

1 INTRODUCTION

1.1 BACKGROUND

Native Vegetation Mapping is a fundamental information resource required for a myriad of uses associated with biodiversity and environment planning and catchment protection. While the primary attributes of such a resource inform vegetation management, it also provides direction on fauna habitat values, streamside protection and cultural heritage values.

The western Blue Mountains catchments of the Capertee, Wolgan – Cox's, Gurnang and Jenolan Valleys were mapped in four discontinuous areas. The first three of these areas were those areas of private lands, state forest and crown land tenures unmapped by the south coast regional vegetation mapping project of Tindall *et al.* (2004) as part of the Department of Infrastructure, Planning and Natural Resources (DIPNR) State-wide Native Vegetation Mapping Program. The Jenolan Valley was included in this project at the request of the Oberon office of the Parks and Wildlife Division of the Department of Environment and Conservation (DEC). The request was supported with additional funding. The total area of mapping undertaken in this project comes to slightly more than 157 000 hectares.

1.2 APPROACH

This project aims to:

- Develop a hierarchical classification system in order to describe vegetation patterns using systematic field data and quantitative analytical methods;
- Describe the floristic composition of the defined vegetation communities and their environmental characteristics;
- Examine floristic relationships between the vegetation communities found in the study area and those occurring within neighbouring landscapes having particular reference to Tindall *et al.* (2004);
- Delineate the extent of native vegetation cover using recent 1:25 000 scale aerial photography, including a coarse assessment of the intensity and type of disturbance present;
- Provide a map of the distribution of vegetation communities over the western parts of the Blue Mountains and therefore the upper reaches of the Hawkesbury – Nepean catchment.

Classification and mapping vegetation in NSW has been undertaken using a wide variety of methods and approaches (Benson 1999; FEWG 1997; Sivertsen & Smith 2001). Each method comes with strengths and weaknesses in terms of accuracy, efficiency and rigour (FEWG 1997). The adoption of systematic field methods provides an explicit and repeatable means of describing recurring patterns in floristic assemblages, hereafter termed vegetation communities. These methods afford the application of quantitative classification techniques that provide robust supporting data to vegetation community definition. In addition, comparison and assessment of broader regional vegetation patterns is more easily achieved and is less driven by subjective judgements.

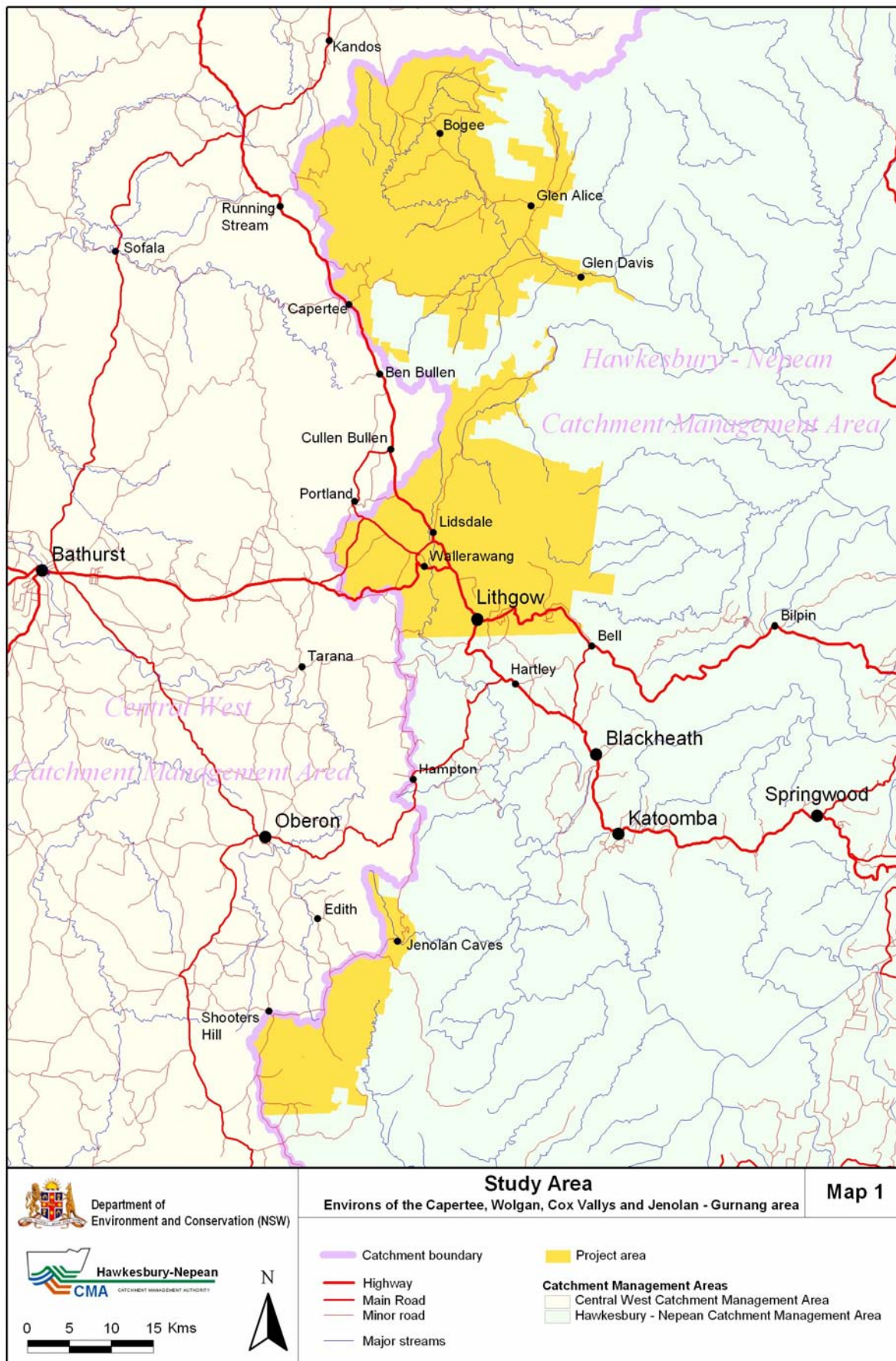
Mapping of vegetation communities defined by field data is always a process of interpolation. In this project, Aerial Photo Interpretation (API) and extensive field reconnaissance have been used to develop an understanding of the patterns in vegetation communities within the areas under consideration.

1.3 STUDY AREA

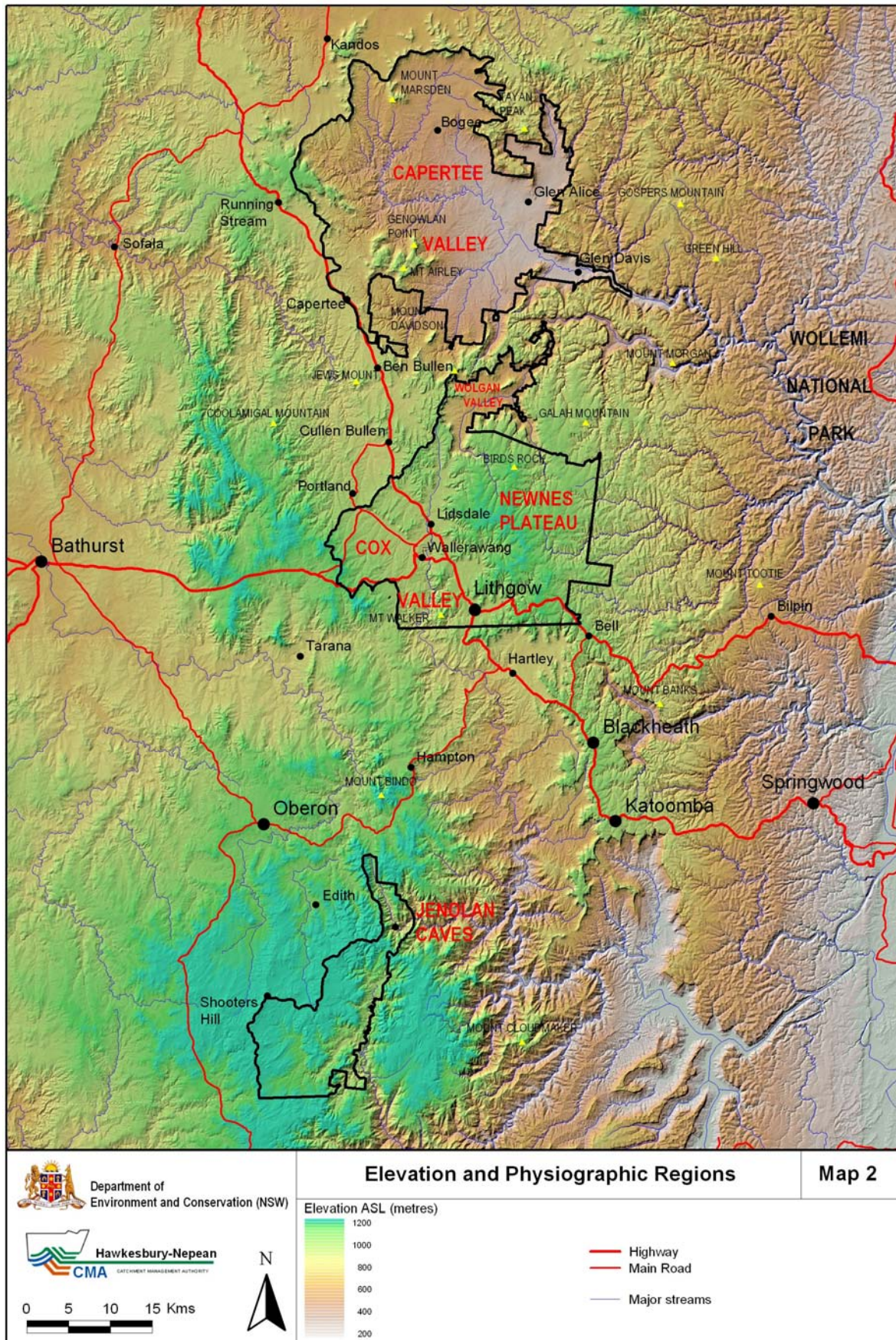
1.3.1 Location

The study area (Map 1) comprises four discontinuous areas that occur in the catchments of the Cox's and Wolgan, the Capertee, the Kowmung and Jenolan rivers in the western Blue Mountains. As the project was largely targeting areas outside existing mapping work the boundaries are map edges, reserve boundaries or the Great Dividing Range.

The individual mapping areas are separated by the Gardens of Stone and Wollemi National Parks in the north, and by the largely agricultural areas of the Megalong and Cox's valleys in the south. A very narrow separation between the Jenolan and Kowmung catchments is within the Kanangra-Boyd National Park, and was captured as part of the Jenolan Trust lands mapping undertaken concurrent to this project.



Map 1: Study Area



Map 2: Elevation and Physiographic Regions

There are a number of well-known physiographic landmarks and localities within the study area or near to the boundaries. A number of these are shown in Map 2. The town of Lithgow lies within the southern boundary of the Newnes (middle) mapping area, and Kandos immediately northwest of the Capertee. Jenolan Caves occurs in the northern isthmus of the southern mapping area. The Capertee Valley forms the basis for the northern mapping area, and the valley of the Kowmung river tributaries (The Hollanders and Tuglow rivers) forms the majority of the Gurnang (southern) mapping area. Shooters Hill, on the Oberon to Goulburn road, is the highest peak (1354 metres) and western boundary of the study area, although Mount Trickett near the top of the hill west of Jenolan Caves (and immediately between the two southern mapping areas) is slightly higher (1360 metres).

The areas of mapping are presented in Table 1.1. In total, they sum to about 60 percent of the area of a 1:100 000 scale map sheet.

TABLE 1.1: AREA OF EACH SURVEY MAPPING AREA

Mapping Area	Features	Area (ha)
Capertee (Northern)	Glen Davis, Mount Airly, Bogee, Kandos SF	74,296.27
Newnes (Middle)	Wolgan Valley, Newnes Plateau, Cox's Valley, Mount Walker	62,297.25
Gurnang (Southern)	Shooter's Hill, Gingkin, Tuglow Caves, Jaunter	17,591.94
Jenolan (Southern)	Jenolan Caves, Jenolan River	2,938.87
Total		157,124.33

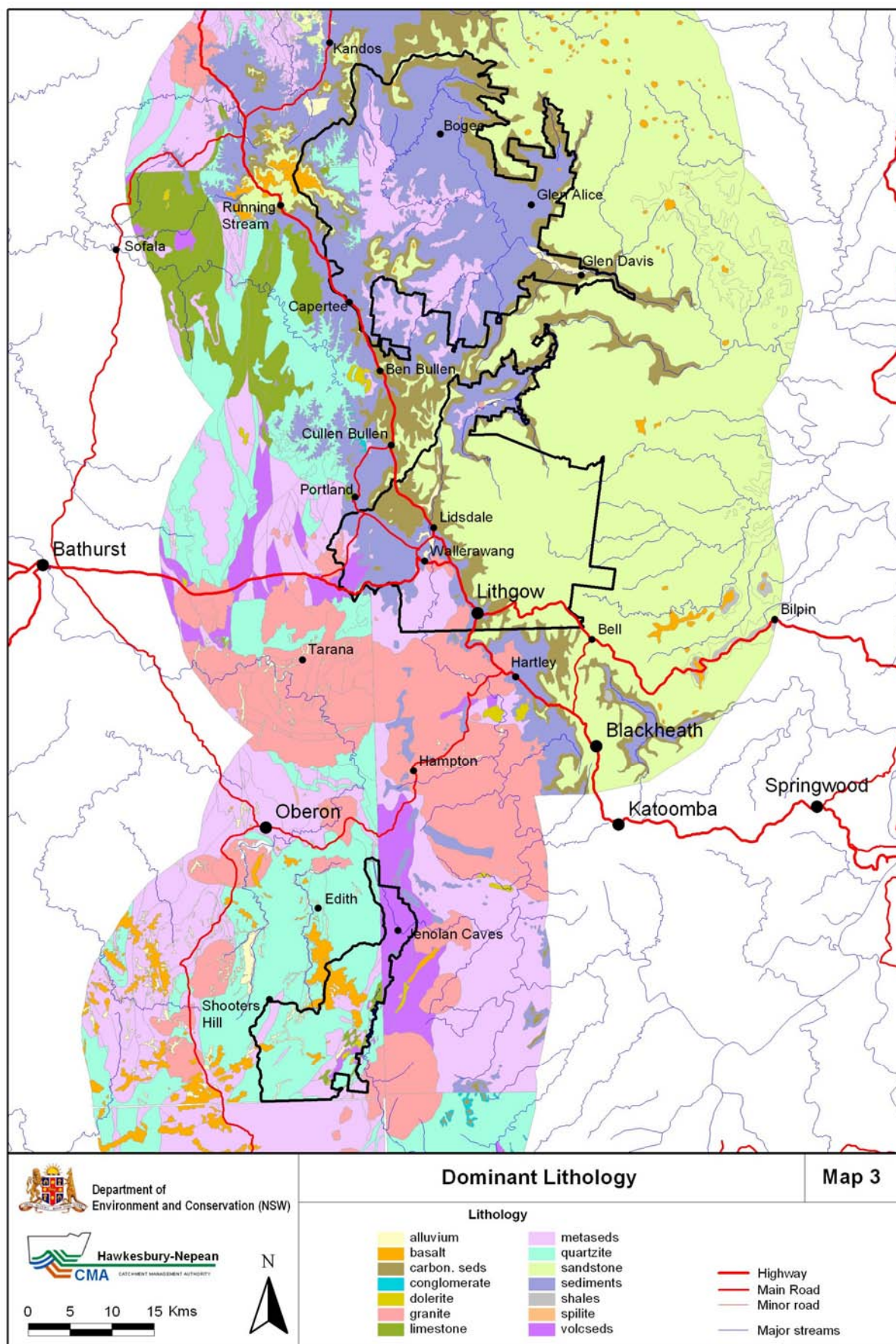
1.3.2 Environmental Setting

Geology

The generalised lithology of this area is presented in Map 3. Geologically, two distinctly different terrane types occur in the study areas, although they are arranged so that one overlies the other. The sandstone plateaux of the western Blue Mountains are formed of (predominantly) Triassic era Narrabeen sediments comprising massive sandstones with inter-bedded shale layers and lenses, tuffaceous shale and conglomerate (Mayne *et al.* 1974). The sandstones are often indurated with leached iron deposits that when weathered produce a distinctive appearance known as pagodas – owing largely to their similarity to the Asian architecture. This overlies the finer sediments of the Permian era coal deposits, and those in turn overlie the Megalong Conglomerate and Shoalhaven Beds – the basal units of the mostly flat-bedded Sydney Basin. The older terranes (parts of the Lachlan Fold Belt and Bathurst Batholith) are mostly altered as a result of regional metamorphism and are dipping, tilted and folded strata that in some cases are then intruded by granite plutons. The majority of the metamorphic material is felsic- or quartz-rich – either sandstone altered to quartzite or porphyritic rhyolites and lavas (Mayne *et al.* 1974), and is typically Ordovician, Silurian or Devonian in age. Large areas are also dominated by limestone and the calcite-rich shale called marl. The caves at Jenolan and Tuglow, and the economically important deposits at Excelsior (near Capertee) and near Kandos are representative of the major outcrops of massive limestone. The deposits that make up the southern limestone are Silurian in age, while those in the north are mapped as Ordovician (Brunker & Rose 1967).

Smaller areas of both granite and basalt occur in the study area. The majority of the granite occurs in the Newnes Mapping Area, with plutons exposed in the Lithgow, Wallerawang, Wolgan Valley and Mount Lambie areas, and a small area near Morong Deep in the extreme south-eastern corner of the Gurnang Mapping Area. Tertiary-age (mostly Eocene to Oligocene, but Miocene in the south) basalt, phonolite and trachyte overlies the older material in several locations in the Capertee Mapping Area and the Gingkin area near Tuglow (Brunker & Rose 1967, Mayne *et al.* 1974). The small bodies in the Capertee area mostly overlie the Narrabeen sediments although a small number of presumably intrusive bodies are found in older sediments in the Bogee area at the northern end of this mapping area. The largest extent of basic volcanic rock in the Capertee is found on the eastern extension of Cherry Tree Hill where it caps the plateau of Mount Vincent.

Basalt does not make a mapped appearance in the Newnes Mapping Area although there is some suggestion of the presence of basalt in small bodies on a number of the higher parts of the mapping area. In the Gurnang Mapping Area the basalt largely overlies the Ordovician age quartzite's, greywacke and slates of the Adaminaby group. Throughout the mapping areas much of the alkali (basalt and related) geology has suffered from clearing as the soils are often deeper than the surrounding areas and much more fertile, and the landform is more usually of a rolling pattern making the areas easily cleared and tended.



Map 3: Dominant Lithology

Apart from the narrow strips of Quaternary (Recent) alluvium that form along the main streams there are several more extensive areas of alluvium that have formed, in the lower parts of the Capertee, in the upper Cox's valley and upper Tuglow river. These areas tend to be flat lying and are dominated mostly by sandy alluvium. Typically these areas have been extensively cleared and support little native vegetation. Some areas of organic soils are formed at higher altitudes on parts of the Newnes Plateau and at Long Swamp in the headwaters of the Cox's River. Some areas on the Newnes Plateau have been identified as having aeolian dunes and have been prospected for silica.

Morphology

The study area comprises a combination of rugged and relatively inaccessible landscapes and rolling terrain that has been largely cleared for agriculture. The main geographic features of the Capertee and Newnes study areas are the extensive sandstone tablelands and the rivers and tributaries which dissect them. The tablelands are comprised of Narrabeen sediments deposited in the Triassic era (Bryan 1966). This includes the Newnes Plateau, the Ben Bullen Range and Western Wollemi as well as the mesas of Mount Airly and the extension out to Genowlan Point and the Great Dividing Range from Mount Vincent north across to Kandos and eastwards north of Bogee. The steep faces of the cliffs form along joint planes, and the weakening of the underlying sediments by weathering produces sizeable rockfalls and landslides resulting in a quartz-enriched talus slope below the cliffs.

The areas of metamorphic rock often produce steep, rocky slopes that are usually deeply dissected by the drainage. The finer-grained materials and the limestone are usually preferentially eroded, leaving steep-sided (but not usually sheer) ridges with much loose rock. This landscape characterises the southern (Gurnang – Jenolan) and the western Capertee mapping areas in particular.

The Narrabeen Sandstone produces an infertile sandy soil (DLWC 2002; Hamilton 1976; Hazelton & Tille 1990) which drains well, but has a shallow, sandy structure and low water-holding capacity (Kovac & Lawrie 1990). In areas of lower slope the admixing of organic matter improves the structure and water holding capacity. The soils that form over the Permian sediments below the escarpments are usually still very sandy in nature, with the sandstone talus weathering into the profile. This soil tends to be of intermediate nutrient status and the additional sand in the profile aids in drainage. The profile can be quite deep, with the accumulation of colluvium producing a deeper, if stony profile. The shale and siltstone material tend to occur in flatter locations, such as on footslopes or eroded ridges. A clay loam soil tends to develop in these areas, which is of slightly higher fertility with a better water holding capacity (DLWC 2002; Hamilton 1976; Hazelton & Tille 1990). Clay subsoil & duplex soils may form on slopes where shales are weathering (Kovac & Lawrie 1990; Dacre King pers. comm.).

Some areas on the sandstones are also suggestive of higher nutrient levels, and this may relate to obscure areas of basalt, or possibly areas from where the basalt has been relatively recently eroded. Some areas on the sandstone are also affected by interbedded layers of shale. The wet soils that form in these locations may support a 'hanging swamp' community on organic-rich clay soils.

The various metamorphic materials weather to produce soils of character similar to the array of rocks from which they are derived. Quartzite weathers to produce a shallow, rocky soil with low to moderate nutrient status and poor water holding capacity, often with cobbles and larger angular stones on the surface. The shales and interbedded volcanic rocks produce a soil of higher nutrient status that may be deep in places, but is usually stony. The water-holding capacity of the soils derived from the shales and volcanics is usually moderate (Kovac & Lawrie 1990). The limestone and marl produce a lime-enriched soil (usually a terra rossa) that often has loose rock on the surface and supports a clay soil. It has good water-holding capacity, but the steep slopes usually limit the accumulation of soil (Dacre King pers. comm.; Kovac & Lawrie 1990).

The soils over the volcanic and plutonic rocks are usually of low-moderate (granite) to moderate-high (basalt) nutrient status, and often of a clay or gritty clay texture. The soils vary in depth but on flatter slopes can become quite deep. Basalt soils tend to support a grassier community, and near Gingkin chocolate soils and krasnozems form over the basalts, while the granites tend to form podzols and sandy earths of low fertility and low to moderate water-holding capacity (Kovac & Lawrie 1990).

Elevation

There is a large elevation range within the study areas (Map 2). The lowest areas occur around the lower ends of the Capertee and Wolgan rivers, where the altitude drops to 233 metres above sea level (ASL) and 502 metres ASL respectively. The highest elevation within the study area is found on the peak of Shooters Hill, on the Great Divide, which is 1354 metres ASL, although several high peaks occur

throughout the area and much of the elevated plateau country in all mapping areas exceeds 1000 metres ASL. Each of the three mapping areas is different with regard to median elevations and terrain. Table 1.2 summarises the main elevation characters of all mapping areas.

TABLE 1.2. ELEVATION LIMITS AND AVERAGES FOR EACH MAPPING AREA

Mapping Area	Highest Point	Lowest Point	Elevation Statistics
Capertee (northern)	Mount Vincent (1111 metres) (Tayan Peak at 1154m is highest in the vicinity, but is excluded from the mapping area)	Capertee River below Glen Davis (233 metres)	Mean: 532 metres SD ¹ : 171.3 metres
Newnes (middle)	Garlands Hill (1221 metres)	Wolgan River at Newnes (502 metres)	Mean: 983 metres SD: 129.0 metres
Gurnang (southern)	Shooters Hill (1354 metres)	Tuglow Hole Creek (860 metres)	Mean: 1165 metres SD: 83.8 metres
Jenolan	Unnamed peak west of Jenolan Caves (1324 metres)	Jenolan River (638 metres)	Mean: 1036 metres SD: 135.5 metres

¹: SD: Standard deviation, the value above and below the mean within which 60 percent of all values occur.

Climate

The climate of the mapping region is variable, being mostly influenced by topography, including ruggedness, position and elevation. Map 4 illustrates the range in average annual rainfall across the study areas. The lower elevations of the Capertee Valley experience a warm and dry climate, as illustrated by Glen Davis having the lowest average rainfall values and highest average temperatures of the meteorological stations examined. The Lithgow data further support that the influence of topography in the regional climate is great, the position below the elevated plateau resulting in a decrease in rainfall values and slight increase in overall temperatures. The higher elevation tablelands and highland areas have both a cooler and wetter climate (NPWS 2003b; BOM 2005). The mean temperatures and annual rainfall summaries from the various weather stations within and nearest to the study areas are presented in Table 1.3 (BOM 2005).

TABLE 1.3: WEATHER STATION DATA FOR THE STUDY AREA

Station	Mean Temps (°C)	Variations in Monthly Rainfall Means (mm)	Rainfall Extremes (mm) – Month and Day Maxima	Mean Annual Rainfall (mm)
Glen Davis (063031)	16.5 - 30.3 (Jan) 2.0 - 15.4 (June)	H – 72.7 (Feb) L – 36.8 (Sep)	Month - 226.6 (June) Day – 113.0 (Mar)	634.0
Gurnang (063033)	9.0 – 22.8 (Jan) -1.6 – 7.4 (Jun)	H – 93.9 (Jun) L – 69.2 (Mar)	M – 345.2 (May) D – 200.3 (Mar)	987.8
Sunny Corner (063079)	10.4 – 25.2 (Jan) -0.2 – 7.1 (Jun)	H – 90.8 (Jan) L – 62.7 (Apr)	M – 316.9 (Feb) D – 135.0 (Sep)	926.4
Jenolan SF (063037)	9.7 – 22.4 (Jan) -1.1 – 7.9 (Jun)	H – 124.9 (Jan) L – 76.5 (Sep)	M – 499.0 (Mar) D – 219.2 (Mar)	1158.4
Oberon (063293)	11.8 – 24.0 (Jan) 0.2 – 8.2 (Jun)	H – 81.3 (Jan) L – 50.2 (Apr)	M – 227.1 (Apr) D – 76.6 (Sep)	784.9
Newnes Forest (063062)	10.2 – 23.2 (Jan) -0.8 – 9.4 (Jun)	H – 121.0 (Jan) L – 67.9 (Sep)	M – 519.4 (Mar) D – 192.0 (Aug)	1071.9
Jenolan Caves (063036)	11.6 – 25.6 (Jan) 0.2 – 9.4 (Jun)	H – 93.5 (Jan) L – 66.3 (May)	M – 429.0 (Feb) D – 153.2 (Aug)	964.3
Lithgow (063224)	11.8 – 25.5 (Jan) 0.7 – 10.4 (Jun)	H – 92.9 (Jan) L – 63.7 (Apr)	M – 374.4 (Aug) D – 179.0 (Jun)	860.1
Lidsdale SF (063046)	11.4 – 24.6 (Jan) -0.3 – 9.5 (Jun)	H – 108.5 (Jan) L – 52.2 (Jul)	M – 361.9 (May) D – 148.6 (Apr)	877.4

Landuse and Tenure

The mapping area is thought to have been occupied by humans for at least 20 000 years before present (NPWS 1991). The project area boundaries represent part of the traditional home of the Dharuk and Gundangarra Aboriginal people (NPWS 1991). Evidence of indigenous use and occupation of the region includes artefacts in rock shelters, camp sites, axe grinding grooves, rock engravings, stone arrangements, burial sites and sites of spiritual significance (NPWS 2001a).

European occupation of the region commenced around the year 1814, after a way was found across the Carmarthen Hills (Blue Mountains) and through to the pasturelands astride and to the west of the Great Dividing Range (NPWS 2001a). Initially farming was mostly restricted to the richer alluvial soils in the Cox's Valley (NPWS 1991) and soon after in the Capertee Valley. One of the peaks to the northern end of the study area (Mount Marsden) commemorates that the Reverend Marsden had a large holding in the upper reaches of the Capertee Valley. Agricultural pursuits in the study areas were centred on extensive sheep and cattle grazing, although there are also limited areas of cropping (mainly in the lower parts of the Capertee Valley).

Logging has an extensive history in the area, and includes both softwood plantation and native hardwoods. Pine (mainly *Pinus radiata*) is grown in extensive plantations in the Newnes Plateau, around Shooters Hill and Jenolan (Jenolan and Gurnang State Forests) and west of Lithgow. Hardwood, mainly as natural timber but to some extent also in plantations, is sourced from the Newnes Plateau and the Ben Bullen area, Kandos SF and in the State Forests between Jenolan and Shooters Hill. Map 5 shows the arrangement of land holdings within the study area, including the location of State Forests and National Parks.

The area also has an extensive history of coal and shale mining (Mayne *et al.* 1974). The largest shale oil plants at Glen Davis and Newnes were served by a rail link that extended from Newnes Junction (near the current upper end of the Zig Zag Tourist railway) across the plateau and through the Glowworm Tunnel down to the town of Newnes. A pipeline to carry shale oil from the processing works at Glen Davis linked with the works at Newnes and the railhead. Production ceased in 1952 owing to the high cost and easier sources of supply for fuel oils (Mayne *et al.* 1974). Other areas with mining production were to be found near the village of Capertee, and works were constructed into Mount Airly to extract oil shale, and at Marrangaroo, where the oil shale yielded the best volumes of fuel oil (Mayne *et al.* 1974). The rim of the Capertee valley is identified as having a number of accessible oil shale deposits. Coal continues to be mined in the areas around Lithgow and Wallerawang, and apart from local electrical generation, coal is also transported to ports at Sydney and Port Kembla by rail. Other mining activities in the area include limestone (quarried at Excelsior, north of Capertee) and diamonds. The latter is mostly sourced from streambeds trapped beneath the tertiary basalts in the Mount Airly and Genowlan Point areas.

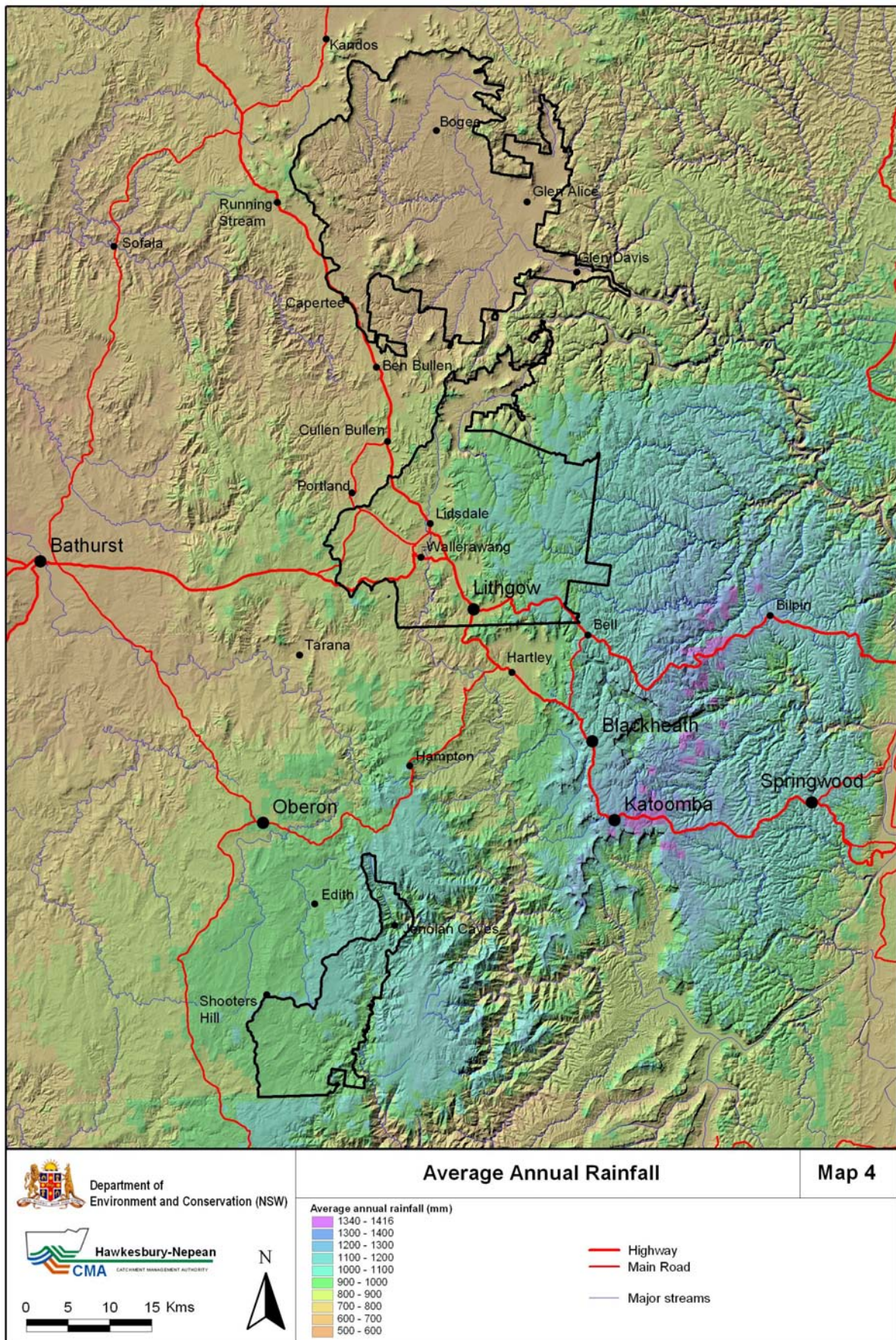
Tourism has become a major income earner for the region. Newnes and Jenolan State Forests are amongst the most frequently visited State Forests in NSW (www.forest.nsw.gov.au/recreation/survey/default.asp). Jenolan Caves is a well-known destination, and being within easy reach of Sydney is well frequented. The Capertee Valley is well known for the opportunities of farm stays and eco-tourism, while the Newnes Plateau is a relatively accessible location for off-road recreation. Military establishments at Lithgow have been responsible for small arms manufacture and testing.

Map 5 also shows that National Parks comprise a significant proportion of the landscape with extensive holdings in Wollemi, Kanangra Boyd, Gardens of Stone and Blue Mountains National Parks. Significant areas of leased and vacant Crown Lands remain in the Capertee hills.

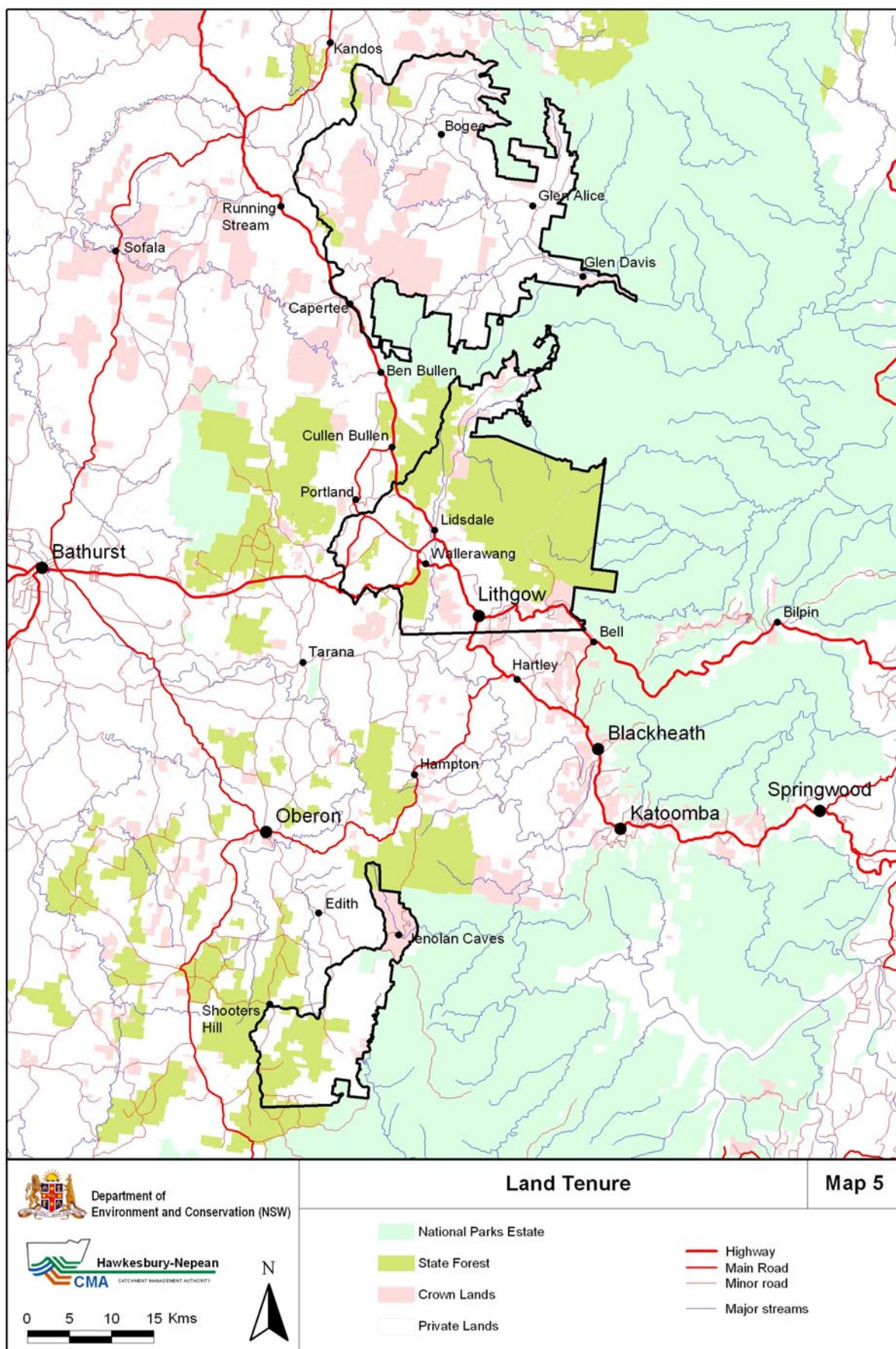
1.3.3 Regional Context

The mapping areas straddle the boundary (see Map 6) between the Sydney Basin and the South-eastern Highlands Bioregions as delineated in the Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway & Cresswell 1995). The purpose of these regions is to establish a framework for conservation planning using broad landscape characteristics to highlight similar influences on flora and fauna. The interactions between climate, geology and broad vegetation are the primary attributes that have been used. The mapping areas include parts of the Central Coast (CC) and the Central Tablelands (CT) botanical regions (Anderson 1961), with the majority of the areas being in the CT. The CC region includes part of the lowest section of the Wolgan Valley, and the lowest parts of the Capertee valley and the elevated country south and east of Glen Alice.

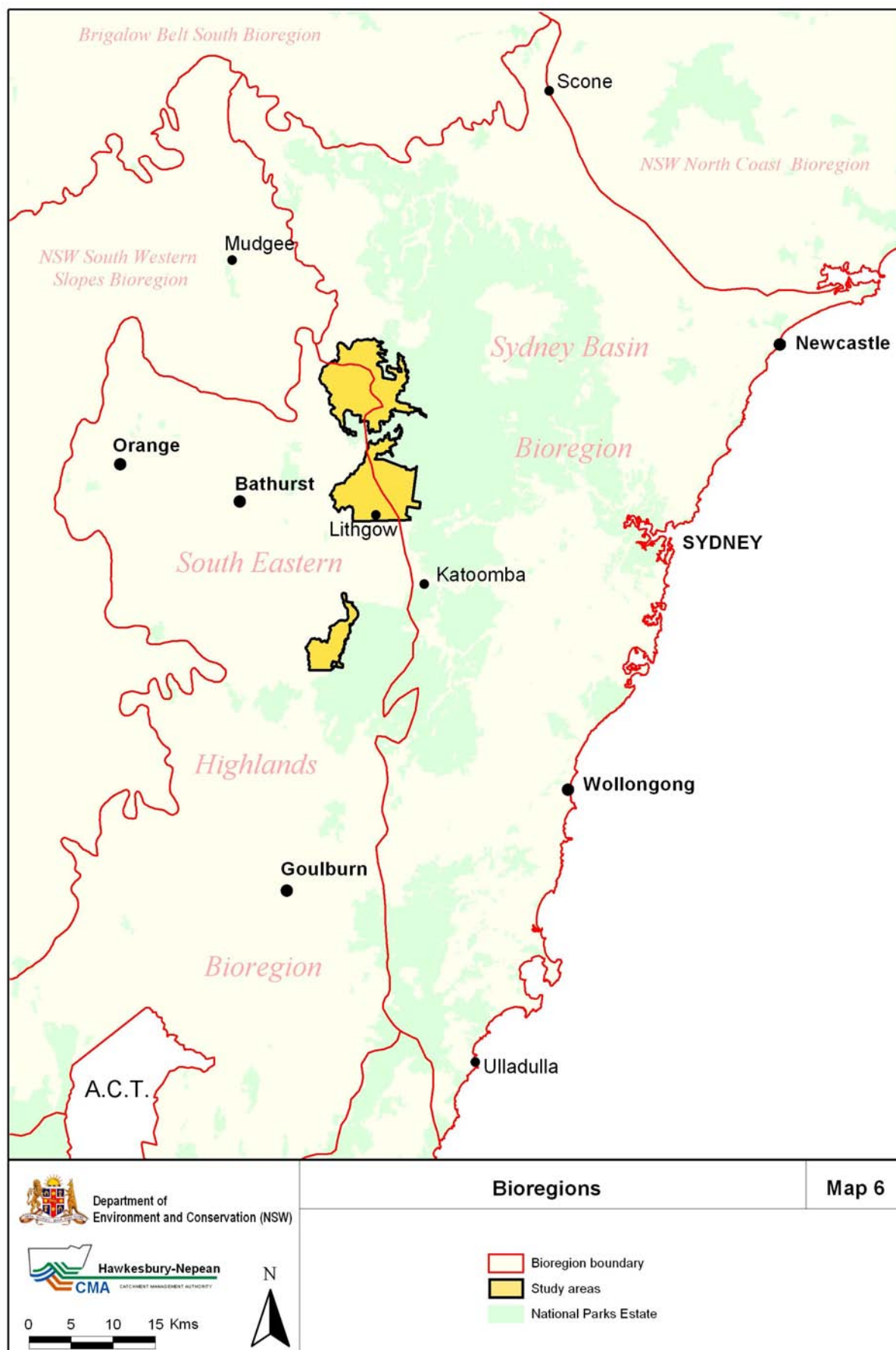
The four mapping areas all encompass very different areas. The Capertee is very similar to the western slopes in its landform and some of the species present. The Newnes Plateau is very typical of the upper Blue Mountains, while the valleys of the Cox's and of the Tuglow are typical of the elevated tableland areas. The Jenolan mapping area is representative of many of the escarpment forest communities.



Map 4: Average Annual Rainfall



Map 5: Land Tenure



Map 6: Bioregions