree height now is commonly about 20 m, but most of these forests have been logged though there are still pockets of big trees in inaccessible gullies. The main species are *Eucalyptus fastigata* and *E. dalrympleana*, though *E. oreades* and *E. piperita* subsp. *piperita* may also be present on drier sites. The understorey has a sparse shrub stratum often with *Acacia dealbata*, *A. buxifolia*, *Cassinia* sp., *Leptospermum flavescens*, *Oxylobium ilicifolium* and *Banksia spinulosa* var. *cunninghamii*. Ferns *Pteridium esculentum* and *Blechnum* sp., herbs *Lomandra longifolia*, *Viola betonicifolia*, *Stellaria flaccida*, *S. pungens*, and *Acaena novae-zelandiae*, and twiners *Clematis aristata* and *Billardiera scandens* make up the continuous groundcover.

Along the creeks associated with this community is shrub swamp, similar to that of the swamps on the plateau (map unit 20a). Common shrub species are *Leptospermum lanigerum*, *L. obovatum*, *Baeckea linifolia* and *Grevillea acanthifolia* subsp. *acanthifolia* together with the graminoids *Gahnia subaequiglumis*, *Restio australis*, *Juncus continuus* and *Empodisma minus*.

#### Map unit 10a – ‘Sydney Sandstone Complex’

The widespread and distinctive vegetation complex found on the low elevation coastal Sydney sandstone plateaus reaches its western limit on the Wallerawang



**Figure 3.** ‘Blue Mountains Sandstone Plateau Forest’ (map unit 9i) with *Eucalyptus sieberi*–*E. piperita* on the eastern side of the Newnes Plateau. Note the lack of straight stems and multi-stemmed nature of many individuals.

map sheet where it is found on sandstones of both the Hawkesbury Formation and the Narrabeen Group. Soils here are low-nutrient grey and yellow-brown uniform sands as found elsewhere on the sandstone (Hamilton 1976), but the increasing elevational and decreasing rainfall gradients from east to west influence floristic composition. For example, the trees *Angophora costata*, *Eucalyptus gummifera* and *E. eximia* are gradually replaced further west by *E. sieberi* and *E. considiana*.

On a local scale, variation relates to changes in physiography, aspect, soil depth and texture, and available moisture. Repeating patterns are evident in the topography and two broad subunits can be recognised: the moist forest associated with gullies and sheltered slopes (10ag); and the drier woodlands of the ridges and plateau (10ar). There is considerable floristic overlap between these subunits and both grade into the higher altitude 'Blue Mountains Sandstone Plateau Forest' (map unit 9i) above 800 m elevation.

### Subunit 10ag - 'Sydney Sandstone Gully Forest'

Open-forest: *Angophora costata* - *E. piperita* - *E. agglomerata*

'Gully Forest' occurs in sheltered gullies with moist, well-drained, sandy soils. Trees of *Angophora costata*, *E. piperita* subsp. *piperita* and *E. agglomerata* less commonly with some *E. punctata* and *Syncarpia glomulifera*, up to 25 m high form an open-forest community. The understorey is mainly of shrubs to 2 m tall; *Leptospermum flavescens*, *Banksia spinulosa* var. *collina*, *Persoonia levis*, *P. linearis*, *Hakea dactyloides* (single-stemmed form), *Pultenaea flexilis*, *P. scabra* var. *scabra*, *Dillwynia retorta*, *Acacia obtusifolia*, *Platysace linearifolia*, *Leucopogon lanceolatus* var. *lanceolatus* and *Epacris pulchella*, with a groundcover of *Dianella caerulea*, *Lomandra gracilis*, *Gonocarpus teucroides* and *Pteridium esculentum*.

### Subunit 10ar - 'Sydney Sandstone Ridgetop Woodland'

Woodland: *Eucalyptus gummifera* - *E. oblonga* - *E. sclerophylla*

Open-forest: *Eucalyptus beyeri* - *E. punctata*

'Ridgetop Woodland' is found on ridges, open slopes and plateau surfaces with shallow, well-drained, sandy soils that are very infertile. The most common trees are *Eucalyptus gummifera*, *E. sclerophylla*, *E. oblonga*, *E. considiana*, and occasionally *Angophora costata*. The understorey is predominantly shrubby with *Banksia spinulosa* var. *collina*, *Hakea dactyloides* (multi-stemmed form), *Lomatia silaifolia*, *Grevillea sericea*, *Persoonia linearis*, *Bossiaea rhombifolia*, *Phyllota squarrosa*, *Daviesia ulicifolia*, *Acacia linifolia*, *Platysace ericoides*, *P. linearifolia* and *Hibbertia acicularis*. *Lomandra obliqua*, *Caustis flexuosa*, *Entolasia stricta* and *Stipa pubescens* make up a sparse groundcover.

On flatter areas of the plateau, deeper clay loams support an open-forest of *Eucalyptus beyeri*, *E. punctata* and *E. oblonga* with the shrubs *Bursaria longisepala*, *Daviesia ulicifolia*, *Oxylobium ilicifolium*, *Indigofera australis*, *Persoonia linearis* and *Breynia oblongifolia* in the understorey. Groundcover species include *Dianella revoluta*, *Patersonia sericea*, *Lomandra longifolia* and *Entolasia stricta*.

The western boundary of the 'Sydney Sandstone Complex' is difficult to define, though it appears to be related to rainfall and minimum temperatures. An altitudinal upper limit of 800 m has been used for physiographic and floristic reasons. The higher country further west is a less dissected landscape with complex pattern of heath, rock outcrops and woodland leading up to the Newnes Plateau. The 800 m contour also approximately separates the 'low elevation species' such as *Angophora costata*, *Eucalyptus gummifera*, *E. punctata* and *Syncarpia glomulifera* from the 'high elevation species' such as *E. mannifera* subsp. *gullickii*, *E. oreades*, *E. radiata* subsp. *radiata* and *Banksia spinulosa* var. *cunninghamii*.

#### Map unit 10f - 'Newnes Plateau Woodland'

Woodland: *Eucalyptus sieberi* - *E. oreades* - *E. dives*

This community is confined to the Newnes Plateau, north of Clarence. This is the highest part of the upper Blue Mountains (above 1050 m), and this vegetation represents the highest and coldest development of vegetation on the Sydney Basin Triassic sediments. Here the sandstone is friable and weathers to a deep, well-drained soil with a moderate clay content (Pecover 1984). Although characterized as woodland, the vegetation includes a range of structural formations from open-forest through woodland to open-woodland and occasionally to low woodland. Structural variation is due to both natural environmental factors, and management treatments, mainly selective logging which has been mostly concentrated in the taller open-forests and woodlands.

The dominant tree species vary considerably. Though some local 'forest types' reflecting local topographic or soil factors could be recognized, these could not be mapped consistently from the aerial photography. The most common tree species are *Eucalyptus sieberi*, *E. oreades*, *E. radiata* subsp. *radiata* and *E. dives*. *Eucalyptus blaxlandii* and *E. dalrympleana* subsp. *dalrympleana* are found in more sheltered situations, while *E. mannifera* subsp. *gullickii* and *E. pauciflora* occur on cold, poorly-drained sites. *Eucalyptus oreades* is notable as the only 'fire sensitive' eucalypt in the area. Adult trees are generally killed by severe fire, which provides conditions for regrowth of seedlings (Glasby et al. 1988). Young trees in Newnes State Forest are a major source of pit-props. Other eucalypt species here resprout from epicormic buds or lignotubers after fire.

The understorey is generally an open shrub layer 1 to 2 m high with an intermittent grassy ground cover. Common shrub species are *Acacia dorothea*, *A. terminalis*, *Daviesia latifolia*, *Boronia microphylla*, *Mirbelia platyloboides*, *Phyllota squarrosa*, *Monotoca scoparia*, *Hibbertia obtusifolia*, *Leptospermum squarrosum*, *Persoonia laurina*, *Lomatia silaifolia*, *Hakea dactyloides* (multi-stemmed form) and *Petrophile canescens*. Juveniles and saplings of the *Eucalyptus* canopy species are frequently common, particularly where there has been logging.

Common ground plants are *Lomandra multiflora*, *L. glauca*, *Dianella revoluta*, *Lepyrodia scariosa* and the grasses *Stipa pubescens*, *Chionochloa pallida* and *Poa labillardieri*. Spreading prostrate shrubs are conspicuous, particularly *Grevillea laurifolia* and *Persoonia chamaepitys*. These appear to be colonizers and are found along roadsides and where the canopy has been removed. The rare *Isopogon prostratus*, a prostrate species closely related to the common *Isopogon anemonifolius*, occurs in small populations in Newnes State Forest.

This species had formerly been recorded from Clarence but had been destroyed by sand quarrying. The nearest known locality is Fitzroy Falls, near Robertson. It has also been recorded from a few isolated localities in the Southern Tablelands, the South Coast and Victoria. Much of the 'Newnes Plateau Woodland' has been cleared for *Pinus radiata* plantations, and most of the remainder is within State Forest and regularly logged.

#### Map unit 10g - 'Scribbly Gum - Stringybark Woodland'

Woodland: *Eucalyptus rossii* - *E. oblonga*

On the drier western aspects of the Triassic sandstone plateau and extending onto Permian sandstones further west is woodland with *Eucalyptus rossii* (Scribbly Gum) and *E. oblonga* (Stringybark). It is particularly common in Ben Bullen State Forest. Rainfall is less than 900 mm p.a and generally, this vegetation occurs on upper ridge slopes where soils are dry, shallow, infertile sandy loams. *Eucalyptus sieberi* and *E. piperita* may be found around sandstone outcrops and in small gullies, where soils are slightly deeper and better-drained. Southerly aspects may have *E. macrorhyncha*.

On the sandstone plateau the understorey is shrubby with *Oxylobium ilicifolium*, *Acacia buxifolia*, *A. terminalis*, *Boronia microphylla*, *Dillwynia phyllicoides*, *Monotoca scoparia*, *Leucopogon muticus*, *Brachyloma daphnoides* and *Persoonia linearis*. Groundcover species include *Chionochloa pallida*, *Lomandra multiflora*, *L. glauca*, *Pseudognaphalium luteo-album* and *Dianella revoluta*. Where *E. rossii* and *E. oblonga* extend onto Permian sediments this unit intergrades with the 'Tablelands Grassy Woodland Complex' (map unit 10h), and grasses predominate in the understorey, particularly *Chionochloa pallida* but also with *Agrostis avenacea*, *Dichelachne rara*, *Echinopogon ovatus*, *Poa sieberiana* and *Stipa* species.

#### Map unit 10h - 'Tablelands Grassy Woodland Complex'

Woodland: *Eucalyptus rossii* - *E. macrorhyncha*

Woodland: *E. mannifera* - *E. dives*

Open-forest: *E. dalrympleana*

Woodland: *E. pauciflora* - *E. rubida*

This map unit includes a number of communities characteristic of the poorer soils of the Tablelands. It is found on soils derived from Permian shales, conglomerates and sandstones along the western edge of the map sheet from Wallerawang north to Ben Bullen. Soils are yellow, hardsetting, texture-contrast, sandy loam soils (Hamilton 1976).

Species groupings appear to be strongly related to topographic position. On hilly sites, particularly on dry, northern to western aspects, is woodland with *Eucalyptus rossii*, *E. macrorhyncha* and less commonly *E. mannifera* subsp. *mannifera*. The understorey is open with scattered grasses and occasional shrubs, the amount of cover depending on season and rainfall conditions. The most common grasses include *Chionochloa pallida*, *Danthonia laevis*, *Poa sieberiana*, *P. labillardieri* and *Agrostis avenacea*. Other groundlayer species include *Lomandra multiflora*, *Dianella laevis*, *Styidium graminifolium* and

*Gonocarpus tetragynus*. There may be shrubs of *Acacia buxifolia*, *Brachyloma daphnoides*, *Lissanthe strigosa* and *Hibbertia obtusifolia*. This vegetation often grades into the Scribbly Gum – Stringybark Woodland (map unit 10g) on adjacent sandstone ridges.

Woodland with *Eucalyptus mannifera* subsp. *mannifera* and *E. dives* occurs on country of lower relief. The understorey composition here is similar to that associated with *E. rossii*, but ground cover may be more dense. On lower slopes with more shelter and deeper colluvial or alluvial soils is open-forest of *E. dalrympleana* subsp. *dalrympleana*, sometimes with *E. bridgesiana* or *E. viminalis*, the latter particularly along creeklines. These forests usually contain one or more tall shrub/small tree layers, commonly with *Acacia dealbata*, *A. obliquinervia*, *Leptospermum flavescens* and *Eucalyptus* sapling regeneration. Ground cover may be 60–80%, with herbaceous species such as *Dichondra repens*, *Gonocarpus tetragynus*, *Acaena nova-zelandiae*, *Viola betonicifolia*, *Glycine clandestina* or frequently may be dominated completely by *Pteridium esculentum* possibly resulting from frequent burning.

Woodland of *E. pauciflora* and *E. rubida* may be found in cold air drainage hollows on undulating to flat country. The relatively uncommon species *E. aggregata* also occurs here, generally associated with creek lines. The understorey is generally heavily disturbed, though remnant species may include *Themeda australis*, *Sorghum leiocladum*, *Asperula conferta*, *Hypoxis hygrometrica* and *Desmodium varians*. This community appears to have been particularly common from Blackmans Flat to Wallerawang but has now been largely cleared.

#### Map unit 10i – ‘Talus-slope Woodland’

Woodland: *Eucalyptus rossii* – *E. macrorhyncha* – *E. polyanthemos* – *E. fibrosa*

Open-forest: *E. cypellocarpa* – *E. eugenioides* – *E. punctata* – *E. melliodora*

The slopes below the major cliff-lines that form the western escarpments of the Triassic sandstone plateaus are composed of strata of the Permian Illawarra Coal Measures together with sandstone blocks and scree material from the Narrabeen Group cliffs above. Soils are Hamilton’s (1976) yellow, hardsetting, texture-contrast, sandy loams.

Vegetation structure and floristics vary with exposure and rainfall. Exposed dry slopes have woodland with *Eucalyptus rossii*, *E. macrorhyncha*, *E. polyanthemos* and *E. fibrosa*. This vegetation is common in the Capertee Valley, which probably receives less rainfall than the Wolgan Valley further south. Escarpment slopes around Lithgow receive the highest rainfall and support ‘Montane Gully Forest’ (map unit 9j). More sheltered slopes, particularly the lower slopes, have open-forest with *E. cypellocarpa*, *E. eugenioides*, *E. punctata*, and *E. melliodora*. Less common trees include *E. crebra*, *E. blakelyi*, *E. tereticornis* and *Angophora floribunda*, while *E. piperita* subsp. *piperita* often intrudes onto the upper slopes from the plateau above. *Eucalyptus dawsonii* and *E. sideroxylon* are species of more localised occurrence here, found on lower slopes near Glen Davis.

The understorey is generally open, with scattered shrubs including *Isopogon dawsonii*, *Acacia obtusifolia*, *A. falciformis*, *Allocasuarina littoralis*, *Correa reflexa*, *Daviesia ulicifolia*, *Dillwynia acicularis*, *Dodonaea triquetra*, *D. viscosa*,

*Leptomeria acida*, *Leptospermum flavescens*, *Leucopogon muticus*, *Lissanthe strigosa*, *Persoonia linearis* and *Prostanthera ovalifolia*. Ground cover depends on exposure and ranges from scattered clumps of grass on bare, rocky hillsides to a herbaceous ground layer on more sheltered sites. Ground species include *Ajuga australis*, *Plantago debilis*, *Lomandra longifolia*, *Dichondra repens*, *Desmodium varians*, *Wahlenbergia stricta* subsp. *stricta* and *Dianella revoluta*.

Along banks and small flats associated with the Wolgan River is open-forest of *Eucalyptus viminalis*, *E. eugenioides*, *E. blakelyi* and occasionally *E. cypellocarpa*. *Casuarina cunninghamiana* lines the water's edge. Small trees of *Acacia filicifolia* are common on the river flats, many of which were cleared many years ago for grazing or for the Newnes shale oil complex. Ground cover consists of small shrubs of *Dodonaea triquetra*, *Indigofera australis*, *Breynia oblongifolia* and ground plants, *Pteridium esculentum*, *Pellaea falcata*, *Viola hederacea* and *Doodia aspera*. Similar vegetation is found along the Capertee River below Glen Davis.

#### Map unit 10j – 'Capertee Valley Woodland'

Woodland: *Eucalyptus melliodora* – *E. blakelyi*

Woodland: *E. fibrosa* – *E. crebra*

The floor of the Capertee valley has yellow, hardsetting, texture-contrast sandy loams developed from Permian shale, sandstone and conglomerate sediments (Hamilton 1976). The valley is within a rain-shadow and rainfall may be as low as 600 mm p.a. Though now generally cleared, there was originally woodland here similar to that of the south-eastern temperate woodlands of the Western Slopes described by Moore (1970). Tree species include *Eucalyptus melliodora* and *E. blakelyi* on flats and in depressions, and *E. albens*, *E. crebra* and *Brachychiton populneus* on rises. There are occasional stands of *E. microcarpa*, *E. conica*, *E. sideroxylon* and *E. parramattensis*. The understorey was originally grassy and has been heavily grazed.

At the western end of the Capertee Valley is a plateau at 500–600 m elevation, forming the foothills of the outlying Narrabeen sandstone mesas – Airly and Genowlan Mountains, and Pantoneys Crown (Figure 4). This has leached yellow gradational sandy loam soils which support woodland with extensive areas of the ironbarks, *Eucalyptus fibrosa* subsp. *fibrosa* and *E. crebra*. The Black Cypress Pine, *Callitris endlicheri* is particularly conspicuous. Tree species associated with the adjacent 'Talus-slope Woodland' (map unit 10i) including *E. macrorhyncha*, *E. rossii*, *E. polyanthemos*, *E. oblonga*, *E. cannonii* and *E. goniocalyx* may also be found. The understorey is open with scattered shrubs such as *Dodonaea viscosa*, *Astroloma humifusum* and *Acrotriche serrulata*, and ground plants such as *Dianella revoluta*, *Dichelachne micrantha*, *Echinopogon ovatus*, *Lepidosperma laterale*, *Bossiaea buxifolia* and *Lomandra glauca*.

#### Map unit 10k – 'White Box Woodland'

Woodland: *Eucalyptus albens* – *Brachychiton populneus*

Woodland: *Angophora floribunda* – *E. melliodora*

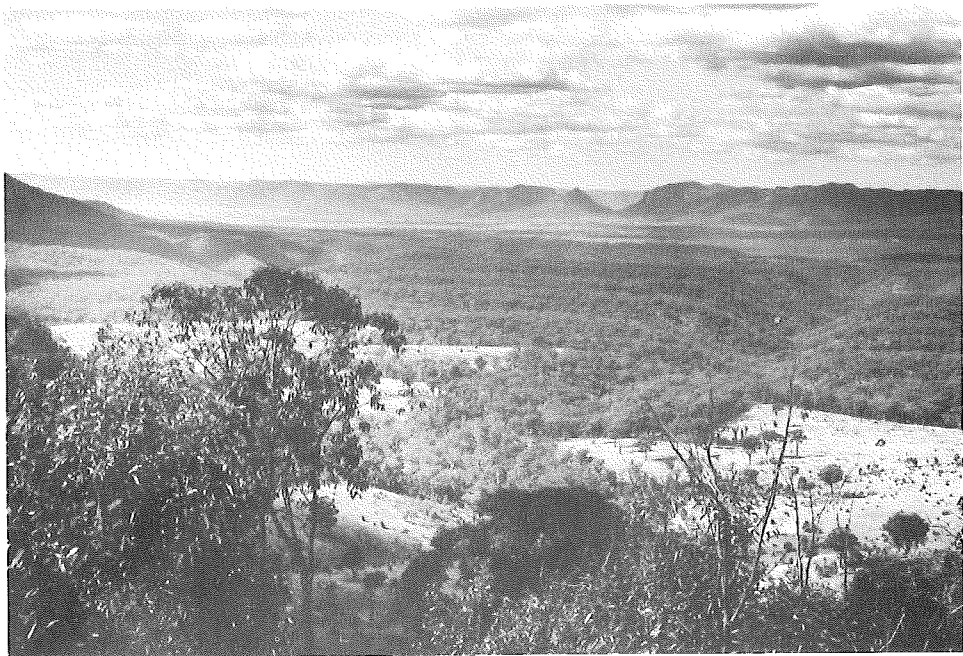
In the dry northwest corner of the map sheet the gorges of Airly, Coco and



Genowlan Creeks, and the upper Capertee River cut deeply into Devonian shales, siltstones, quartzites, tuffs and limestone (Figure 5). Here, are steep slopes with yellow, leached, gradational, loamy soils, with a woodland, 15–20 m high, of trees of *Eucalyptus albens* and occasionally *Brachychiton populneus*. The understorey is sparse (about 20% cover) with the grasses *Aristida vagans*, *Poa sieberiana*, *Themeda australis* and herbs *Desmodium brachypodum*, *Ajuga australis*, *Plantago debilis* and *Asperula conferta*. There are occasional shrubs of *Acacia implexa*, *Acacia falciformis*, *Pimelea hirsuta*, *Bursaria spinosa*, *Notelaea microcarpa* and *Indigofera australis*.

Dense populations of *Xanthorrhoea glauca* subsp. *angustifolia* up to 4 m tall are a conspicuous feature of some spurs and ranges on Devonian geology, particularly in the southern Capertee Valley near Crown Creek. These are associated with populations of the characteristic inland grass *Triodia irritans* var. *laxispicata*, which appears to be a relict of a once more continuous distribution in the Pleistocene Period (Jacobs 1982). Other grasses *Cymbopogon refractus*, *Dichanthium sericeum*, *Themeda australis*, *Aristida vagans*, *A. ramosa* and *Stipa* sp. There are occasional shrubs of *Acacia decora*.

Alluvial areas associated with this community may have trees of *Eucalyptus melliodora*, *E. tereticornis*, *Angophora floribunda* and less commonly *E. viminalis*. Ground cover is generally dense (90%) with *Pteridium esculentum*, *Hydrocotyle laxiflora*, *Dichondra repens*, *Echinopogon ovatus*, *Lomandra*



**Figure 4.** View to east of Capertee Valley from Pearsons Lookout showing Capertee Valley woodland (map unit 10j) with *E. fibrosa* and *E. crebra* in centre foreground. On right is incised gorge of Airly Creek with *E. albens* White Box Woodland (map unit 10k), while on left are lower slopes of Airly Mountain. In background is sandstone plateau with Talus-slope Woodland on margins (map unit 10i). Capertee River gorge and Glen Davis are in background centre. Compare with 1868 view on map sheet.

*longifolia* and *Rumex brownii*. The exotic species, *Cirsium vulgare*, *Echium plantagineum* and *Conium maculatum* are common.

### Map unit 10m – ‘Mount Walker Complex’

Woodland: *Eucalyptus dives* – *E. mannifera* – *E. bridgesiana* – *E. rossii*

West of Lithgow is an island of rugged country between 1000 and 1100 m elevation, bisected by the Coxs River. Hillsides are very steep with shallow, yellow, well-drained, hardsetting sandy loams derived from Devonian Lambie Group quartzites, sandstones, siltstones and claystones. Vegetation structure is mainly woodland (canopy cover ranges from 10 – 30%), and tree height ranges from 8 to 25 m depending on position (Benson & Keith 1985). *Eucalyptus dives* and *E. mannifera* subsp. *praecox* are the most common trees. *Eucalyptus bridgesiana* is frequent on the lower slopes. *Eucalyptus rossii* may be found occasionally on ridges though it is more common in drier country west of Coxs River.

The understorey has an open shrub layer with *Lissanthe strigosa*, *Bursaria spinosa*, *Hibbertia obtusifolia*, *Acacia falciformis*, *Dillwynia phylloides* and *Persoonia linearis*. The groundcover is mid-dense with various grasses *Chionochloa pallida*, *Danthonia tenuior*, *Poa labillardieri*, *Themeda australis* and the introduced *Anthoxanthum odoratum*; herbs including *Poranthera microphylla*, *Gonocarpus tetragynus*, *Hypericum gramineum* and *Dianella revoluta*, and twiners *Glycine clandestina* and *Hardenbergia violacea*. A bank of alluvium associated with the Coxs River supports *Eucalyptus viminalis* and a



**Figure 5.** Looking upstream across large shrub swamp on Newnes Plateau (map unit 20a). Swamp and adjacent forest here have been burnt by wildfire about 2 years previously and both trees and shrubs are resprouting vigorously.

scrub of *Callistemon paludosus* and species of *Leptospermum*. On the upper exposed slopes of Mount Walker itself (1187 m) is woodland of *Eucalyptus pauciflora* with *E. mannifera* subsp. *praecox*, an understorey of scattered shrubs of *Persoonia linearis*, *Leucopogon lanceolatus* and *Lomatia myricoides* and groundcover of *Lomandra longifolia*, *Stellaria pungens*, *Stylidium graminifolium* and *Poa labillardieri*. Too small to be mapped here, it is an outlier of the *E. pauciflora* 'Snow Gum Woodland' (map unit 10I on the adjoining Katoomba 1:100 000 map sheet of Keith & Benson 1988). Below this, on the moist, southerly aspect of Mount Walker is open-forest of *E. fastigata* and *E. viminalis*. Here the understorey is mesic with occasional shrubs of *Acacia melanoxylon* and *Rubus parvifolius* and a dense ground cover of ferns including *Polystichum proliferum*, *Blechnum nudum* and *Pteridium esculentum*, and herbs such as *Geranium potentilloides*, *Epilobium billardieranum* subsp. *cinereum*, *Wahlenbergia stricta* subsp. *stricta*, *Senecio hispidulus*, *Hydrocotyle acutiloba* (sens. lat.), *Stellaria pungens*, *Lomandra longifolia* and *Carex appressa*. This is an outlier of the 'Montane Moist Forest', open-forest of *E. fastigata* – *E. dalrympleana* – *E. viminalis* (map unit 9n on the Katoomba map sheet). An outlier of the 'Mount Walker Complex' is found south of Hartley on the Katoomba map (Keith & Benson 1988) though the main trees there are *Eucalyptus macrorhyncha* and *E. melliodora*.

In small rocky places *Eucalyptus sieberi* may be found with *E. rossii* and a shrubby understorey. The main species include *Leptospermum flavescens*, *Oxylobium ilicifolium*, *Dillwynia phyllicoides*, *Daviesia virgata*, *Hibbertia obtusifolia*, *Platysace lanceolata*, *Brachyloma daphnoides*, *Leucopogon virgatus*, *Monotoca scoparia*, *Persoonia linearis* and *Hakea dactyloides*.

#### Map unit 10n – 'Dry Basalt Cap Woodland'

Woodland: *Eucalyptus polyanthemos* – *E. macrorhyncha*

This community is confined to basalt caps on the western sandstone mesas of Airly and Genowlan Mountains. These caps are of very limited extent and weather to a stony, though high nutrient clay soil. Because of the low rainfall (probably less than 800 mm), these support woodland vegetation in contrast to the tall open-forests on the higher rainfall basalt caps further east (map unit 6g). Tree species are *Eucalyptus polyanthemos* and *E. macrorhyncha*. The ground cover is mainly herbaceous with *Hydrocotyle laxiflora*, *Stellaria pungens*, *Viola betonicifolia*, *Ajuga australis*, *Desmodium varians*, *Plantago debile*, *Geranium potentilloides*, *Urtica incisa*, *Veronica plebeia*, *Dichondra repens* and *Cheilanthes sieberi*. There are occasional shrubs of *Melichrus urceolatus*, *Bursaria longisepala*, *Cassinia uncata* and patches of *Indigofera australis*. This vegetation occupies an intermediate position on a sequence of basalt soil sites along a rainfall gradient between the high rainfall tall open-forest and rainforest sites at Mount Wilson (Keith & Benson 1988) and the low rainfall (500–600 mm p.a.) open woodland sites on the Merriwa Plains (McRae & Cooper 1985).

#### Map unit 11a – 'Open Mottled Gum Woodland'

Open-woodland: *Eucalyptus mannifera* – *E. dives* – *E. pauciflora*

Open-woodland is found in the poorly-drained basins of creeks on the Newnes Plateau, particularly on the eastern half. It is generally associated with treeless

shrub- or sedge-swamps (map unit 20a). Mottled Gum, *Eucalyptus mannifera* (mostly subsp. *gullickii* though there are intergrades with subsp. *mannifera*) is the most common tree species though *E. radiata* subsp. *radiata*, *E. dives* and *E. dalrympleana* subsp. *dalrympleana* may also be present. *Eucalyptus pauciflora* subsp. *pauciflora* is common on the southern part on the plateau, above about 1170 m altitude.

The understorey is generally open, but with patches of locally denser scrub. The most common shrubs include *Leptospermum flavescens*, *L. myrtifolium*, *L. juniperinum*, *Hakea dactyloides*, *Lomatia silaifolia*, *Phyllota squarrosa* and *Boronia microphylla*. The open ground cover consists of *Helichrysum scorpioides*, *Dianella revoluta*, *Lomandra longifolia*, *Gahnia filifolia* and *Lepyrodia scariosa*.

### Map unit 20a - 'Newnes Plateau Shrub-Swamps'

Closed-heath: *Leptospermum grandifolium* - *Baeckea linifolia* - *Grevillea acanthifolia*

Sedgeland: *Gymnoschoenus sphaerocephalus* - *Xyris ustulata*

Narrow, elongate, shrub-swamps are a conspicuous feature of the eastern half of the Newnes Plateau. These swamps are formed in characteristic low-slope headwater valleys, mostly tributaries of Carne Creek where sandy organic sediments are deposited from the surrounding ridges. These sediments are relatively deep, with a high organic matter content and sandy or loamy texture, and are periodically waterlogged. The swamp vegetation is essentially dominated by shrubs and varies in structure from open-scrub to closed-heath, with sedgeland dominated by graminoids in very wet sections. There is a considerable variation in the floristic composition, which is probably related to the soil type and the extent and duration of waterlogging. Soils on the western part of the plateau appear to have more clay than those of the eastern part, which are more sandy, while in each swamp the floristic composition is related to a drainage gradient from occasionally flooded sites to almost permanently running water. Trees are normally absent though there is generally a fringing open-woodland of *Eucalyptus mannifera* subsp. *mannifera* and occasionally the Mallee Snow Gum, *E. gregsoniana*. Dead trees in some swamps appear to indicate fluctuations in drainage conditions.

The most extensive plant community is dominated by shrubs, *Epacris paludosa*, *E. microphylla*, *Grevillea acanthifolia* subsp. *acanthifolia*, *Leptospermum grandifolium* (previously included with *L. lanigerum*), *Baeckea linifolia*, *B. utilis* and *Boronia deanei* with graminoids such as *Restio australis*, *Lepyrodia scariosa*, *Empodisma minus*, *Lepidosperma limicola*, *Xyris ustulata* and *Patersonia fragilis*. Local patterns appear to relate to drainage. Dense vegetation along permanent water channels within the swamp is dominated by *Gleichenia dicarpa* and *Gymnoschoenus sphaerocephalus* (Figure 5). In the drier, more open areas, there is an herbaceous ground cover with *Hydrocotyle* sp., *Viola hederacea* subsp. *sieberiana*, *Gonocarpus tetragynus* and *Xanthosia dissecta*.

In the swamps with a higher clay content, *Leptospermum* species are increasingly important, particularly *Leptospermum flavescens*, *L. myrtifolium*, *L. continentale* J. Thompson, and *L. obovatum*. Ground cover often includes *Restio australis*, *Juncus continuus* and *Lomandra longifolia*.

Periodic fire plays a part in modifying the structure of the shrub-swamp vegetation. After hot burns that kill all above ground vegetation, the sedges and smaller shrubs grow quickly in the increased light, to form a sedgeland, 0.3–0.5 m high. Some of the interesting locally restricted small shrub species such as *Boronia deanei*, *Dillwynia stipulifera* and *Celmisia* sp. aff. *longifolia* are conspicuous at this stage. The sedgeland is gradually overtopped by the taller growing shrubs, which gradually form a dense canopy about 2–3 m high.

The orientation of these swamps relate to the Deanes Creek Lineament and the Happy Valley Lineament which dominate the hydrology in the central part of the Newnes Plateau (Pecover 1984). The orientation of these swamps (NNE–SSW) contrasts markedly with the deeply incised easterly drainage pattern developed throughout much of the Blue Mountains and Wollemi National Parks and suggests a paleo-drainage pattern on the Newnes Plateau that is considerably older than drainage regimes that have formed many of the deeply incised valleys of the western Blue Mountains. Pecover (1984) suggests that the present land surface of the Newnes Plateau may be at or near the position of a paleo-land surface of Tertiary age or older.

#### Map unit 20b – ‘Coxs River Swamps’

Closed-heath: *Leptospermum obovatum* – *Leptospermum continentale*

Sedgeland: *Carex* species

Alluvium-filled swamps near Ben Bullen along tributary creeks of the Turon River, and along the upper Coxs River and its tributaries north of Lidsdale are more clayey and perhaps have a higher nutrient status than the Newnes Plateau Shrub Swamps (map unit 20a). In more waterlogged areas there is closed-sedgeland of *Carex gaudichaudiana* and *C. fascicularis*, with herbs including *Viola caleyana*, *Stellaria angustifolia*, *Hydrocotyle tripartita*, *Mitrasacme serpyllifolia*, *Epilobium billardieranum* subsp. *hygrophyllum*, *Utricularia dichotoma*, and grasses including *Poa labillardieri* and *Deyeuxia quadriseta*. Sphagnum may be present. In other sites may be closed-heath with *Leptospermum obovatum*, *L. continentale* and *L. flavescens*. *Restio australis* and *Baeckea utilis* may be associated with more localized sandy textured soils. Drier areas carry *Poa labillardieri* grassland, occasionally with a light shrub cover of *Leptospermum continentale*. Open-forest of *Eucalyptus viminalis* and *E. dalrympleana* subsp. *dalrympleana* often surrounds these swamps.

Rather similar swamps are found at Hartley Vale and below Nellies Glen on the Katoomba map (Keith & Benson 1988).

#### Map unit 21c – ‘Montane Heath’

Open-heath: *Allocasuarina nana* – *Banksia ericifolia* – *Leptospermum attenuatum* – *Phyllota squarrosa*

Spectacular areas of open-heath are found at high elevations (above 850 m) (Figure 6), mainly on the southern half of the Newnes Plateau, particularly to the north of Lithgow. Heath occupies exposed ridgetops with skeletal sandy soils derived from Narrabeen Group sandstones. Major shrub species are *Allocasuarina nana*, *Leptospermum attenuatum*, *L. arachnoides*, *Isopogon anemonifolius*, *Banksia ericifolia* var. *ericifolia*, *Hakea dactyloides*

(multistemmed form), *H. propinqua*, *Brachyloma daphnoides*, *Epacris microphylla*, and *Monotoca scoparia*. Species restricted to high elevations include *Acacia gunnii*, *A. dorothea*, *Mirbelia platyloboides*, *Phyllota squarrosa*, *Pultenaea canescens*, *Petrophile canescens*, *Boronia microphylla* and *Eriostemon obovalis*. Localized patches of mallee eucalypts, *Eucalyptus* sp. nov. 'MOKII' or *E. stricta* may be present, though *E. stricta*, found only on the southern half of the plateau, is more common in Montane Heath on the Katoomba map (Keith & Benson 1988). *Eucalyptus gregsoniana*, another mallee, and *E. mannifera* subsp. *gullickii*, a small tree, are less common and restricted to higher elevations.

Sedges and forbs make up the ground cover. The most common species include *Gahnia filifolia*, *G. microstachya*, *Lepidosperma viscidum*, *Schoenus villosus*, *Chionochloa pallida*, *Patersonia longifolia*, *Dampiera stricta* and *Goodenia bellidifolia*. In sites with very shallow soil, or poor drainage, shrubs are less frequent and expanses of sedgeland predominate. *Lepidosperma viscidum* may be particularly common on exposed rocky sites.

#### Map unit 21d - 'Pagoda Rock Complex'

Open-heath: *Allocasuarina nana* - *Leptospermum arachnoides* - *Lepidosperma viscidum*

Open-scrub: *Eucalyptus* sp. nov. 'MOKII'

Woodland: *E. piperita* - *E. rossii*

Along the escarpments on the margins of the Triassic sandstone plateaus are exposed sandstone cliffs, ridges and rocky outcrops, frequently weathered to large, rocky and scenically very striking domes, often of a characteristic 'pagoda' or beehive shape. Vegetation structure on these escarpments ranges from open-forest to woodland, low woodland, open-scrub and open-heath, depending on the extent, shape and exposure of outcropping sandstone. In the sheltered sites there is open-forest of *Eucalyptus piperita* subsp. *piperita*, *E. sieberi* and *E. oblonga* (intrusions from the 'Sandstone Plateau Forest', map unit 9i). With increasing exposure, *E. rossii* and *E. punctata* become common, while around the exposed rocky outcrops and among the 'pagodas' are mallees of *E.* sp. nov. 'MOKII' with *E. oreades* and *E. rossii* (Figure 6).

Understorey species of the forests and woodlands are mostly sclerophyllous shrubs, similar to those of the Blue Mountains Sandstone Plateau Forest (map unit 9i). Common species include *Acacia terminalis*, *A. ulicifolia*, *A. obtusifolia*, *Banksia ericifolia*, *Calytrix tetragona*, *Phyllota phyllicoides*, *Platysace lanceolata*, *Boronia microphylla*, *Isopogon dawsonii*, *Allocasuarina distyla*, *Hakea dactyloides* and *Leptospermum sphaerocarpum*. Patches of 'Montane Heath' (map unit 21c) are associated with the most exposed, rocky sites, though in the northern part of the map sheet area, some of the higher elevation species may be absent.

## Discussion

### Vegetation patterns

The influences of geology, physiography, elevation and rainfall are evident in



**Figure 6.** Extensive slopes of recently burnt Montane Heath, and Pagoda Rock Complex (map units 21c & 21d). Valley on left has Montane Gully Forest with *Eucalyptus fastigata* and *E. cypellocarpa* (map unit 9j) while skyline shows Newnes Plateau Woodland of *E. sieberi*-*E. oreades* (map unit 10f). Site is on Newnes Plateau just north of Lithgow.

the vegetation patterns recognised on the Wallerawang map sheet. Of these geology is probably the most important. Particular geological units are associated with most of the plant communities recognized, a similar situation to other parts of the Sydney Basin, particularly near the coast (e.g. Pidgeon 1937, Benson & Fallding 1981; McRae & Cooper 1985). This association appears to be a response to the texture and nutrient status of the soils. In particular, Beadle (1954, 1962) related the distribution of major vegetation formations to levels of soil phosphorus; from rainforest vegetation associated with high soil phosphorus to sclerophyll heath and woodland associated with very low levels.

On the Wallerawang map sheet, soil types can be divided into two major soil groupings: those with a sandy texture, very low in nutrients and derived from Triassic sandstones; and those with a higher clay content, principally the clay-loams weathered from sedimentary and metamorphic rocks of Permian and Devonian age and from Tertiary and Jurassic igneous rocks. The distinctiveness of these groups is well illustrated by the distributions of the main tree species. Of the 35 eucalypt and related tree species associated with the two major soil groupings (Table 2) 29 species are largely confined to one group of sediments. Of those confined to the Triassic sediments, 9 of the 12 species belong to the eucalypt subgenus *Monocalyptus* (Pryor & Johnson 1971) while 12 of the 17 on Permian sediments belong to subgenus *Symphyomyrtus*. In this area, as well as elsewhere, the predominance of a particular subgenus relates to differences in the nutrient content of the soils (L.A.S. Johnson pers. comm.) *Symphyomyrtus* species are most widespread on fertile soils while *Monocalyptus* species are more common on the least fertile soils. Tree species belonging to the eucalypt subgenus *Corymbia* are here confined to Triassic sandstone, perhaps reflecting a preference for low elevation sites as much as for the low nutrient soils.

Similarly, understorey composition on the two soil groups differs. A diverse sclerophyllous shrub understorey characterises the sandy low-nutrient Triassic

**Table 2.** Tree species associated with major geological units, with the eucalypt subgenus given in parentheses: *C*, *Corymbia*; *M*, *Monocalyptus*; *S*, *Symphyomyrtus*.

Confined mostly to Triassic sediments	Confined mostly to Permian sediments	Found on both Triassic and Permian sediments
<i>Eucalyptus (C) gummifera</i>	<i>E. (M) eugenioides</i>	<i>E. (M) oblonga</i>
<i>E. (M) blaxlandii</i>	<i>E. (M) macrorhyncha</i>	<i>E. (M) dives</i>
<i>E. (M) piperita</i>	<i>E. (M) rossii</i>	<i>E. (M) pauciflora</i>
<i>E. (M) sieberi</i>	<i>E. (M) fastigata</i>	<i>E. (M) radiata</i>
<i>E. (M) agglomerata</i>	<i>E. (S) viminalis</i>	<i>E. (S) mannifera</i>
<i>E. (M) sp. nov. MOKII</i>	<i>E. (S) dalrympleana</i>	<i>E. (S) punctata</i>
<i>E. (M) sclerophylla</i>	<i>E. (S) rubida</i>	
<i>E. (M) oreades</i>	<i>E. (S) cypellocarpa</i>	
<i>E. (M) gregsoniana</i>	<i>E. (S) melliodora</i>	
<i>E. (M) stricta</i>	<i>E. (S) fibrosa</i>	
<i>E. (S) beyeri</i>	<i>E. (S) crebra</i>	
<i>Angophora costata</i>	<i>E. (S) albens</i>	
	<i>E. (S) blakelyi</i>	
	<i>E. (S) dealbata</i>	
	<i>E. (S) microcarpa</i>	
	<i>E. (S) polyanthemus</i>	
	<i>Angophora floribunda</i>	



soils, typified by the well-known 'Hawkesbury Sandstone flora'. In contrast, grasses, graminoids and herbs characterise the understorey on the more fertile, clayey soils derived from Permian and Devonian sediments and the limited igneous geology.

At higher elevations, differences relating to geology are less clear-cut. Woodlands on some Devonian and Permian sediments above 900 m near Wallerawang have similar tree and shrub species to those on the Triassic sediments, though there appear to be differences amongst the less common species. The Scribbly Gum – Stringybark Woodland (map unit 10g) may occur on either Triassic or Permian geology, though again there are differences in understorey species. Keith & Benson (1988) also noted similar vegetation on different geological groups at high elevations on the Boyd Plateau.

The range of localised physiographic conditions present within some map units results in considerable structural and floristic variation. The best examples of this include Blue Mountains Sandstone Plateau Forest (9i), the Sydney Sandstone Complex (10ag & 10ar), Tablelands Grassy Woodland Complex (10n), Talus-slope Woodland (10i) and the Pagoda Rock Complex (21d). Physiographic influence is evident in the distribution of heath communities (map units 21c & 21d) which relate to particularly exposed situations.

Altitude and climate also have a profound effect on vegetation patterns. The differences between Montane Gully Forest and Talus-slope Woodland (map units 9j & 10i) relate mainly to their different elevations and climates, as they occupy similar geology and topographic positions. The sandstone plateau communities, 10ar-9i-10f, also form an altitudinal sequence from the lower elevation Sydney Sandstone Ridgetop Woodland to the high elevation Newnes Plateau Woodland. Differences in altitude and rainfall appear to have greater effects on communities on clayey or higher nutrient soils than those on sandy soils. For example, there are marked differences between vegetation on high and low rainfall basalt sites (compare units 6g & 10n), but less obvious differences between vegetation on adjacent sandstone (map unit 9i in both cases) growing under similar altitudinal and rainfall conditions.

### Management and conservation

Human influences have been concentrated in the valleys on the western side of the map sheet area, where the main impact on the vegetation has been from clearing for agriculture, or on the Newnes Plateau, clearing for *Pinus radiata* plantations. There has also been some disturbance to shrub swamps from siltation and run-off. Also in the native forests on the Plateau, a long history of selective logging for saw logs and pit props, has resulted in a maze of roads and trails, but appears to have caused relatively little floristic change, though vegetation structural change is apparent. Fire frequencies appear to have been generally low, with intervals of 15–20 years between fires, a regime that appears to be suitable to sustain the major plant communities.

The impacts of the various mining and industrial activities have been varied. The industrial complexes at Newnes, Airly and Glen Davis severely disturbed localised sites, but where vegetation has been allowed to regenerate naturally, there has been significant recovery, particularly at Newnes. Currently coal mines are sited along the western edge of the Newnes Plateau, to minimize direct impacts on the Plateau vegetation, but there has been cliffline collapse

and damage to 'Pagoda Rock Complex' associated with subsidence from the underground workings.

Major conservation reserves on the Wallerawang map sheet include Wollemi National Park, Blue Mountains National Park, and Pantoneys Crown Nature Reserve (Figure 7, Table 3). These two national parks cover large areas of sandstone on the eastern half of the map sheet, and plant communities widespread in this area (map units 9i, 10ag, 10ar, 10g & 21d) are well conserved. The more restricted communities on the western sandstone plateau are, in general, less adequately treated. An exception is the Moist Basalt Cap Forest (map unit 6g) most of which is included in Wollemi National Park. However, only very small samples of communities in map units 10f, 11a, 20a & 21c are represented in reserves. These typify high elevation sandstone vegetation and, with the exception of the Montane Heath (21c), are restricted to the Newnes Plateau. The Newnes Plateau is already the site of extensive pine plantations and some sand quarries, and has been proposed as a future major source for Sydney's construction sand (Pecover 1984, N.S.W. Dept. of Planning 1990). Action to ensure adequate conservation of these vulnerable plant communities is needed.

Plant communities on the western part of the map sheet associated with Permian and Devonian geology are also very poorly conserved. Forster (1981), in an assessment of conservation values for vegetation in the western coalfields and Upper Hunter, described such forests and woodlands as only moderately to reasonably reserved in Australia. He regarded their conservation suitability in the Wallerawang area as high. Samples of Capertee Valley Woodland and White Box Woodland (map units 10j & 10k), and a small area of Talus-slope Woodland (10i) are included in Pantoneys Crown Nature Reserve. Other woodland communities in the western part of the area (in map units 10h, 10m & 10n), and the Coxs River Swamps (20b) are not represented in any local reserves.

Extensions to Wollemi National Park to include the Mount Airly and

**Table 3. Major conservation reserves in the area covered by the Wallerawang 1:100 000 vegetation map sheet.**

Reserve	Administered by	Approximate area (ha) on map sheet	Map units included
Blue Mountains National Park	National Parks & Wildlife Service	21,000	9i, 9j, 10ar, 10ag, 11a*, 20a*, 21d
Wollemi National Park	National Parks & Wildlife Service	95,000	6g, 9i, 9j, 10ar, 10ag, 10g, 10i, 11a*, 20a*, 21d
Pantoneys Crown Nature Reserve	National Parks & Wildlife Service	3,230	9i, 10i, 10j, 10k*, 21d
Birds Rock Flora Reserve	Forestry Commission	415	9i, 9j, 10f*, 21c*, 21d

Map units not conserved: 10h, 10m, 10n, 20b.

\* represented by small examples only

Genowlan mesas in the Capertee Valley were recommended by Falconer (1986) and would conserve examples of map unit 10n and additional areas of map units 10i, 10j and 10k. A proposal put forward by the National Parks Association in June 1985 to establish a Nature Reserve at Mount Walker would adequately conserve map unit 10m.

Twenty-two plant species of particular conservation significance have been listed for the Wallerawang map sheet (Table 4) though because of the inaccessibility of the area, this is probably an underestimate. Some species, such as *Apatophyllum constablei* and *Rupicola* sp. 1, are highly restricted local endemics, known only from a few localities; while others, locally restricted to particular habitats, have also been recorded in other regions. For example, *Eucalyptus gregsoniana*, *Boronia deanei* and *Dillwynia stipulifera* are locally restricted to swamps on Newnes Plateau, but have also been recorded from the Budawangs. Other species, such as *Pultenaea incurvata* and *Eriostemon obovalis*, have been recorded elsewhere in the Blue Mountains. Particular concentrations of rare species appear to be on the high elevation Newnes Plateau, and in the Capertee region near Glen Davis, and these areas may represent refugia during periods of climate change. Two very localized species were recently recorded from the Newnes Plateau, *Leptospermum blakelyi* and the first record of what appears to be a new species of *Micromyrtus* (Peter Wilson pers. comm.). These are near the recently notified Snow Gum Forest Preserve No 215 (Forestry Commission of N.S.W. 1989), though the adequacy of the reserve to protect these species is yet to be assessed.

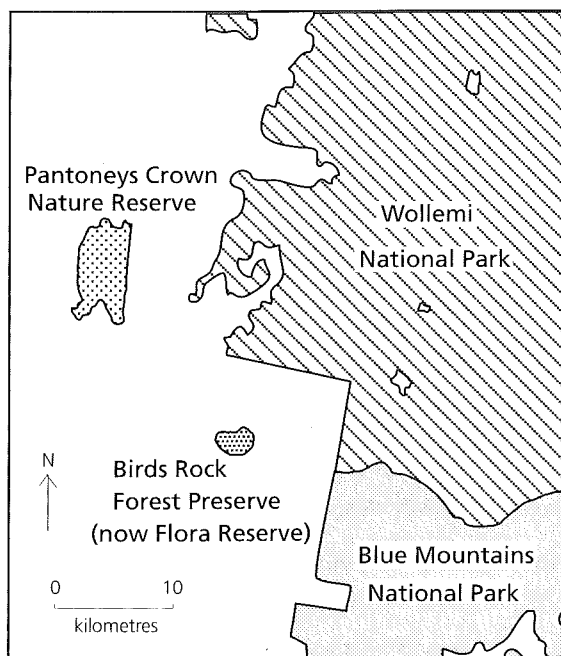


Figure 7. Location of conservation reserves in the area covered by the Wallerawang map sheet.

**Table 4. Species of particular conservation significance within the Wallerawang 1:100 000 map sheet area.** Species listed here are either rare or threatened (Briggs & Leigh 1988), or of botanical significance in terms of geographic distribution or localised populations disjunct from other occurrences. Localities refer to Wallerawang map sheet occurrences. Nth = northern, Sth = southern, codings are from Briggs & Leigh (1988).

Species (family)	Habitat/Locality	Significance
APIACEAE <i>Eryngium vesiculosum</i>	Hartley Vale	Disjunct local population
ASTERACEAE <i>Celmisia</i> sp. nov. aff. <i>longifolia</i> <i>Olearia quercifolia</i>	Newnes Plateau swamps, Blackheath, Wentworth Falls Swamps, Clarence to Wentworth Falls	Disjunct local population 3RC-, local endemic
CELASTRACEAE <i>Apatophyllum constablei</i>	Cliff line, Glen Davis	2E, very restricted local endemic
EPACRIDACEAE <i>Rupicola</i> sp. 1	Cliffs, Glen Davis	2R, restricted local endemic
FABACEAE <i>Acacia asparagoides</i> <i>Acacia kybeanensis</i>	Blackheath, Newnes Plateau Clarence, Newnes	2R, local endemic local disjunct population. Nth-limit
<i>Dillwynia stipulifera</i>	Swamps, Newnes Plateau	3RCi, local disjunct population. Nth-limit
<i>Pultenaea incurvata</i>	Swamps, Newnes Plateau, Mt Wilson, Wentworth Falls	2RCt, local endemic
HALORAGACEAE <i>Haloragodendron lucasii</i>	Yarramun Creek, open-forest on creek bank	2KC-, local disjunct population (Orchard 1990)
LAMIACEAE <i>Prostanthera cryptandroides</i>	Glen Davis	2VCt, local endemic
MYRTACEAE <i>Eucalyptus gregsoniana</i>	Poorly-drained heath Newnes Plateau Clarence-Blackheath	3RCa, local disjunct population
<i>Eucalyptus</i> sp. nov. 'MOKII'	Heath on rock out-crops, Newnes Plateau	3RC-t, local endemic
<i>Darwinia peduncularis</i>	Glen Davis, below cliffs	3RCi, local disjunct population
<i>Leptospermum blakelyi</i>	Hassans Walls, Lithgow Water Supply, heath	2R, local endemic (Benson 1990)
<i>Micromyrtus</i> sp. nov.	Lithgow Water Supply, heath	recently discovered endemic taxon (Peter Wilson pers. comm.)
PROTEACEAE <i>Banksia conferta</i> var. <i>penicillata</i>	Newnes Plateau	3RC-, local endemic variety

Species (family)	Habitat/Locality	Significance
<i>Grevillea johnsonii</i>	Mount Gundangaroo, Capertee Valley	2RCi, local disjunct population. Sth-limit
<i>Isopogon prostratus</i>	Newnes Plateau	local disjunct population. Nth-limit
<i>Persoonia marginata</i>	Capertee	2V, local endemic
RUTACEAE		
<i>Boronia deanei</i>	Swamps, Newnes Plateau	2VCa, local disjunct population. Nth-limit
<i>Eriostemon obovalis</i>	Newnes Plateau, Blackheath-Bell	3RCa, local endemic
SCROPHULARIACEAE		
<i>Parahebe</i> sp.1	Clarence, Mt Horrible	2RC-, local endemic

The area of the Wallerawang map sheet contains a rich variety of plant communities, but although there are extensive conservation reserves, they conserve only part of the diversity of plant communities and species. Very little of the dry western woodlands on Permian and Devonian geology are included in reserves. More important are the woodlands, heath and swamps on the Newnes Plateau, one of the most elevated sandstone plateaus in Australia and of significant regional conservation importance. Though threatened by a potentially massive sand extraction industry, they remain unprotected.

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