

4 Discussion (D Steller, A Bryant, S House, N Kearnes and C Simpson)

4.1 Data

In 1998 the Georges River catchment S22 Committee representatives were asked to provide any information or references to sources of biodiversity data that would be relevant to this study. Many councils, agencies and individuals were able to provide a range of information from general environmental reports through to specific, well-documented species records (see Section 3.1). All data and reports obtained up to mid-1999 have been incorporated into the study.

The lack of species of conservation concern recorded during the surveys, particularly for those species confined to the Cumberland Plain, is a reflection of the loss of habitat to agricultural and urban purposes and the degradation of the remaining area through fragmentation, exotic species, rubbish dumping and incompatible land use. The cryptic and often seasonal nature of these sparsely distributed species also makes detection difficult.

However the lack of records of species of conservation concern during these surveys should not be interpreted as meaning there is a lack of fauna value. This is for two major reasons. Firstly, the potential for habitat improvement and subsequent re-colonisation by these rarer species in the future. Secondly, the Georges River catchment contains significant habitat for fauna species *currently* considered common which, if current land practices continue, could subsequently be endangered in the future.

The data referred to in this report are based on aerial photography from late 1997 (or in some cases from 1994) and other information dating from prior to 2002. It is envisaged that this data will be updated in an ongoing way, however until such time as a suitable process for achieving this goal is established the data are limited by age and should be considered in that context.

4.2 Vegetation—ecological communities

This survey sought to build upon previous vegetation studies to refine and standardise the classification of ecological communities occurring on the Cumberland Plain and Woronora Plateau. The use of analytical techniques for deriving and mapping floristic communities is often advocated because it allows for the consistent interpretation of pattern as well as the continual augmentation of databases (Benson 1999). Subjectively derived classifications are potentially more difficult to replicate, and are less suitable as a basis for further refinement and extension.

The methods applied in this survey reflected an acceptance of the importance of systematic and explicitly defined observations as a basis for accurate vegetation mapping. A comprehensive sampling strategy was implemented on the Cumberland Plain to provide the raw data for the derivation and description of ecological communities. Analysis of data collected in this survey resulted in a classification scheme for the Cumberland Plain that closely resembled that of Benson (1992), although several refinements were added. Approximately half of the units in Benson's classification were represented by essentially equivalent units in the classification used in this study, although the different approaches to mapping meant that their distributions did not always coincide exactly. The existing classification for the

Cumberland Plain was thus refined in the current survey, with additional communities described and mapped. By comparison, the identity of clusters amongst sample sites on the Woronora Plateau was extremely difficult to resolve. Variation in the application of an apparently standard survey technique amongst observers meant that the combined data set provided a relatively poor basis for the further refinement of floristic communities. While the existing classification for the Cumberland Plain was refined in the current survey, with additional communities described and mapped, communities previously described for the Woronora Plateau had to be amalgamated for presentation at an equivalent scale.

4.2.1 Shale communities

Variation in full floristic composition was frequently independent of patterns in overstorey composition in communities on the Cumberland Plain. Communities occurring on shale soils varied in association with regional gradients in elevation and rainfall, as well as local topographic variability and the degree of sandstone influence in the soil. A gradient in increasing elevation, rainfall and ruggedness from the central Cumberland Plain to the Razorback Range at Picton was paralleled by a floristic gradation represented by three communities. An overstorey dominated by either *Eucalyptus moluccana*, *E. tereticornis* or to a lesser extent *E. crebra* was typical throughout this gradient. Shale Plains Woodland (MU10) is typical of the flat, low rainfall areas of the Cumberland Plain and grades into Shale Hills Woodland (MU9) at higher elevations in the southern half of the study area. Moist Shale Woodland (MU14) occurs at the upper end of the rainfall gradient, generally on the upper portion of very steep sheltered slopes, while Dry Rainforest (MU13) is frequently found in sheltered gullies.

As annual rainfall increases above 950 mm, Shale Plains Woodland (MU10) grades into Turpentine–Ironbark Forest (MU15) in the eastern extremities of the Cumberland Plain. Ascending to the Hornsby Plateau, Turpentine–Ironbark Forest grades into Blue Gum High Forest (MU152) as rainfall exceeds 1050 mm. This transition occurs at an altitude of approximately 100 m above sea level, although Turpentine–Ironbark Forest is found at altitudes of up to 200 m on the Western edge of the Hornsby Plateau where rainfall falls below 1050 mm. The overstorey composition is not always a reliable indicator of floristic differences in these communities. Turpentine–Ironbark forest may be dominated by *Eucalyptus saligna* at the upper end of its rainfall/elevation range, for example in Darvall Park and Denistone Park near Eastwood. Blue Gum High Forest is frequently dominated by *E. pilularis*.

4.2.2 Shale/sandstone transitional communities

A second gradient is apparent approaching the margins of the Cumberland Plain and relates to an increase in the influence of sandstone in the soil associated with the diminishing thickness of the overlying shale stratum. Pigeon (1941) recognised this gradient as a shale/sandstone ecotone and noted the composition of the overstorey varied with location along the shale/sandstone boundary. A similar observation was made in NPWS (1997), where Shale/Sandstone Transition Forest was recognised as a distinct assemblage, with a variable composition dependant on the composition of adjoining communities and the relative influence of shale and sandstone in the soil. A description of this nature is clearly more appropriately applied to an ecotone rather than a unique floristic assemblage. Nevertheless, the recognition of transitional communities on the margin of the Cumberland Plain appears justified on the basis of three criteria:

- Communities of species are recognisable at different points of the gradient independent of geographic location.
- The distribution of communities is more broadly defined than localised interfaces between shale and sandstone.

- The communities contain species not represented in adjoining shale and sandstone communities.

Clustering indicated that floristic variation in the transitional zone warranted the recognition of three separate communities. Two communities were defined in areas receiving less than 950 mm rainfall annually. These reflected high and low levels of sandstone influence (Map Units 1 and 2). The boundary locations are somewhat arbitrary, and where a boundary between high and low sandstone influence is mapped the two communities are likely to be indistinguishable. The third community, Turpentine–Ironbark Margin Forest (MU43) was recorded in areas of high sandstone influence and high rainfall, and was represented by sample sites on the edge of the Hornsby and Woronora Plateaux, and between Grose Vale and Bowen Mountain near Kurrajong. This community was floristically most similar to Turpentine–Ironbark Forest (MU15). In these areas, soils derived from Wianamatta Shale are restricted to remnant caps along the sandstone ridges. Vegetation on those pure shale caps was not sampled in this survey, but it is likely to be floristically similar to Turpentine–Ironbark Forest (MU15) as suggested by Benson (1992). The smaller shale remnants are likely to support transitional communities with a low sandstone influence, although none were sampled in this rainfall zone.

4.2.3 Communities occurring on Tertiary Alluvium

Four communities were recognised occurring on two separate deposits of Tertiary Alluvium in the north-west (Castlereagh) and south-east (Holsworthy) corners of the study area (Map Units 3, 4, 6 and 103). These correspond well with Benson's Castlereagh Ironbark Forest, Swamp Woodland, Scribbly Gum Woodland and Shale/Gravel Transition Forest (respectively). The distribution of these communities is related to the extent of exposure of soils from three depositional phases (the St Marys, Rickabys Creek Gravel and Londonderry Clay Formations) (Bannerman & Hazelton 1990), as well as local drainage conditions. Castlereagh Ironbark Forest (MU3) occurs on soils with a high clay content while Scribbly Gum Woodland (MU6) is more common on sandy loam soils. Soils with a high clay content underlie sandier soils but are exposed through erosion, especially towards the margins of the alluvial deposits. Scribbly Gum Woodland (MU6) thus tended to occur on slight rises (> 34m ASL) deep in the heart of the alluvial deposits. The stand of Castlereagh Ironbark Forest (MU3) located in Castlereagh State Forest was an exception to this rule, and presumably reflects a local occurrence of the Londonderry Clay Formation laid down in the third depositional phase. Castlereagh Swamp Woodland (MU4) occurs in poorly drained depressions in both the Holsworthy and Castlereagh areas. The distribution of this community could not be modelled satisfactorily, but was interpreted using aerial photo patterns. Small aeolian deposits in the vicinity of Agnes Banks support a distinct community of sclerophyllous species (MU8). Variability within this Map Unit was not well sampled in this survey, but was described by Benson (1981, 1992).

On the margins of the alluvial deposits, Castlereagh Ironbark Forest (MU3) grades into Shale/Gravel Transition Forest (MU103). As the name implies, this community has features characteristic of an ecotone, but unlike the Shale/Sandstone transitional communities it contains few unique species. Isolated deposits of Tertiary Alluvium overlying Wianamatta Shale are mapped throughout the Cumberland plain (Bannerman & Hazelton 1990), and support stands of Shale/Gravel Transition Forest. This assemblage is also present in areas with a high concentration of iron-indurated gravels (Benson & Howell 1994). These lateritic gravels are highly resistant to weathering and may accumulate near the soil surface following long-term erosion of the clay soils in which they are often embedded.

The few remaining remnants of native vegetation in the vicinity of Ashfield, Auburn and Bankstown have been the focus of considerable debate. Benson and Howell (1990) constructed a picture of the original vegetation of this area using documents predating the suburban development which took place after World War I. Several communities

are thought to have occurred, including dense shrublands, probably dominated by *Melaleuca nodosa*, interspersed with woodland dominated by *Eucalyptus moluccana*, *E. fibrosa*, *E. longifolia* and *E. eugenioides*. Examples of this vegetation are located at Rookwood Cemetery, in the upper reaches of Salt Pan Creek and in Norfolk Park, Greenacre (Benson & Howell 1990). Pure shale communities representative of both higher and lower rainfall areas are also thought to have been present, with patches of Dry Rainforest (MU13) occurring in sheltered localities (Benson & Howell 1990).

Remnant shrubland and ironbark woodland in this area has been ascribed to various communities. Benson and Howell (1994) described such areas as Shale/Gravel Transition Forest. In the absence of mapped deposits of Tertiary Alluvium, NPWS (1997) concluded they were better described as an eastern form of Shale/Sandstone Transition Forest. This classification recognised the close proximity of the shale/sandstone boundary, as well as outcrops of Minchinbury Sandstone between layers of shale. However, the Scientific Committees determination for the Endangered Ecological Community Shale/Sandstone Transition Forest noted that these areas were considered to be represented by another Endangered Ecological Community; namely, the Cooks River Clay Plain Scrub Forest. In the current survey, samples located at Rookwood Cemetery, Duck River, Norfolk Park (Greenacre), Carysfield Park (Bankstown) and Moorebank brickworks clustered with sites recognised as Castlereagh Ironbark Forest (MU3). This is consistent with Benson and Howell's (1994) observations on the floristic similarities between these areas and communities further west on Tertiary Alluvium (which were the basis for their Shale/Gravel Transitional classification). Despite the isolation of these remnants, and the high potential for floristic anomalies relating to human disturbance, the floristic association with sites representative of Castlereagh Ironbark Forest (MU3) was consistent, and sites sampled later in the survey joined the dendrogram in the same location. Therefore, despite the obvious structural differences (which may relate to past disturbances such as timber removal), this report classes these areas as Castlereagh Ironbark Forest (MU3).

The distribution of these stands of Castlereagh Ironbark Forest (MU3) around Bankstown and Auburn is correlated with the distribution of the Villawood Soil Series mapped by Walker (1960). The Villawood Series is a yellow podsollic soil extensively permeated with fine, concretionary ironstone (laterite). The link between Shale/Gravel Transition Forest and ironstone gravels has been previously noted (Benson & Howell 1994). The distribution of the Villawood series accounts for the distribution of shrublands described in historical records (Benson & Howell 1990) more satisfactorily than other features, such as the Birrong Soil Landscape. The Villawood Series is not differentiated in more recent soil maps (Chapman & Murphy 1989).

Shale/sandstone transitional communities also occur in the Auburn/Bankstown area, consistent with the observations made in NPWS (1997). Sites sampled in this survey were highly modified and often could not be classified with a high degree of confidence. Two sample sites located in the former Newington Naval Armaments Depot at Silverwater were classified as Turpentine–Ironbark Margin Forest (MU43). A small patch representative of Shale/Sandstone Transition Forest, Low Sandstone Influence (MU1) occurred at Rookwood Cemetery, but was dominated by an introduced species *Corymbia citriodora*. A small, highly degraded remnant located at the junction of the Cooks River and an unnamed creek (adjacent to First Avenue, Belfield) contained species characteristic of a high sandstone influence.

4.2.4 Riparian communities

Three communities were recognised occurring on soils of recent alluvial origin (Map Units 5, 11 and 12). Riparian Woodland (MU5) is confined to the riparian edge and adjacent swampy areas, and is most closely related to Castlereagh Swamp Woodland (MU4) in terms of floristic composition. Riparian Woodland was not sufficiently sampled to enable its distribution to be mapped reliably. Riparian Forest (MU12) corresponds to

communities occurring on the Hawkesbury–Nepean River and major tributaries described in NPWS (1997), and includes the Camden White Gum Forest Community described by Benson (1992). Samples representative of Riparian Forest (MU12) were restricted to within 100 m of the Hawkesbury–Nepean and Georges Rivers. Historical accounts suggest that this assemblage may once have been more extensively distributed across the Hawkesbury–Nepean floodplains (Benson and Howell 1990), but in the absence of comprehensive data the floodplains have been mapped here as supporting Alluvial Woodland (MU11). This Map Unit corresponds to communities occurring on Cumberland Plain Creek Systems as described in NPWS (1997b), but was sampled on major floodplains at distances greater than 100 m from the river. Toward the edge of the floodplain Alluvial Woodland grades into Shale Plains Woodland (MU10), and this latter assemblage may have occupied some parts of the floodplain. The modelled distribution of Alluvial Woodland may thus slightly overestimate the original extent of this assemblage.

4.2.5 Sandstone communities

The influence of sandstone in the soil is immediately apparent beyond the boundaries of the Cumberland Plain, however the influence of shale is still apparent in areas where the interbedded shale and sandstone of the Mittagong Formation are exposed. The Mittagong Formation is located stratigraphically between the Wianamatta Group Shales and Hawkesbury Sandstone (Bannerman & Hazelton 1990) and is exposed mainly along ridgelines bordering the Cumberland Plain on its north-east and south-east boundaries. Floristic composition varies with the degree of shale influence in the soil, with relative pure shale or shale/sandstone transitional communities evident in a few localised, rich outcrops of shale. Generally, the sandstone influence is dominant, and the vegetation is essentially a sandstone woodland, but often with a high representation of grass species in the understorey. In the Campbelltown area, this is exemplified by Upper Georges River Sandstone Woodland (MU32). This assemblage may also occur along the north-eastern boundary of the plain, but that area was not sampled in this survey.

Sandstone Ridgetop Woodland (MU31) merges into Upper Georges River Sandstone Woodland (MU32) as the shale influence decreases, and is dominant on ridgetops with soil derived from Hawkesbury Sandstone. This transition occurs over a relatively short distance in areas south of Campbelltown. However, Upper Georges River Sandstone Woodland (MU32) occupies a much broader zone in the central and northern portions of the Holsworthy Military Area. Upper Georges River Sandstone Woodland (MU32) grades into a variant of Sandstone Ridgetop Woodland (MU62) in the Holsworthy Military Area east of Long Point (see French *et al.* in press for a discussion on the distribution of this assemblage). Two forms of forest occur in the gullies dissecting the sandstone plateau: Western Gully Forest (MU33) and Eastern Gully Forest (MU61) (described by Keith 1994). The transition between these communities parallels a gradient in rainfall decreasing away from the Illawarra Escarpment, with Western Gully Forest occurring in areas receiving less than about 1050 mm of rainfall annually. Riparian scrub (MU35) occurs along major creeklines in sandstone gullies.

4.3 Species diversity—fauna

The Georges River catchment displays a wide variety of habitats and as such a large diversity in fauna species and assemblages, with some 352 species of fauna recorded in the catchment. As has been demonstrated for vegetation communities, the fauna of the catchment falls into two broad ecological and geomorphological units representing the Cumberland Plain and the Woronora Plateau. Whilst there are many generalist species that occupy both habitats, e.g. the Common Eastern Froglet (*Crinia signifera*), these two areas display significant differences in overall species composition. The

range of land uses, from high density urban to rural and relative wilderness in the Georges River catchment, combined with an understanding of future potential development patterns and a broad understanding of the ecological communities and their relative conservation status, creates a significant challenge in meeting biodiversity conservation goals. The need for a range of mechanisms to protect and manage fauna assemblages in this catchment is a clear outcome of this analysis.

In order to facilitate integrated management responses that embrace the role of fauna in ecological processes, the fauna of the Georges River catchment have been considered in terms of fauna assemblages (i.e. a group of fauna species that have similar habitat requirements). In order to describe fauna assemblages for each of the vegetation communities of the Georges River catchment, fauna specialists within the DEC consulted:

- existing fauna records (Atlas of NSW Wildlife—including all fauna records from this study)
- a range of literature
- expert specialists in fauna ecology and a range of individuals with local knowledge (see Acknowledgments).

This analysis identified four broad vegetation/landscape categories that became a canvas for describing these assemblages:

- Shale Ecosystems (Cumberland Plain Communities)
- Sandstone Ecosystems (Sandstone Plateau and Gully Communities, including the Sedgeland community)
- Estuarine Ecosystems (Mangrove and Saltmarsh Communities)
- Freshwater Wetland Ecosystems.

Appendix E lists these broad assemblages based on the conservation status of each species, as listed under the TSC Act, and in relation to their significance within the region. It is also noted that all native fauna are protected under the NP&W Act. Appendix F presents faunal assemblage profiles for each of eighteen vegetation communities identified in the Georges River catchment.

Considered together, these broad-scale assemblages provide a good basis for regional planning, however local planning and management initiatives require careful consideration of the specific assemblages of each locality. For instance, throughout this volume of the report generalised vegetation communities have been adopted for riparian communities—Riparian Woodland (MU5), Alluvial Woodland (MU11), Riparian Forest (MU12), Sedgelands (MU63), and Freshwater Wetlands (MU36) (see Appendix C). However, for the purposes of the third part of this report (*Aquatic Biodiversity of the Georges River catchment*), these classifications were insufficient and refinements were required.

The following sections broadly discuss the results of assemblage analysis for Birds (diurnal), Reptiles (diurnal), Bats and Frogs. Appendix F provides profiles of the fauna assemblages of each of the vegetation communities of the Georges River catchment.

4.3.1 Bird assemblages (diurnal)

i) Assemblages

Diurnal birds were the most thoroughly surveyed fauna group, and were surveyed at 189 sites throughout the Georges River catchment. There were many significant differences between the bird assemblages of the mapped vegetation communities (Table 55). In the Georges River catchment, it appears that the diurnal birds fall into

five main assemblages: Shale/Alluvium Woodlands; Sandstone Forests and Woodlands; Transition Forests; Aquatic environments; and Urban/Cleared habitats. The main bird assemblages have been mapped in Figure 25).

The Shale/Alluvium Woodlands group was characterised by the presence of Superb Fairy-Wrens, Silvereyes, Yellow Thornbills, Grey Fantails and Eastern Yellow Robins (Table 56). The four vegetation communities that comprised this group were Alluvial Woodland, Shale Hills Woodland, Shale Plains Woodland and Castlereagh Scribbly Gum Forest. Only minor differences were recorded between their bird assemblages (Table 56). It is interesting to note that within each of these vegetation communities there were sites that were lacking in small birds, with concurrent high numbers of Noisy Miners and other larger aggressive species. Noisy Miners are well known to opportunistically invade areas with a disturbed understorey, and it is likely that their presence relates to the level of disturbance at a site rather than to the vegetation.

The Sandstone Assemblage is typified by such species as New Holland Honeyeater, Eastern Spinebill, Brown Thornbill, Little Wattlebird, Yellow-faced Honeyeater and Grey Fantail. Several of these species are commonly associated with flowering banksia, which is a feature of sandstone vegetation communities. The vegetation communities that were found to support this bird assemblage were Sandstone Ridgetop Woodland, Eastern Gully Forest and Riparian Scrubland (Table 55). There were no significant differences between the ridgetops and gullies of the sandstone vegetation (Table 55). This is surprising, as it is widely known that some bird species are more likely to associate with wetter vegetation types. It is possible that we were unable to discriminate between these vegetation communities in terms of their bird communities because of the positioning of the sites, or because most birds are highly mobile and will regularly utilise vegetation communities adjacent to their preferred habitat.

Urban/Cleared environments were defined by an assemblage of birds dominated by exotic species such as Common Myna, Spotted Turtle-Dove and House Sparrow.

Table 55 Bird assemblages (diurnal)—differences in mapped vegetation communities (ANOSIM analysis)

Vegetation community	Alluvial Woodland	Castlereagh Scribbly Gum Forest	Eastern Gully Forest	Riparian Scrub	Sandstone Ridgetop Woodland	Shale Hills Woodland	Urban/Cleared	Shale Plains Woodland	Shale/Sandstone Transition Forest (high)	Upper Georges River Sandstone Woodland
Alluvial Woodland	–	–	–	–	–	–	–	–	–	–
Castlereagh Scribbly Gum Forest	0.22*	–	–	–	–	–	–	–	–	–
Eastern Gully Forest	0.86***	0.89***	–	–	–	–	–	–	–	–
Riparian Scrub	0.87**	0.77**	0.18	–	–	–	–	–	–	–
Sandstone Ridgetop Woodland	0.80***	0.78***	0.02	0.21	–	–	–	–	–	–
Shale Hills Woodland	0.03	0.02	0.61***	0.52**	0.52***	–	–	–	–	–
Urban/Cleared	0.40**	0.34**	0.97***	0.94**	0.91***	0.31***	–	–	–	–
Shale Plains Woodland	0.10	0.01	0.68***	0.64***	0.62***	0.02	0.25**	–	–	–
Shale/Sandstone Transition Forest (high)	0.21*	0.24*	0.61***	0.38**	0.57***	0.18**	0.49***	0.25***	–	–
Upper Georges River Sandstone Woodland	0.23***	0.24**	0.18***	0.09	0.13*	0.15**	0.54***	0.27***	0.08	–
Western Gully Forest	0.85***	0.88***	0.23***	0.11	0.37***	0.46***	0.96***	0.57***	0.39***	0.04

Global R = 0.35 (P<0.01). Values given are the R Statistic for each matched pair, and the significance of each pairing (*<0.05; **<0.01; ***<0.001).

Bird assemblages in aquatic fauna communities were not included in the statistical analyses as only a small number of sites were completed in these environments.

Nevertheless species such as Bar-tailed Godwit, Australian Pelican, Eastern Curlew and Cormorants are unlikely to be found inhabiting terrestrial ecosystems.

Table 56 Bird species (diurnal)—relative species diversity and species richness

Vegetation community ¹	No. of sites	Richness (average no. of spp./site)	Diversity (Shannon–Wiener Index)	Defining species (SIMPER)
Eastern Gully Forest	20	11.35	2.01	New Holland Honeyeater, Eastern Spinebill, Brown Thornbill, Little Wattlebird, Yellow-faced Honeyeater, Grey Fantail.
Alluvial Woodland	7	10.71	2.12	Superb Fairy-wren, Willie Wagtail, Yellow Thornbill, Common Myna, White-plumed Honeyeater, Silveryeye, Spotted Turtle-Dove.
Sandstone Ridgetop Woodland	11	10.18	2.08	New Holland Honeyeater, Eastern Spinebill, Brown Thornbill, Little Wattlebird, Yellow-faced Honeyeater, Grey Fantail.
Western Gully Forest	12	10.17	2.15	Spotted Pardalote, Brown Thornbill, Eastern Yellow Robin, Red-browed Finch, Yellow-faced Honeyeater, White-browed Scrubwren.
Shale Hills Woodland	21	10.14	2.01	Superb Fairy-wren, Silveryeye, Yellow Thornbill, Grey Fantail, Eastern Yellow Robin.
Upper Georges River Sandstone Woodland	25	9.88	1.99	Spotted Pardalote, Brown Thornbill, Eastern Yellow Robin, Red-browed Finch, Yellow-faced Honeyeater, White-browed Scrubwren.
Shale/Sandstone Transition Forest (high sandstone influence)	13	9.15	1.92	Not clearly defined.
Riparian Scrub	4	9.00	1.99	Not clearly defined.
Urban/Cleared	10	8.90	1.83	House Sparrow, Common Myna, Spotted Turtle-Dove, Common Starling, Welcome Swallow.
Shale Plains Woodland	37	8.54	1.89	Superb Fairy-wren, Silveryeye, Yellow Thornbill, Grey Fantail, Eastern Yellow Robin.
Castlereagh Scribbly Gum Forest	6	6.67	1.57	Not clearly defined.
Castlereagh Ironbark	2	12.50	2.31	Preliminary data—less than 4 sites.
Mangrove/Saltmarsh	3	7.33	1.04	Preliminary data—less than 4 sites.
Riparian Forest	3	9.33	1.97	Preliminary data—less than 4 sites.
Moist Shale Woodland	3	12.33	2.38	Preliminary data—less than 4 sites.
Sedgeland Heath Complex	1	11.00	2.30	Preliminary data—less than 4 sites.
Shale/Gravel Transition Forest	1	14.00	2.41	Preliminary data—less than 4 sites.
Shale/Sandstone Transition Forest (low sandstone influence)	2	15.50	2.33	Preliminary data—less than 4 sites.

1. Vegetation communities are ranked in terms of their species richness (except for those communities that only have preliminary data).

ii) Diversity and Richness

There were many differences in the richness and diversity of the bird assemblages (Table 56; Figure 26). Eastern Gully Forest, Alluvial Woodland, Sandstone Ridgetop Woodland and Western Gully Forest had more diverse diurnal bird assemblages than other vegetation communities in the Georges River catchment. A high level of diversity is retained in the ribbons of Alluvial Woodland across the Cumberland Plain (Figure 26). This finding emphasises the value of even small patches of certain habitat types and the importance of rehabilitation efforts in such patches.

Shale Plains Woodland and Shale Hills Woodland both had relatively low richness and diversity of birds. In these communities there was a great degree of variability from one site to the next. As many sites from these communities were disturbed, it is possible that the overall low ranking of these communities is an artifact of the high level of disturbance of much of the Cumberland Plain.

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FIGURE 25**

Figure 25 Bird assemblages (diurnal) in the Georges River catchment

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Figure 26

Bird diversity (diurnal) in the Georges River catchment

Reptile assemblages (diurnal)

i) Assemblages

Reptile assemblages were found to follow a similar pattern to the diurnal birds, with analysis uncovering several broad assemblages that related to parent geology (Figure 27). Reptiles are relatively immobile and therefore can more often relate to the microhabitat in which they were found. However, the reptile assemblage is strongly influenced by the presence of other abiotic features, such as streams and rock outcrops, which can occur across many vegetation communities. Broadly, there were four main assemblages. The first was associated with the vegetation of the sandstone geologies and can be tied to sandstone outcropping. It is characterised by the presence of the Coppertail Skink (*Ctenotus taeniolatus*), Grass Skink (*Lampropholis delicata*) and Jacky Dragon (*Amphibolurus muricatus*). This assemblage closely relates to Sandstone Ridgetop Woodland (Table 58), though it can be found in any of the vegetation communities on sandstone-derived soils where there is exposed rock.

The next assemblage is associated with the watercourses of sandstone environments. It includes such species as the Water Skink (*Eulamprus quoyii*), Leaf-tailed Gecko (*Phyllurus platurus*) and Water Dragon (*Physignathus lesueurii*). In the GRC, this reptile assemblage is typical of Riparian Scrub (Table 57) but can be found in any sandstone-influenced vegetation adjacent to running water.

The remaining two reptile assemblages were defined by the presence of either Garden Skink (*Lampropholis guichenoti*) or the closely related Grass Skink (*L. delicata*). These species are forest dwellers with low thermal requirements that allow them to be active under a dense canopy (Taylor & Fox 2001). In the Georges River catchment there was a clear split, with the forested communities on shale-derived soils being dominated by Garden Skink and the forested communities of sandstone-derived soils being dominated by Grass Skink.

Table 57 Reptile assemblages (diurnal)—differences in mapped vegetation communities (ANOSIM analysis)

Vegetation community	Riparian Scrub	Shale–Gravel Transition Forest	Shale Hills Woodland	Shale Plains Woodland	Sandstone Ridgetop Woodland	Shale/Sandstone Transition Forest (high)	Upper Georges River Sandstone Woodland
Riparian Scrub	–	–	–	–	–	–	–
Shale–Gravel Transition Forest	0.38	–	–	–	–	–	–
Shale Hills Woodland	1.00*	0.16	–	–	–	–	–
Shale Plains Woodland	0.99*	0.52	-0.02	–	–	–	–
Sandstone Ridgetop Woodland	0.44	0.47	0.57**	0.80***	–	–	–
Shale/Sandstone Transition Forest (high sandstone influence)	0.08	0.08	0.76*	0.93**	0.35	–	–
Upper Georges River Sandstone Woodland	1.00*	0.81*	0.93**	0.98**	0.26*	0.17	–
Western Gully Forest	0.11	-0.14	0.61**	0.83***	0.10	-0.04	0.37*

Global R = 0.55 (P<0.01). Values given are the R Statistic for each matched pair, and the significance of each pairing (*<0.05; **<0.01; ***<0.001).

ii) Diversity and Richness

Like the birds, there were many differences in the richness and diversity of the reptile assemblages (Table 58; Figure 28).

Table 58 Reptiles species (diurnal)—relative species diversity and species richness

Vegetation community ¹	No. of sites	Richness (average no. of spp./site)	Diversity (Shannon–Wiener Index)	Defining species (SIMPER)
Riparian Scrub	2	5.0	1.13	Water Skink (<i>Eulamprus quoyii</i>), Leaf-tailed Gecko (<i>Phyllurus platurus</i>) and Water Dragon (<i>Physignathus lesueurii</i>).
Shale Plains Woodland	9	3.3	0.77	Garden Skink (<i>Lampropholis guichenoti</i>).
Sandstone Ridgetop Woodland	9	3.2	0.79	Coppertail Skink (<i>Ctenotus taeniolatus</i>), Grass Skink (<i>Lampropholis delicata</i>), Jacky Dragon (<i>Amphibolurus muricatus</i>).
Shale–Hills Woodland	5	2.8	0.70	Garden Skink (<i>Lampropholis guichenoti</i>).
Shale/Sandstone Transition Forest (high sandstone influence)	3	2.7	0.78	Grass Skink (<i>Lampropholis delicata</i>).
Shale–Gravel Transition Forest	2	2.5	0.60	Unable to be clearly defined.
Western Gully Forest	5	2.2	0.70	Unable to be clearly defined.
Upper Georges River Sandstone Woodland	5	1.8	0.39	Grass Skink (<i>Lampropholis delicata</i>).
Eastern Gully Forest	2	1.0	0.33	Unable to be defined.
Castlereagh Ironbark Forest	1	5.0	1.56	Preliminary data.
Castlereagh Scribbly Gum Forest	1	3.0	0.95	Preliminary data.
Moist Shale Woodland	1	3.0	0.37	Preliminary data.
Sedgeland Heath Complex	1	3.0	0.60	Preliminary data.

1. Vegetation communities are ranked in terms of their species richness (except for those communities that only have preliminary data).

The richest and most diverse vegetation community, in terms of its reptiles, was Riparian Scrub, probably because the assemblage of reptiles found at these sites is enriched by species normally associated with water, such as the Water Skink (*Eulamprus quoyii*) and the Water Dragon (*Physignathus lesueurii*). Not surprisingly, Sandstone Ridgetop Woodland was also found to be a highly diverse community, a reflection of the significant habitat value of exposed and exfoliating sandstone that can be found throughout patches of this vegetation community. Shale Hills Woodland was also a fairly rich and diverse community, with an average of three species per site.

Eastern Gully Forest was one of the lowest ranked communities, probably due to prevailing low light conditions, although if sites had been examined within patches of this community near streams it is likely that the diversity of reptiles would have been greater.

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FIGURE 27**

Figure 27

Reptile assemblages in the Georges River catchment

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FIGURE 28**

Figure 28

Reptile diversity in the Georges River catchment

Bat assemblages

i) Assemblages

The results of the analysis of the harp trapping and bat ultrasound data provide a more ambiguous picture of bat assemblages than did the survey results for diurnal birds and reptiles because:

- both harp trapping and ultrasound detection methods record bats in flyways (i.e. regular flight paths used by bats to travel between roosting and feeding sites) and bats detected in these areas may therefore be transient
- the setting and clearing of harp traps and the interpretation of ultrasound recordings are extremely labour intensive, and therefore the number of sites examined was less than optimal.

Nevertheless, some patterns in bat assemblages emerged, particularly with the harp trapping data. The vegetation communities of the Woronora Plateau tended to have very low capture rates, with Little Forest Bat (*Vespadelus vulturnus*) and Gould's Wattle Bat (*Chalinolobus gouldi*) dominating. Vegetation communities on shale-derived soils tended to have bat communities more alike than vegetation communities on sandstone-derived soils (Table 59). Vegetation communities on the shale-derived soils had a higher capture rate, and a more diverse assemblage including many threatened species such as Large-footed Myotis (*Myotis adversus*). The ANOSIM of the ultrasound recording data did not reveal any significant differences between vegetation communities, and hence the results have not been presented here.

Table 59 Bat assemblages—differences in mapped vegetation communities (ANOSIM analysis)

Vegetation community	Alluvial Woodland	Castlereagh Ironbark Forest	Eastern Gully Forest	Moist Shale Woodland	Shale Hills Woodland	Shale Plains Woodland	Sandstone Ridgetop Woodland	Shale/Sandstone Transition Forest (high)	Upper Georges River Sandstone Woodland
Alluvial Woodland	–	–	–	–	–	–	–	–	–
Castlereagh Ironbark Forest	-0.13	–	–	–	–	–	–	–	–
Eastern Gully Forest	0.24	0.73*	–	–	–	–	–	–	–
Moist Shale Woodland	0.33	0.92	0.68**	–	–	–	–	–	–
Shale Hills Woodland	0.26	0.67	0.13	0.35	–	–	–	–	–
Shale Plains Woodland	0.02	0.52	0.40*	-0.15	0.23	–	–	–	–
Sandstone Ridgetop Woodland	0.013	0.36	0.07	0.52*	-0.01	0.18	–	–	–
Shale/Sandstone Transition Forest (high sandstone influence)	0.08	0.31	0.1	0.48*	0.06	0.16	-0.12	–	–
Upper Georges River Sandstone Woodland	0.26	0.80*	-0.01	0.56*	-0.14	0.28*	-0.07	-0.24	–
Western Gully Forest	0.24	0.64	-0.11	0.63*	-0.06	0.22*	-0.08	-0.09	-0.06

Global R = 0.16 (P<0.05), Only vegetation communities with > 2 replicates were included in this analysis.

Values given are the R Statistic for each matched pair, and the significance of each pairing (*<0.05;

<0.01; *<0.001).

ii) Diversity and Richness

The results set out in tables 60 and 61 show that species diversity and richness of bat assemblages is greater in vegetation on shale-derived soils than vegetation on

sandstone-derived soils. This is an important finding of this study (see Figure 29). It shows that not only is the bat assemblage of the Cumberland Plain different to that of the Woronora Plateau, but that it is also richer and more diverse despite the high level of fragmentation and disturbance. Given the large number of threatened bat species that are known to exist on the Cumberland Plain, this result is of even greater significance.

Table 60 Bat species (ultrasound)—relative species diversity and species richness

Vegetation community ¹	No. of sites	Richness (average no. of spp./site)	Diversity (Shannon–Wiener Index)	Defining species (SIMPER)
Moist Shale Woodland	4	3.00	0.92	Assemblage not defined—includes Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>).
Upper Georges River Sandstone Woodland	2	2.50	0.90	Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>), Little Forest Bat (<i>Vespadelus vulturnus</i>) and Large Footed Myotis (<i>Myotis adversus</i>).
Shale Hills Woodland	5	2.40	0.74	Large-footed Myotis (<i>Myotis adversus</i>), Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>) and Little Forest Bat (<i>Vespadelus vulturnus</i>).
Shale Plains Woodland	8	2.25	0.65	Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>) and Chocolate Wattled Bat (<i>Chalinolobus morio</i>).
Shale–Gravel Transition	1	2.00	0.69	Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>) and Little Forest Bat (<i>Vespadelus vulturnus</i>).
Shale/Sandstone Transition Forest (high sandstone influence)	4	2.00	0.72	Little Forest Bat (<i>Vespadelus vulturnus</i>) and Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>).
Alluvial Woodland	2	1.50	0.35	Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>) and Lesser Long-eared Bat (<i>N. geoffroyi</i>).
Riparian Forest	1	1.00	0.00	Assemblage not defined—includes Gould's Wattled Bat (<i>Chalinolobus gouldii</i>).
Riparian Scrub	2	1.00	0.35	Gould's Wattled Bat (<i>Chalinolobus gouldii</i>), and Mormopterus sp 1.
Shale/Sandstone Transition Forest (low sandstone influence)	1	1.00	0.00	Preliminary data—less than 4 samples.
Eastern Gully Forest	11	0.55	0.13	Assemblage not defined—includes Little Forest Bat (<i>Vespadelus vulturnus</i>).
Western Gully Forest	6	0.50	0.12	Assemblage not defined—includes Large-footed Myotis (<i>Myotis adversus</i>).
Sandstone Ridgetop Woodland	3	0.33	0.00	Assemblage not defined—includes Little Forest Bat (<i>Vespadelus vulturnus</i>) and Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>).
Castlereagh Ironbark Forest	2	0.00	0.00	Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>) and Little Forest Bat (<i>Vespadelus vulturnus</i>).

1. Vegetation communities are ranked in terms of their species richness (except for those communities that only have preliminary data).

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FIGURE 29**

Figure 29 Bat diversity in the Georges River catchment

Table 61 Bat species (harp trap)—relative species diversity and species richness

Vegetation community ¹	No. of sites	Richness (average no. of spp./site)	Diversity (Shannon–Wiener Index)	Defining species (SIMPER)
Shale–Gravel Transition	1	2.00	0.64	Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>) and Little Forest Bat (<i>Vespadelus vulturnus</i>).
Shale Plains Woodland	5	2.00	0.48	Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>) and Chocolate Wattled Bat (<i>Chalinolobus morio</i>).
Alluvial Woodland	2	1.50	0.37	Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>) and Lesser Long-eared Bat (<i>N. geoffroyi</i>).
Castlereagh Ironbark Forest	2	1.50	0.19	Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>) and Little Forest Bat (<i>Vespadelus vulturnus</i>).
Sandstone/Shale Transition Forest (high sandstone influence)	5	1.40	0.28	Little Forest Bat (<i>Vespadelus vulturnus</i>) and Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>).
Moist Shale Woodland	3	1.33	0.14	Assemblage not defined—includes Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>).
Eastern Gully Forest	9	1.11	0.08	Assemblage not defined—includes Little Forest Bat (<i>Vespadelus vulturnus</i>).
Sandstone Ridgetop Woodland	5	0.60	0.00	Assemblage not defined—includes Little Forest Bat (<i>Vespadelus vulturnus</i>) and Gould's Long-eared Bat (<i>Nyctophilus gouldi</i>).
Upper Georges River Sandstone Woodland	5	0.60	0.14	Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>), Little Forest Bat (<i>Vespadelus vulturnus</i>) and Large Footed Myotis (<i>Myotis adversus</i>)
Shale Hills Woodland	7	0.57	0.10	Large-footed Myotis (<i>Myotis adversus</i>), Lesser Long-eared Bat (<i>Nyctophilus geoffroyi</i>) and Little Forest Bat (<i>Vespadelus vulturnus</i>).
Western Gully Forest	5	0.20	0.00	Assemblage not defined—includes Large-footed Myotis (<i>Myotis adversus</i>).
Riparian Scrub	1	0.00	0.00	Gould's Wattled Bat (<i>Chalinolobus gouldii</i>), and Mormopterus sp 1
Shale/Sandstone Transition Forest (low sandstone influence)	1	0.00	0.00	Preliminary data—less than 4 samples.

1. Vegetation communities are ranked in terms of their species richness (except for those communities that only have preliminary data).

4.3.2 Frog assemblages

i) Assemblages

Frogs are similar to reptiles in that they are relatively immobile and can often be tied closely to the microhabitat in which they have been recorded. Although frog assemblages are influenced by vegetation, they are more highly constrained by the types of water bodies available to them. All species of frog have a preferred type of water body in which to live and breed. Some species will only breed in ephemeral pools, some in flowing streams and others in swamps. However, different types of water bodies are related to geology and topography and hence are correlated with vegetation types. Thereby we get an indirect association of frog assemblages with vegetation communities.

In the Georges River catchment there were found to be few differences between the mapped vegetation types in terms of their frog assemblages. The only significant difference in the ANOSIM was between Eastern Gully Forest and Sandstone Ridgetop Woodland, and hence the results matrix has not been presented. The reason that relatively few significant differences were found can be related to the indirect association that most frogs have with vegetation. Many vegetation communities will support a range of water bodies, and therefore a range of frog species. The differences that we do see are because Sandstone Ridgetop Woodland does not contain running streams, and Eastern Gully Forest does not contain many swamps or standing water.

Sandstone Ridgetop Woodland was defined by the presence of the Smooth Toadlet (*Uperoleia laevigata*), Common Eastern Froglet (*Crinia signifera*), Peron's Tree Frog (*Litoria peronii*) and Reed Frog (*L. fallax*) (Table 62). Aside from the Common Eastern Froglet, which is a generalist, these are all species that prefer to breed in still pools or dams. Meanwhile, Eastern Gully Forest had a frog community that was typified by Leaf Green Tree Frog (*L. phyllochroa*) and Common Eastern Froglet (*C. signifera*). The Leaf Green Tree Frog is a species that is only found in association with running water.

ii) Diversity and Richness

There is little information about frog diversity by vegetation community. It is apparent that Sandstone Ridgetop Woodland has a high level of richness and diversity, with an average of five species per site (Table 62). This is a reflection, once again, of the types of water bodies surveyed in this community. Swamps and dams support much more diverse assemblages of frogs than do stream environments such as those found in Eastern Gully Forest, which had an average species richness of three species per site.

Table 62 Frog species—relative species diversity and species richness

Vegetation community ¹	No. of sites	Richness (average no. of spp./site)	Diversity (Shannon–Wiener Index)	Defining species (SIMPER)
Sandstone Ridgetop Woodland	4	4.75	1.10	Smooth Toadlet (<i>Uperoleia laevis</i>), Common Eastern Froglet (<i>Crinia signifera</i>), Peron's Tree Frog (<i>Litoria peronii</i>).
Sedgeland Heath Complex	2	3.50	1.00	Assemblage not defined—includes Freycinet's Frog (<i>Litoria freycineti</i>) and Eastern Banjo Frog (<i>Limnodynastes dumerilii</i>).
Shale Plains Woodland	2	3.00	0.82	Assemblage not defined—includes Smooth Toadlet (<i>Uperoleia laevis</i>), Verreaux's Tree Frog (<i>Litoria verreauxii</i>), Peron's Tree Frog (<i>L. peronii</i>) and Common Eastern Froglet (<i>Crinia signifera</i>).
Eastern Gully Forest	7	2.63	0.63	Common Eastern Froglet (<i>C. signifera</i>), Leaf Green Tree Frog (<i>L. phyllochroa</i>).
Western Gully Forest	4	2.50	0.65	Assemblage not defined—includes Common Eastern Froglet (<i>Crinia signifera</i>), Smooth Toadlet (<i>Uperoleia laevis</i>), Red-crowned Toadlet (<i>Pseudophryne australis</i>), Eastern Dwarf Tree Frog (<i>Litoria fallax</i>), Broad-palmed Rocket Frog (<i>L. latopalmata</i>), Peron's Tree Frog (<i>L. peronii</i>) and Leaf Green Tree Frog (<i>L. phyllochroa</i>).
Upper Georges River Sandstone Woodland	2	1.50	0.19	Assemblage not defined—includes Common Eastern Froglet (<i>Crinia signifera</i>) and Laughing Tree Frog (<i>Litoria tyleri</i>).
Riparian Forest	1	1.00	0.00	Preliminary data only—less than 4 samples—includes Peron's Tree Frog (<i>L. peronii</i>).
Moist Shale Woodland	1	6.00	1.68	Preliminary data only—less than 4 samples—includes Common Eastern Froglet (<i>Crinia signifera</i>), Spotted Grass Frog (<i>Limnodynastes tasmaniensis</i>), Eastern Dwarf Tree Frog (<i>Litoria fallax</i>), Peron's Tree Frog (<i>L. peronii</i>), Verreaux's Tree Frog (<i>L. verreauxii</i>) and Smooth Toadlet (<i>Uperoleia laevis</i>).
Freshwater Wetland	1	4.00	0.98	Preliminary data only—less than 4 samples.
Castlereagh Scribbly Gum Woodland	1	2.00	0.23	Preliminary data only—less than 4 samples—includes Common Eastern Froglet (<i>Crinia signifera</i>) and Bleating Tree Frog (<i>Litoria dentata</i>).
Shale/Sandstone Transition Forest (high sandstone influence)	1	1.00	0.00	Preliminary data only—less than 4 samples—includes Common Eastern Froglet (<i>Crinia signifera</i>).

1. Vegetation communities are ranked in terms of their species richness (except for those communities that only have preliminary data).

4.4 Species diversity—flora

Seven species of flora were selected to represent the threatened flora of the Georges River catchment during survey work, and to be subjected to predictive modelling processes with a view to improved habitat identification and management. These species were:

- *Pimelea spicata*
- *Persoonia nutans*
- *Pultenaea parviflora*.
- *Pterostylis saxicola*
- *Pterostylis gibbosa* (*no detailed model*)
- *Cynanchum elegans*
- *Gyrostemon thesioides*

Predictive modelling for the selected flora species, including the detailed habitat models developed for six of the species, indicate that there is potential habitat for all seven species within the Georges River catchment.

There are no known records of these species in some of the areas identified by the modelling process as potential habitat, therefore the potential habitat maps should be used as a guide for targeted species surveys. This is particularly important whenever potentially destructive processes (e.g. clearing, grazing or any new development) is proposed within these areas.

4.5 Conservation assessment

The primary objective of a conservation assessment is to identify land which achieves defined biodiversity objectives and to provide advice on appropriate management of this land. The conservation assessment undertaken for the Georges River catchment consists of the following five steps:

1. **Identifying biodiversity aims and objectives.** The aims and objectives reflect the intent of the *Greater Metropolitan Regional Environmental Plan No. 2—Georges River Catchment* (the REP) for the protection and management of biodiversity values within the study area (see Section 4.5.1).
2. **Identifying biodiversity indicator features to define the objectives.** Information is required that will enable the objectives for the study area to be defined. The objectives can be defined by a group of biodiversity indicator features, such as vegetation communities and modelled fauna and flora habitat within the study area (see Section 4.5.2).
3. **Developing land management classes.** These are required in order to define management outcomes for land within the study area. For instance, areas of the highest conservation value will require specific management outcomes which differ from areas of lower value. A hierarchy of four land management classes—Core Areas, Support Areas, Enhancement Areas and Other Land—was developed for the study area. These land management classes are referred to as regional management areas (RMAs) (see Section 4.5.3).

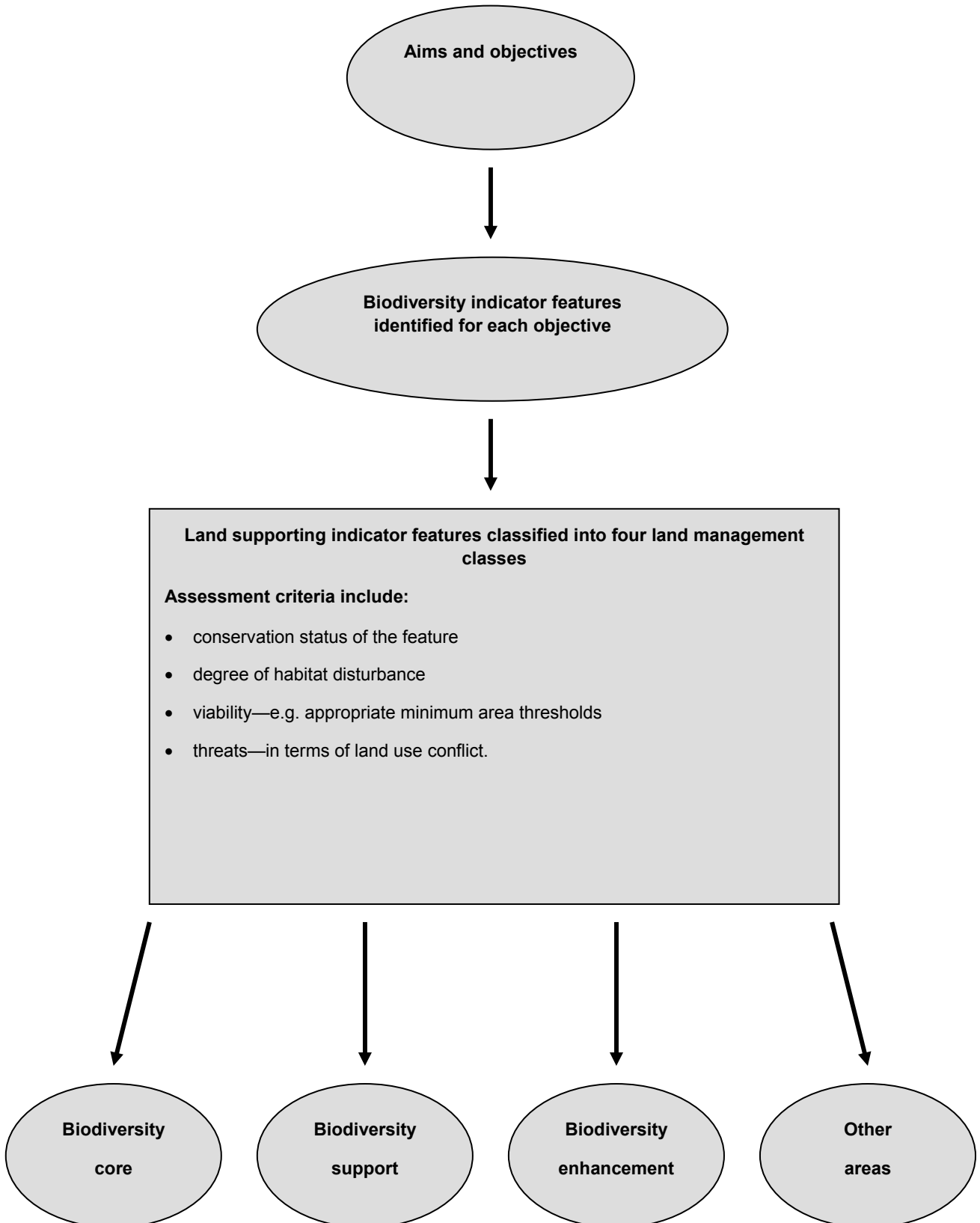
4. Classifying land containing features into land management classes.

Land containing biodiversity indicator features is then assessed against criteria to determine if it warrants inclusion within a land management class. The criteria used include the conservation status of the indicator features present, the condition and viability of the habitat, and known threats. These criteria were then applied to the specific indicator biodiversity features identified for the catchment and the land was then assigned to one of the four land management classes (see Section 4.5.4).

5. Developing an implementation framework. Assigning land to a land management class will not automatically ensure its appropriate management. A strategy for achieving these management outcomes must be prepared. In this case, a base framework has already been established for management of natural resources in the catchment—Sharing the Georges River Catchment. The framework consists of statutory planning provisions in the REP and actions by government agencies outlined in the strategy. Section 4.5.5 of this report also provides recommendations on measures to prioritise and report on initiatives to achieve appropriate management on the identified land.

Figure 30 illustrates the process adopted to identify appropriate land management classes for the management of biodiversity features. Sections 4.5.1—4.5.5 provide detail about the application of this process in the Georges River catchment.

Figure 30 Conservation assessment methodology



4.5.1 Identification of a biodiversity goal

The conservation assessment was based on the consideration of biodiversity aims and objectives for the Georges River catchment. The aims and objectives were developed by DIPNR in consultation with the Georges River Catchment Section 22 Committee and are consistent with the aims of the REP. These aims and objectives are set out in Table 63.

Table 63 Aims and objectives for biodiversity management in the Georges River catchment

Aims:	<p>To ensure that the natural environment is sustained for current and future generations by ensuring that ecological processes and biodiversity are conserved.</p> <p>To ensure that the management of natural values of the catchment is effective by ensuring that the planning process:</p> <ul style="list-style-type: none"> • focuses effort on the protection of ecological processes and ecosystems • identifies and protects sensitive natural areas.
Objectives	
1	<p>With respect to endangered and regionally significant ecological communities,¹ to:</p> <ul style="list-style-type: none"> • maintain high-quality remnants and essential ecological processes • improve the quality and integrity of protected remnants • restore areas of lower quality habitat wherever possible • reduce the impacts of processes known to threaten these communities.
2	<p>With respect to threatened and regionally significant species and populations,² to:</p> <ul style="list-style-type: none"> • maintain existing populations and known habitats • improve the quality of habitat for these species • restore areas of lower quality habitat so as to increase habitat opportunities for these species wherever possible • reduce the impacts of processes known to threaten these species.
3	<p>With respect to species and communities which are currently common or widespread, to:</p> <ul style="list-style-type: none"> • ensure that these species/communities remain common or widespread • maintain areas of high-quality habitat and habitat linkages for these species and communities • ensure that these species and communities are adequately represented in the reserve system.
4	<p>Maintain and enhance habitat linkages to ensure the viability of significant habitats, and to maintain ecological processes throughout the catchment.</p>
5	<p>Maintain and protect sensitive natural areas, and their ecological functions and processes, including through protection of key habitat types or areas:</p> <ul style="list-style-type: none"> • wetlands—including freshwater wetlands, upland swamps, mangroves and salt marsh • riparian lands—including floodplains • undisturbed catchments—for example, the relatively undisturbed catchments of the upper Woronora, O'Hares Creek and other subcatchments of the Holsworthy Military Area.

1. Endangered and regionally significant communities were defined in this assessment as communities listed as Endangered Ecological Communities under the TSC Act, or communities classified as Critically Endangered or Endangered in Table 66.

2. Threatened species and populations were defined in this assessment as species and populations listed under the TSC Act. Regionally significant species were not classified in this assessment.

4.5.2 Identification of indicator features

Once the aims and objectives were defined, the assessment then focused on developing information to enable them to be considered. Given the complexity of biological systems, it is impossible to define objectives in terms of the total biodiversity present. Selected features are therefore required to act as indicators of the achievement of an objective. These features act as surrogates for the complexity of the total biodiversity referred to in an objective, and so must be carefully selected to represent the range of this diversity.

The features used to define the biodiversity objectives are identified in Table 64.

As an example of this approach, Objective 3 refers to the maintenance of high-quality habitat of common and widespread species. Information is not available on all of these species' habitats and so particular species were selected to represent the diversity of species present. This was done by first identifying the broad ecological assemblages within the catchment, namely the shale, sandstone, freshwater wetland and estuarine assemblages. Indicator species were then selected for these assemblages. In the shale ecological assemblage, the indicator feature was a group of woodland foraging birds considered to be of conservation concern. In the sandstone ecological assemblage, the features selected were a group of species known to require large home ranges or to be wide ranging. Management actions for these indicator species will provide benefits for other non-targeted species. For instance, the protection of habitat for wide-ranging species will benefit other sandstone-based species with more localised habitat requirements, such as the Red-crowned Toadlet, Rock Warbler and forest bats.

As noted in Table 64, some objectives are defined and assessed in *Aquatic biodiversity of the Georges River catchment* and are not included here.

Table 64 Objective-based biodiversity indicator features

Objective	Features used to address the objective
<p>1. Endangered & regionally significant communities</p>	<p>These communities predominantly occur on the shale landforms. This objective was addressed by identifying:</p> <ul style="list-style-type: none"> • core and support remnants of a size and condition considered capable of supporting ecological processes • small and disturbed remnants of Critically Endangered communities.
<p>2. Endangered & regionally significant species</p>	<p>Data is currently available for defining land significant for the following endangered and regionally significant species:</p> <ul style="list-style-type: none"> • the Koala—the Georges River Koala population is of state significance • a group of species known to require large areas of relatively unfragmented habitat. These species are the Powerful Owl, Sooty Owl, Heath Goanna and Tiger Quoll. (The Koala is also within this group however is already included above as a separate indicator feature.)
<p>3. Common species & communities</p>	<p>Four broad ecological assemblages of fauna and flora were identified for the catchment. The diversity of species within each assemblage was represented by the following Indicator species or groups of species:</p> <ul style="list-style-type: none"> • shale ecological assemblage: represented by a group of Cumberland Plain Woodland birds. Habitat for these and other common shale species is identified in Inclusion Criteria C1 and S1 (see Table 65). • sandstone ecological assemblage: represented by a group of species known to require large areas of habitat or that are vulnerable to habitat fragmentation. These species are the Powerful Owl, Sooty Owl, Heath Goanna, Tiger Quoll and Koala. Habitat for these and other common sandstone species is identified in Inclusion Criteria C3, S2 and S3 (see Table 65). • Freshwater Wetland assemblage: all habitat of the Freshwater Wetland community is identified in Inclusion Criteria C4. • Estuarine ecological assemblage: habitat for this assemblage was identified through the Aquatic Biodiversity Study and not included in this Section.
<p>4. Habitat linkages</p>	<p>Habitat linkages and Enhancement Areas were defined on the shale landforms by identifying corridors between areas of core or support habitat. Specific habitat corridors are identified in Section D5e of this report.</p>
<p>5. Sensitive natural areas</p>	<ul style="list-style-type: none"> • Wetlands—The objective was defined by identifying all Freshwater Wetland habitat and all Upland Swamp (Sedgeland) habitat. Saltmarsh and mangrove communities were assessed in the aquatic biodiversity assessment and not included in this section. • Undisturbed Catchments—This objective was defined by identifying all undisturbed catchments or catchments of minimal disturbance within the study area. • Riparian Lands—The assessment of riparian lands has been included in a separate section from the biodiversity assessment.

4.5.3 Development of land management classes

In order to provide a land use basis for the management of biodiversity values, a framework of land management classes termed regional management areas (RMAs) were defined. Three RMAs have been developed, with other lands that can be managed through generic activity-based development controls. A description of the three RMAs and the fourth class for other lands, and the objectives for management of biodiversity values in them, are listed in Table 65.

Table 65 Land management classes

Land management class	Description	Management objective
1. Biodiversity Core Area	These are the areas of highest conservation value. They represent areas where species or communities are at imminent risk of extinction, or areas within the region that constitute the backbone of a viable conservation network across the landscape.	<ul style="list-style-type: none"> • To ensure that the identified lands are managed principally for the purpose of biodiversity protection. This includes secure protection provisions and active management for biodiversity. • To ensure, as a first priority, that no development or activity, including public access, recreation and land management activities, result in adverse impacts or loss of habitat within the identified area (i.e. a decline in the area, condition or conservation status of the habitat). Impacts or losses of habitat should only be permitted in exceptional circumstances.
2. Biodiversity Support Area	<p>These are areas within the region that provide a range of support values to the Critically Endangered and Core habitat, including increasing the size of and buffering these areas.</p> <p>The focus is to identify priority areas for restoration work in order to enhance the ecological functions and contribution of the areas to the conservation of biodiversity values in the region.</p>	<ul style="list-style-type: none"> • To rehabilitate the identified habitat to a condition suitable for inclusion in a Core Area. • To ensure that the identified lands are managed principally for the purpose of biodiversity protection. This includes secure protection provisions and active management for biodiversity. • To ensure, as a first priority, that no development or activity results in an adverse impacts or loss of habitat within the identified area (i.e. a decline in the area, condition or conservation status of the habitat). Impacts or losses of identified habitat should only be permitted in exceptional circumstances.
3. Biodiversity Enhancement Area	<p>These are areas within the region (including cleared land) that have strategic values, particularly for the potential provision of intra- and interregional linkages.</p> <p>The focus is to identify priority areas for restoration work in order to enhance the ecological functions and contribution of the areas to a conservation network in the region.</p>	<ul style="list-style-type: none"> • To rehabilitate the identified land in order to maintain and gradually increase the area and integrity of habitat. • To rehabilitate the identified land in order to facilitate linkages between Core and Support areas and to provide ecological buffers to these areas. • To ensure that existing vegetation within the identified land is maintained and protected wherever possible. Impacts or losses of identified habitat should only be permitted after a full consideration of measures to avoid or minimise impacts.

<p>4. Other Land</p>	<p>Areas of native vegetation that do not fall within above areas, but which are still of conservation significance. These areas may be of significance for currently unidentified features (e.g. threatened species), may be of local significance, or may have other values (e.g. aesthetic, recreational).</p>	<ul style="list-style-type: none"> To ensure that existing vegetation within the identified land is maintained and protected wherever possible. Impacts or losses of identified habitat should only be permitted after a full consideration of measures to avoid or minimise impacts.
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4.5.4 Classification of features into land management classes

Assessment criteria

The biodiversity indicator features were assessed based on a consideration of the following criteria in order to determine whether they warranted inclusion within a Core, Support, Enhancement or Other Land management class.

- 1. Conservation Status.** This was based on a consideration of the rarity of the species or community, the level of loss of habitat and the representation of the remaining habitat within reserves. The conservation status of vegetation communities is indicated in Table 66. Threatened species and populations were as listed under the TSC Act. A list of regionally significant fauna species for the catchment is provided in Appendix E.
- 2. Naturalness (degree of disturbance).** Six classes of vegetation condition were identified, based on the integrity of the canopy cover and size of the vegetation remnant (see Section 2, Table 5). For the purposes of this study, vegetation Classes A, B, C and S were defined as good condition vegetation and were preferentially selected for inclusion in management areas where warranted due to their relatively high habitat value. Classes Tx, Txu and Txr (i.e. scattered tree cover) were selected for inclusion in management areas where features of high conservation value were known to be present. These included buffers, linkages and habitat for Critically Endangered communities. In addition to Condition Class, which is based on canopy density, information on understorey condition was incorporated into the identification of Cumberland Plain bird habitat (refer to Appendix E).
- 3. Viability.** Factors affecting the viability of a vegetated area include the size and shape (area to boundary ratio) of the vegetated area, the presence of corridors linking vegetated areas and the presence of buffers to surrounding, threatening land uses. A consideration of viability is also interrelated to the issue of manageability. Many small remnants may only be viable in the long term if there is ongoing management of the vegetated area. Viability is therefore also dependent on the willingness of the community to pay for the management of small remnants.

Minimum area thresholds were defined in this study for some features, such as for Cumberland Plain Endangered Ecological Communities. In other instances, all vegetation of Classes A, B, C and S (minimum area of 0.5 ha) were considered viable, subject to ongoing management. Vegetation adjoining identified Core Areas was also selected in order to increase the viability of the Core Areas (see Table 66—Support for Core). This land provides opportunities to buffer Core Areas from surrounding threatening land uses and to maintain ecological functions by increasing the area of habitat available.
- 4. Threats.** The value of an area for biodiversity is affected by the range and intensity of continuing threats to the condition of the area. Threats include conflicts between different land management objectives for the land. To

address this issue, a zoning layer has been incorporated as a broad indicator of the current land management objectives for vegetated areas within the catchment. The zoning layer was prepared by information obtained from councils in 1999. This information was used for some features, notably those in the sandstone landform, habitat linkages and Critically Endangered communities, to identify land with the least land use conflict and with the greatest opportunity for sympathetic management.

It is recognised that management threats, including pest and weed species, inappropriate fire regimes, inappropriate recreational activity etc., are not included in the assessment, however may be addressed through the management provisions defined for the land management classes in the REP.

- 5. Diversity of species, habitat, communities.** The diversity of species and communities present within a site has not been assessed and the above four criteria were considered satisfactory for the purposes of this study. The fauna study has identified vegetation communities that display high species richness for certain fauna assemblages and this information is available in Section 3.4.

The use of these criteria is described in more detail in the sections below. It should be reiterated that these criteria have limitations, notably the scale of data collection, accuracy of models and clearing since the date of mapping (see Section 2).

Assigning features to land management classes

The land occupied by the biodiversity indicator features identified in Section 4.5.2 will have varying conservation value according to the conservation status of the feature; the condition and viability of the habitat; the diversity of habitat present; and threats to that habitat. For instance, the conservation value of an area containing a large patch of an Endangered community in good condition is greater than a patch of the same community of smaller size or in poorer condition. The area of higher conservation value warrants management in a land class commensurate with that value.

The next step in the assessment therefore is to assign the land occupied by biodiversity features to the various land management classes according to the conservation value of that land. This requires the development of criteria for inclusion of features into the four management classes. The purpose of the inclusion criteria is to match the conservation value of a unit of land with the management objectives of one of the land management classes.

As indicated in Figure 31, thirteen inclusion criteria were developed from the biodiversity features identified in Section 2.5.2. Each inclusion criterion contains a rule set defining when land occupied by a biodiversity feature should be included in Core, Support or Enhancement land classes.

Figure 31 illustrates the process by which inclusion criteria were derived from objectives and biodiversity indicator features. The inclusion criteria codes (e.g. C1) refer to the inclusion criteria summarised in Table 66 and described in Section 4.5.4.

Figure 31 Framework for developing inclusion criteria

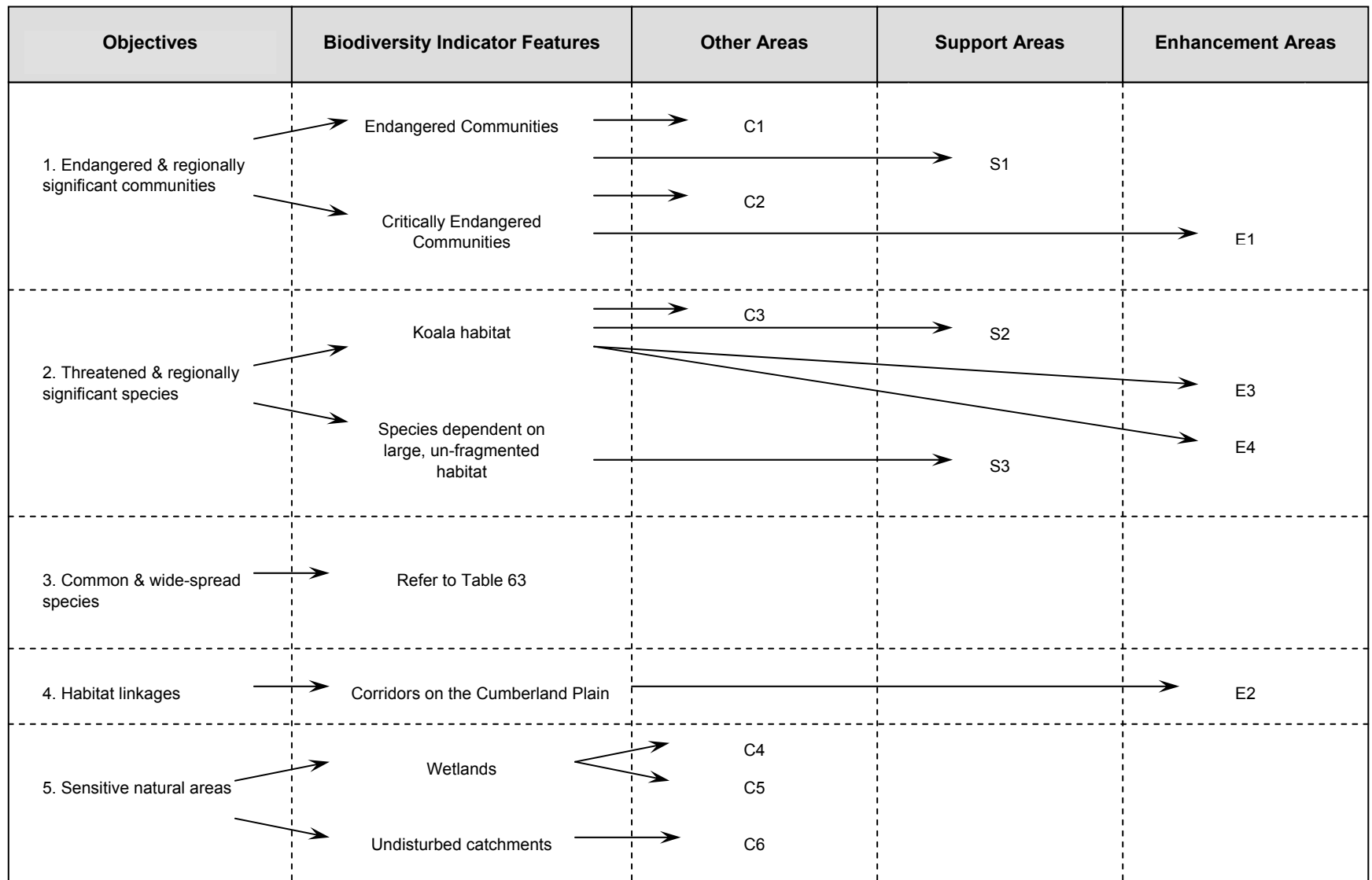


Table 66 Land management classes—inclusion criteria

RMA Class	Ref.	Inclusion criterion
Biodiversity Core	C1	• Core Cumberland Plain Endangered communities
	C2	• Critically Endangered communities (Subclass 1)
	C3	• High-quality Koala habitat
	C4	• Freshwater wetlands
	C5	• Upland swamps
	C6	• Undisturbed catchments
Biodiversity Support	S1	• Support for Core Cumberland Plain Endangered communities
	S2	• Medium-quality Koala habitat on the Woronora Plateau
	S3	• Species dependent on large, unfragmented habitat
Biodiversity Enhancement	E1	• Critically Endangered communities (Subclass 2)
	E2	• Cumberland Plain corridors
	E3	• Medium-quality Koala habitat in urban areas
	E4	• Cleared areas that adjoin high-quality Koala habitat
Other Land		• All other native vegetation within the GRC

Biodiversity Core Areas—inclusion criteria

C1	Core Cumberland Plain Endangered communities
Description	<p>An objective for the conservation assessment refers to the maintenance of high-quality remnants of Endangered and regionally significant communities. These communities are considered to consist of the Endangered Ecological Communities listed or preliminarily listed under the TSC Act (refer to Table 65). The methodology for classifying the communities into these conservation status classes is provided in Appendix H. It should be noted that the Endangered Ecological Community O'Hares Creek Shale Forest has not been included in the above communities because it is well represented in existing reserves and is classified as being of Least Concern in Table 67.</p> <p>The Endangered and regionally significant communities of the Georges River catchment principally occur in the Cumberland Plain landform in relatively small, often disturbed remnants. While ideally all remnants of these communities would be afforded the highest protection, it is recognised that the smaller, isolated remnants would not be viable without considerable management effort. This assessment has taken the approach of prioritising the conservation effort for Endangered and regionally significant communities to the larger, more viable remnants. Remnants above a certain size and in good condition are considered to have greater ecological value than small remnants and have been preferentially included in the Biodiversity Core land management class. It is recognised that the smaller remnants also have conservation value and should be fully considered in local initiatives and decisions.</p> <p>The remnants of highest ecological value were selected based on the known or likely value of these remnants to an assemblage of targeted native species. The species used for this purpose consisted of a group of native bird species referred to as shale birds, which have been used as biodiversity indicators. Many of these species are habitat specialists and have declined in numbers on the Cumberland Plain.</p> <p>Appendix H contains details of the methodology used relating to the maintenance of viable habitat for this group of species. In summary, these birds are considered to require bushland remnants of greater than 10 ha in size with good condition canopies in order to maintain viable populations. In remnants below this size there is a substantial loss of these species, which is indicative of an overall loss of biodiversity.</p> <p>Linkages between these remnants and opportunities to enhance these remnants are also considered essential for the maintenance of these bird species and the ecological communities they represent. These requirements have been addressed in inclusion criteria E2 and S1 respectively.</p>
Areas included in RMA Core	<p>Rule set: All contiguous A, B, C and S Class Cumberland Plain vegetation which is 10 ha or more in area.</p> <p>The term contiguous refers to a cluster of adjoining polygons that, as a group, satisfy the rule set.</p> <p>The term Cumberland Plain vegetation refers to communities associated with the Cumberland Plain landform as classified in Table 67.</p> <p>Areas that satisfy this rule set are mapped in Figure 32.</p>

Table 67 Conservation status of vegetation communities of the Georges River catchment

Status ¹	Vegetation communities		Landform ²
Critically Endangered Subclass 1	• Castlereagh Ironbark Forest	(EEC) ³	Cumb.
	• Cooks River Clay Plain Scrub Forest	(EEC)	Cumb.
	• Castlereagh Swamp Woodland	(EEC)	Cumb.
	• Western Sydney Dry Rainforest	(EEC)	Cumb.
	• Moist Shale Woodland	(Part of EEC)	Cumb.
	• Turpentine–Ironbark Forest	(Part of EEC)	Cumb.
	• Turpentine–Ironbark Margin Forest	(Part of EEC)	Cumb.
Critically Endangered Subclass 2	• Blue Gum High Forest	(EEC)	Cumb.
	• Shale Plains Woodland	(Part of EEC)	Cumb.
Endangered	• Alluvial Woodland	(Part of EEC)	Cumb.
	• Shale/Sandstone Transition Forest (Low Sandstone)	(Part of EEC)	Cumb.
Endangered	• Shale/Sandstone Transition Forest (High Sandstone)	(Part of EEC)	Cumb.
	• Shale Hills Woodland	(Part of EEC)	Cumb.
	• Riparian Forest	(Part of EEC)	Cumb.
	• Shale/Gravel Transition Forest	(Part of EEC)	Cumb.
	• Mangrove/Saltmarsh Complex		Estuarine
Vulnerable	• Castlereagh Scribbly Gum Woodland		Cumb.
Near Threatened	• Freshwater Wetland	(Part of EEC)	F.Wetland
	• Upper Georges River Sandstone Woodland		Wor.
	• Woodland Heath Complex		Wor.
Least Concern	• Sandstone Ridgetop Woodland		Wor.
	• Western Sandstone Gully Forest		Wor.
	• Riparian Scrub		Wor.
	• Eastern Sandstone Gully Forest		Wor.
	• Sedgeland Heath Complex		Wor.
	• O'Hares Creek Shale Forest	(EEC)	Wor.

1. The conservation status terms Critically Endangered Subclass 1, Critically Endangered Subclass 2, Endangered, Vulnerable, Near Threatened and Least Concern are as described in Appendix H.

2. The landform code Cumb. refers to communities associated with the Cumberland Plain. The code Wor. refers to communities associated with the Woronora Plateau; Estuarine refers to estuarine communities and F.Wetland refers to Freshwater Wetland community.

3. EEC refers to Endangered Ecological communities, or part of one of these communities, as listed under the TSC Act as at January 2002.

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FIGURE 32**

**Figure 32 Core Area criteria C1—core Cumberland Plain Endangered
communities**

C2	Critically Endangered communities (Subclass 1)
Description	<p>Some ecological communities have been affected to the extent that the risk of extinction is imminent. These communities are classed as Critically Endangered in Table 67, using the methodology provided in Appendix H, Subclass 1 identifies a subset of these Critically Endangered communities where there is less than 3 000 ha extant. It is considered that vegetation containing these communities warrants protection within the Core land management class.</p> <p>The high conservation status of the Critically Endangered communities warrants additional effort to retain and enhance all remnants of these communities wherever possible. This effort is particularly warranted where the land is in a land use, zoning or ownership that is sympathetic to protection of the vegetation, such as Environmental Protection, Open Space, Rural and Special Use zones. These areas are considered capable of enhancement and warrant specific management effort.</p> <p>This inclusion criterion selects all remnants of these communities in good condition (i.e. Condition Classes A, B, C and S) for inclusion in the Core Area. In addition, it selects some of the poor condition remnants (Classes Tx and Txr) of these communities if they are sympathetically zoned to support protection.</p> <p>The smaller and poor condition remnants in the urban environment (i.e. Condition Class Txu) have not been included in the Core Area. While enhancement of these areas would ideally be undertaken, the typically small lot size, multiple ownership and incompatible land use makes these areas unsuitable for inclusion in the Core Area. It is considered that these areas in the urban context are more appropriately managed through local planning and education initiatives.</p>
Areas included in RMA Core	<p>This inclusion criterion consists of the following two rule sets:</p> <ul style="list-style-type: none"> • All A, B, C and S Class vegetation of the Critically Endangered Subclass 1 communities. • All Tx and Txr Class vegetation of the Critically Endangered Subclass 1 communities where this vegetation is located on land zoned Environmental Protection, Open Space, Special Use or Rural. <p>Areas that satisfy these rule sets are indicated in Figure 33.</p>

C3	High-quality Koala habitat
Description	<p>In New South Wales the Koala occurs principally on the central and north coast ranges and adjacent slopes with a sparse and scattered distribution on the north-west plains and south coast (Reed <i>et al.</i> 1990). The Koala population of the Georges River catchment is one of the few populations surviving on the coast and ranges south of Sydney and probably one of the larger. Estimates of the size of this population range between 90 and 200 individuals, but it is thought this is an underestimate as the large area contained in the Holsworthy Military Area has not been thoroughly surveyed (Ward 2001). Small populations are also known from the Metropolitan Water Catchments, Morton NP and the far south coast forests in the Bega/Eden area.</p> <p>Recent studies by Steven Ward (Ward 2001) and Dr Rob Close (University of Western Sydney) have identified breeding colonies of Koalas in the Wedderburn and Kentlyn areas (western edge of the GRC). Koalas range throughout the catchment—from Sandy and Alford's points in the north, east to Heathcote and Royal National parks and south to Douglas Park (S.Ward pers.comm.). Recent investigations have shown this population to be genetically distinct from Koalas in the nearby Avon River catchment to the south (Dr Rob Close pers.comm.). Given the small number and size, and apparent decline (Reed <i>et al.</i> 1990), of Koala populations of the coast and ranges south of Sydney, the low density, relatively disease-free Koala population of the Georges River catchment (Close 1993) is considered of state conservation significance.</p>
Areas included in RMA Core	<p>Rule set: All high-quality Koala habitat (see Section 3.2.2) where this habitat is located on land zoned Environmental Protection, Open Space, Special Use or Rural zones. These zones are considered to provide a management boundary to the contiguous, high-quality vegetation of the Woronora Plateau.</p> <p>Habitat that satisfies this criterion is indicated in Figure 34.</p>

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Figure 33 Core Area criteria C2—Critically Endangered communities

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FIGURE 34**

Figure 34 Core Area criteria C3—high-quality Koala habitat

C4	Freshwater wetlands
Description	Freshwater Wetlands are listed as an Endangered Ecological Community under the TSC Act and provide a range of ecological functions in terms of habitat provision and water quality enhancement. Wetlands are also relatively uncommon within the catchment with 18 ha extant at only five locations.
Areas included in RMA Core	Rule set: All A, B, C and S Class vegetation identified as Freshwater Wetlands. The habitat that satisfies this criterion is indicated in Fig 35.

C5	Upland swamps
Description	Upland Swamps (mapped as Sedgeland) are not listed as an Endangered Ecological Community under the TSC Act and are considered to be of Least Concern in terms of its conservation status. Nonetheless, the community provides a range of ecological functions in terms of habitat provision and water quality enhancement that are critical to the condition of the catchment.
Areas included in RMA Core	Rule set: All A, B, C and S Class vegetation identified as Sedgeland. The habitat that satisfies this criterion is indicated in Fig 36.

C6	Undisturbed catchments
Description	<p>The undisturbed catchments of the Upper Georges River and Holsworthy Military Area provide a large area of natural habitat, which is contiguous with the extensive areas contained in the Metropolitan Water Catchments and the NPWS reserves of Heathcote National Park and Dharawal SRA. Together these lands provide a conservation resource of high significance in southern Sydney.</p> <p>The undisturbed catchments of the Upper Georges are very important for the conservation of flora and fauna, especially wide ranging fauna, sites of Aboriginal cultural heritage, undisturbed streams and the provision of clean water to the lower catchment. O'Hares and Stokes Creek in the upper catchment are listed in the Directory of Important Wetlands in Australia and are presently being assessed for eligibility for Ramsar listing.</p> <p>Keith (1994) noted the relatively undisturbed nature of the vegetation of the catchment and minimal weed invasion limited predominantly to the parts of the periphery of the catchment on the Bulli–Appin road.</p> <p>The area identified as the Undisturbed Catchment Area is important for threatened species inhabiting the Woronora Plateau such as the Giant Burrowing Frog (includes majority of modelled habitat), Red-crowned Toadlet (includes majority of modelled habitat), Broad-headed Snake (includes majority of modelled habitat, restricted access provides protection from illegal collection for this species), Fishing Bat (<i>Myotis adversus</i>) includes majority of modelled habitat), Koala (significant area of modelled habitat), Powerful Owl (includes majority of modelled habitat), Tiger Quoll (not modelled), and also the Heath Monitor (not modelled). It is also important for priority species such as the Rock Warbler (includes majority of modelled habitat) and a wide range of other non-threatened and regionally significant fauna e.g. Eastern Wallaroo and Platypus.</p> <p>The unimpounded streams within the Undisturbed Catchment Area are also important for many fish species, particularly those that migrate between freshwater and estuarine environments.</p> <p>A large proportion of catchments in the Sydney Basin have their catchments compromised by development or pollution making the relatively undisturbed catchment of the Upper Georges River very important.</p>
Areas included in RMA Core	Rule set: All undisturbed catchments of the Woronora Plateau, as identified by mapping catchments or portions of catchments with minimal vegetation clearing. Habitat identified within undisturbed catchments is indicated in Figure 37.

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Figure 35 Core Area criteria C4—Freshwater Wetlands

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Figure 36 Core Area criteria C5—Upland swamps

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Figure 37 Core Area criteria C6—Undisturbed catchments

Biodiversity Support Areas—inclusion criteria

S1	Support for Core Cumberland Plain Endangered communities
Description	This inclusion criterion refers to remnants of vegetation which, as a group, are contiguous with the Core Areas identified by inclusion criteria C1 and C2. These areas adjoin the Core Areas and provide a support function to these areas by providing an ecological buffer. The Support Areas also provide a strategic opportunity for rehabilitation to high-quality habitat and so to enable an increase in area and rehabilitation of the Endangered Ecological Communities of the Cumberland Plain.
Areas included in RMA Support	<p>Rule set: All A, B, C, S, Tx and Txr Class Cumberland Plain vegetation which, as a group, is contiguous with, but not within, the Core Areas identified in the inclusion criteria C1 and C2.</p> <p>The term Cumberland Plain vegetation refers to communities associated with the Cumberland Plain landform as classified in Table 65.</p> <p>The term contiguous refers to a cluster of adjoining polygons that, as a group, satisfy the rule set.</p> <p>Areas that satisfy these rule sets are indicated in Figure 38.</p>

S2	Medium-quality Koala habitat on the Woronora Plateau
Description	<p>Medium-quality Koala habitat consists of two forms of habitat:</p> <ul style="list-style-type: none"> • Medium-quality A habitat, comprising of secondary preference communities (i.e. Eastern Gully Forest and Ridgetop Woodland) that is of high condition on the Woronora Plateau, and • Medium-quality B habitat, comprising of primary preference communities (Upper Georges River Sandstone Woodland, Shale/Sandstone Transition Forest and Western Gully Forest) in disturbed condition. <p>This inclusion criterion selects portions of the Medium-quality A Habitat. (Medium-quality B Habitat is addressed in inclusion criterion E3). As indicated in Section 3.3.2, the vegetation of secondary preference contains a number of Koala records and is likely to provide an important role for the movement or dispersal of Koalas, particularly non-breeding females and dispersing males (S.Ward pers.comm.). It is also noted that the value of these communities has not been fully assessed due to a lack of public access. The significance of the Georges River catchment Koala population and the likely value of this medium-quality habitat is considered to warrant its protection in the Biodiversity Support land management class.</p>
Areas included in RMA Support	<p>Rule set: All medium-quality Koala A habitat that is located on land zoned Environmental Protection, Open Space, Special Use or Rural zones. These zones provide a management boundary to the contiguous vegetation of high condition on the Woronora Plateau.</p> <p>Habitat that satisfies this criterion is indicated in Figure 39.</p>

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**Figure 38 Support Area criteria S1—Support for Core Cumberland Plain
Endangered communities**

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**Figure 39 Support Area criteria S2—Medium-quality Koala habitat on the
Woronora Plateau**

S3	Species dependent on large, unfragmented habitat
Description	<p>Broad contiguous bands or near contiguous bands of vegetation which link catchments, such as the Nepean, Woronora and Cataract rivers, and subcatchments, e.g. Mill Creek, provide both important habitat and movement corridors for a wide array of species, particularly those that are wide ranging or have large home ranges or those that undertake seasonal or periodic migrations.</p> <p>In the Georges River catchment this would include threatened species such as the Koala; Tiger Quoll; Powerful, Sooty, Masked and Barking owls; Heath Monitor; and Grey-headed Flying Fox, and regionally significant species such as the Eastern Wallaroo, Swamp Wallaby and large numbers of microchiropteran bats and birds.</p> <p>In the south-eastern forests the Powerful Owl is reported to have a home range area of 800 to 1 000 ha and studies of the Sooty Owl in the Hacking and Woronora catchments found it foraged over an area of 3000 ha (Kavanagh & Jackson 1997).</p> <p>In respect to Koalas in the catchment, Ward (2001) has reported movements from Kentlyn to Alford's Point (19 km), Kentlyn to Heathcote NP (11 km) and Kentlyn to Douglas Park.</p> <p>Corridors often follow rivers and creeklines or ridgetops. As the landscape becomes more fragmented through urban and agricultural development these remaining corridors become increasingly valuable for the survival of species both inhabiting and moving through the region.</p> <p>Corridors are particularly important following events such as extensive bushfires that periodically occur in this landscape, providing routes for recolonisation for displaced fauna following the recovery of the vegetation.</p> <p>Apart from species requiring large areas of intact habitat for the maintenance of populations, another species, the Broad-headed Snake, warrants particular conservation effort as a species vulnerable to habitat fragmentation.</p> <p>The Broad-headed Snake is considered threatened at state and national levels. The species distribution is largely restricted to the sandstone geologies of the Sydney Basin. Habitat modelling undertaken by the NPWS for the Sydney Basin indicates that the Woronora Plateau, the Illawarra Escarpment and plateaux of the Metropolitan Water Catchments contain a significant portion of the predicted high-quality habitat for this species.</p> <p>Significant threats to the survival of the Broad-headed Snake include the removal of bushrock—the incidence of which is greatly increased by the presence of tracks and roads (Goldingay 1998)—and habitat loss due to urbanisation of ridgetops (Webb & Shine 1994), both of which contribute to fragmentation of the habitat reducing the species range (Cogger <i>et al.</i> 1993). Increased fragmentation also allows greater opportunity for illegal collection and arson, both of which have also been identified as significant threats to the species' survival (NPWS 1999).</p>
Areas included in RMA Support	<p>Rule set: All contiguous native vegetation of the Woronora Plateau where this habitat occurs on land zoned Environmental Protection, Open Space, Special Use or Rural zones. These zones provide a management boundary to the contiguous vegetation of high condition on the Woronora Plateau.</p> <p>Habitat that satisfies this criterion is indicated in Figure 40.</p>

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**Figure 40 Support Area criteria S3—Species dependent on large,
unfragmented habitat**

Biodiversity Enhancement Areas—inclusion criteria

E1	Critically Endangered communities (Subclass 2)
Description	<p>Critically Endangered Subclass 2 communities are Critically Endangered communities with greater than 3000 ha extant. Vegetation of these communities is considered to warrant different management approaches to the communities included in Critically Endangered Subclass 1. The reason for this is that the greater extant area of these communities enables greater opportunities and flexibility for achieving conservation outcomes. Management approaches can therefore be less prescriptive and may be complemented by local planning initiatives.</p> <p>The high conservation status of the Critically Endangered communities warrants additional effort to retain and enhance the poor condition remnants of these communities wherever possible. This effort is particularly warranted where the land is in a land use, zoning or ownership that is sympathetic to protection of the vegetation. These areas are considered capable of enhancement and warrant specific management effort.</p> <p>The poor condition remnants in the urban environment (i.e. Condition Class Txu) have not been included in the area identified for management effort. While enhancement of these areas would ideally be undertaken, the typically small lot size, multiple ownership and incompatible land use makes this area unsuitable for inclusion in an area identified for enhancement. It is considered that these areas in the urban context are more appropriately managed through local planning and education initiatives.</p> <p>This inclusion criterion selects all remnants of these communities in both good and poor condition (i.e. Condition Classes A, B, C, S, Tx, Txr) which are on land zoned Environment Protection, Open Space, Special Use, or Rural.</p>
Areas included in RMA Core	<p>Rule Set: All A, B, C, S, Tx and Txr Class vegetation of the Critically Endangered Subclass 2 communities where this vegetation is located on land zoned Environmental Protection, Open Space, Special Use or Rural.</p> <p>Areas that satisfy this Rule Set are indicated in Figure 41.</p>

E2	Cumberland Plain corridors
Description	<p>A corridor network was developed in order to identify areas of cleared land and vegetation where rehabilitation would have a strategic benefit in enhancing habitat linkages across the catchment. The purpose of the habitat linkages is to maintain biodiversity and ecological communities within the fragmented landscape of the Cumberland Plain.</p> <p>Land suitable for inclusion within corridors was identified by the use of a least-cost pathway analysis to identify the linkages of greatest ecological value. In this analysis, the least-cost paths were linkages between remnants of good condition (i.e. A, B, C or S Condition Classes) which included the least distance of either poor condition vegetation or cleared land.</p> <p>These least-cost paths were then assessed in conjunction with land use zoning information. Those areas deemed to have zoning sympathetic towards the establishment of habitat linkages (i.e. Environmental Protection, Open Space, Special Use or Rural zones) were identified for inclusion in the corridor network. In some instances, Urban zoned land was included if it was considered critical as a missing link in maintaining the functions of a corridor.</p> <p>There are also instances where sympathetically zoned land was included to create a linkage even though this land was not identified as a least-cost pathway. The reason for this is that these areas are considered to provide opportunities for rehabilitation (due to the zoning) which will provide regional ecological linkages. An example of this occurs in the Central Hills west of Campbelltown. Even though few remnants of native vegetation occur in the southern portion of the Central Hills (north of Narrellan Road), this area is zoned Environmental Protection and provides valuable opportunities of a regional corridor. The identification of this area enables the future establishment of a habitat corridor spanning from the Nepean River at Mount Annan in the south to Prospect Reservoir and Eastern Creek in the north (see Section 4.5.5 (c) Habitat Linkages).</p> <p>These identified lands therefore represent areas, which have strategic value for the provision of regional corridors. It is recognised that these corridors operate at a regional level and will require augmentation by local linkages in order to maximise their effectiveness. The <i>Draft Cumberland Plain Endangered Ecological Communities Recovery Plan</i>, the Green Web plan and other local planning initiatives are considered to provide this local level of habitat linkages which will complement the identified regional corridors.</p>
Areas included in RMA Core	The areas identified by the above methodology are indicated in Figure 42.

E3	Medium-quality Koala habitat in urban areas
Description	This is disturbed vegetation of a type that is of primary preference for Koalas, and still utilised by Koalas including breeding females (RobClose pers. comm.), and has the potential for enhancement as habitat to support the long-term viability of the population. Enhancement of these areas would include protection of existing feed trees and rehabilitation of understorey with recruitment of juvenile feed trees.
Areas included in RMA Core	<p>Rule set: All land containing the vegetation communities Upper Georges River Sandstone Woodland, Shale/Sandstone Transition Forest (high and low sandstone influence) and Western Gully Forest which is of Condition Classes Tx, Txr and Txu and is located on land zoned Rural, Special Uses or Environmental Protection zoning, and adjoins land identified as high-quality Koala habitat.</p> <p>Habitat that satisfies this criterion is indicated in Figure 43.</p>

E4	Cleared areas adjoining high-quality Koala habitat
Description	Rehabilitation of cleared land that adjoins areas of high-quality Koala habitat provides a strategic opportunity to extend the habitat of the Koala population in areas of known Koala activity. Cleared land at Wedderburn and Kentlyn is particularly important for this role. The high number of records in these areas is likely to represent the high nutrient food resource in these areas where the vegetation is particularly influenced by interbedding shale lenses. Given this preference, effort is warranted to increase the area of habitat in these highly utilised locations.
Areas included in RMA Core	<p>Rule set: All cleared land that:</p> <ul style="list-style-type: none"> • is zoned Rural, Special Uses or Environmental Protection zoning • is contiguous with vegetation mapped as High-quality Koala Habitat • is on land modelled to have contained (prior to clearing) the preferred vegetation communities for Koalas (i.e. Shale/Sandstone Transition Forest, Upper Georges River Sandstone Woodland and Western Gully Forest). <p>Habitat that satisfies this criterion is indicated in Figure 44.</p>

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FIGURE 41**

**Figure 41 Enhancement Area criteria E1—Disturbed habitat for Critically
Endangered communities**

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FIGURE 42**

Figure 42 Enhancement Area criteria E2—Shale ecosystem corridors

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FIGURE 43**

**Figure 43 Enhancement Area criteria E3—Medium-quality Koala habitat in
urban areas**

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FIGURE 44**

**Figure 44 Enhancement Area criteria E4—Cleared areas adjoining high-
quality Koala habitat**

Final compilation of land management classes

The analyses described above have resulted in the compilation of a series of mapped layers which represent areas that are significant for the biodiversity indicator features referred to in Section 4.5.2. Six of these mapped layers were based on inclusion criteria (see Table 66) warranting land being placed in the Core land management class. The final area of core habitats was derived by overlaying these six layers into a single layer and then excluding any area already reserved. Reserved land was defined as land within a NPWS reserve or Special Area managed by the Sydney Catchment Authority (including Prospect Reservoir).

The land included in the Biodiversity Core Area is identified in Figure 45.

In a similar manner, the three layers based on the inclusion criteria for Biodiversity Support were superimposed to form a single layer. Any land already identified as reserve or Biodiversity Core was then excluded from this layer. The final layer of Biodiversity Support land is identified in Figure 46.

Finally, the Biodiversity Enhancement layer was formed by superimposing the four selection criteria for this RMA and then excluding any land identified as reserve or as Core or Support Areas. The land derived for inclusion in the Biodiversity Enhancement is identified in Figure 47.

As indicated in Section 4.5.3 the land management classes derived in this assessment are referred to regional management areas (RMAs). The following RMAs have been identified:

- *RMA (Biodiversity Core)*
- *RMA (Biodiversity Support)*
- *RMA (Biodiversity Enhancement).*

The fourth land management class, termed Other Land is not referred to as a Regional Management Area.

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FIGURE 45**

Figure 45 Biodiversity Core RMAs in the Georges River catchment

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FIGURE 46**

Figure 46 Biodiversity Support RMAs in the Georges River catchment

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FIGURE 47**

**Figure 47 Biodiversity Enhancement RMAs in the Georges River
catchment**

4.5.5 Discussion

Vegetation communities

The data available from the study enables an assessment of the extent to which biodiversity indicator features are represented in the regional management areas. Tables 68 to 70 provide statistics on the area of vegetation extant within the various condition classes, and how much of this vegetation is within the current reserve system and within the regional management area network. Table 71 provides a summary of this information for good condition vegetation only (i.e. Condition Classes A, B, C and S).

As was expected, the extent of Endangered and Vulnerable communities within the catchment is low. In some cases, such as Turpentine–Ironbark Forest, only tens of hectares remain extant within the catchment. What is more, only a negligible amount of the extant vegetation of these communities is currently protected in reserves. Of the eighteen Endangered and Vulnerable communities, eleven are not represented at all within NPWS or Sydney Catchment Authority lands within the catchment. Another three have less than 10 ha formally protected.

The biodiversity objectives and selection criteria for the conservation assessment (Tables 64 and 66 respectively) specifically targeted Critically Endangered and Endangered communities for protection and management. As indicated in Table 70, the result of this selection process is that practically all the remaining patches of the above communities in good condition have been selected for inclusion within RMA (Biodiversity Core). Despite the high level of representation of this extant vegetation with RMA (Biodiversity Core), this still reflects less than 10% of the original extent of these communities (as indicated by the pre-1750 model in Figure 3) and so their conservation remains critical.

In addition to the eleven Critically Endangered or Endangered communities, two other communities were preferentially selected for inclusion in the RMA areas and so afforded a higher level of protection. For both these communities, Freshwater Wetlands and Sedgeland (Upland Swamp), all of the extant area was selected for inclusion in the RMA (Biodiversity Core Area). This was on the basis that these communities were identified in the study's biodiversity objectives as being of particular significance within the catchment for the maintenance of ecological functions, including water quality and flow regimes. Only 18.2 ha of Freshwater Wetland is extant within the catchment and so the protection of this community is of particular significance.

As a general comment, Table 70 indicates that a high proportion of all vegetation communities have been selected for inclusion in an RMA area. This reflects not only the conservation status of the Endangered and Vulnerable communities of the Cumberland Plain, but also the value of the Woronora Plateau as fauna habitat and as a large natural area capable of sustaining ecological processes. Many of the communities of least conservation concern in the sandstone landform were indirectly selected because of their significance for the above reasons. The maintenance of all vegetation on the Woronora Plateau in a state of high integrity and condition is particularly important for fauna species which are wide ranging or are vulnerable to habitat fragmentation. These species are indicated in Section 4.5.4.

Table 68 Extent of the vegetation communities pre-1750 and at present

Vegetation community	Status	Modelled area (ha)	Totals, top classes (ha)					Totals, Tx classes				Total, all classes	Proportion of pre-1750 modelled vegetation remaining (%)	
			A	B	C	S	All top classes	Tx	Txr	Txu	All Tx Classes		A+B+C+S Only	All Codes
1. Shale/Sandstone Transition Forest (LSI)	E	1595.3	145.6	42.3	0.0	0.0	187.8	187.2	0.0	276.2	463.4	651.3	11.8	40.8
2. Shale/Sandstone Transition Forest (HIS)	E	2267.1	535.9	11.7	0.0	26.6	574.2	113.5	64.4	575.2	753.1	1327.3	25.3	58.5
3. Castlereagh Ironbark Forest (incl 3a)	CE	5915.1	77.6	3.5	48.2	0.0	129.3	59.7	0.0	102.5	162.2	291.5	2.2	4.9
3a. Cooks River Clay Plain Scrub Forest	CE	#	6.5	1.6	12.5	0.0	20.6	22.6	0.0	21.3	43.9	64.5	#	#
4. Castlereagh Swamp Woodland	CE	#	18.4	0.0	14.3	0.0	32.7	1.5	0.0	0.0	1.5	34.2	#	#
6. Castlereagh Scribbly Gum Woodland	V	#	208.6	0.0	0.9	0.0	209.4	30.7	0.0	17.2	47.9	257.3	#	#
8. Agnes Banks Woodland	CE	375.0	0.0	0.0	0.0	8.0	8.0	0.0	0.0	0.0	0.0	8.0	2.1	2.1
9. Shale Hills Woodland	E	6853.4	557.2	96.0	0.0	0.0	653.2	437.8	39.3	427.3	904.3	1557.5	9.5	22.7
10. Shale Plains Woodland	CE	15651.5	741.2	216.2	0.0	0.0	957.4	829.9	94.0	761.2	1685.0	2642.4	6.1	16.9
11. Alluvial Woodland	CE	5080.0	225.0	18.2	216.3	0.0	459.5	218.8	8.5	22.1	249.4	708.8	9.0	14.0
12. Riparian Forest	E	453.1	91.8	1.7	0.0	0.0	93.5	12.4	0.0	0.0	12.4	105.9	20.6	23.4
13. Western Sydney Dry Rainforest	CE	48.4	2.1	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	2.1	4.3	4.3
14. Moist Shale Woodland	CE	126.0	50.1	1.7	0.0	0.0	51.8	15.2	0.0	0.0	15.2	67.0	41.1	53.1
15. Turpentine–Ironbark Forest	CE	928.9	1.2	0.0	0.0	0.0	1.2	6.3	0.0	34.4	40.7	41.9	0.1	4.5
31. Sandstone Ridgetop Woodland	LC	20537.3	104.0	0.0	0.0	15173.1	15277.2	3.6	13.7	0.0	17.4	15294.5	74.4	74.5
32. Upper Georges River Sandstone Woodland	NT	6250.3	1988.2	7.9	0.0	3524.4	5520.6	44.5	89.3	544.3	678.1	6198.7	88.3	99.2
33. Western Sandstone Gully Forest	LC	8565.3	482.7	0.0	0.0	7371.5	7854.1	27.4	0.0	55.6	83.0	7937.1	91.7	92.7
34. Mangrove/Saltmarsh Complex	E	492.1	0.0	0.0	73.8	246.7	320.5	0.0	0.0	0.0	0.0	320.5	65.1	65.1
35. Riparian Scrub	LC	1111.9	0.8	0.0	0.0	788.6	789.4	0.0	0.0	0.0	0.0	789.4	71.0	71.0
36. Freshwater Wetlands	NT	17.1	2.3	15.9	0.0	0.0	18.2	0.0	0.0	0.0	0.0	18.2	106.2	106.2
43. Turpentine–Ironbark Margin Forest	CE	1230.2	0.8	0.0	0.0	52.6	53.4	0.0	0.0	16.9	16.9	70.2	4.3	5.7
61. Eastern Gully Forest	LC	11445.8	0.0	0.0	0.0	9364.0	9364.0	0.0	0.0	0.0	0.0	9364.0	81.8	81.8
62. Woodland/Heath Complex (NE and central)	NT	2821.3	0.3	0.0	0.0	2154.9	2155.1	76.5	0.0	39.6	116.1	2271.2	76.4	80.5
63. O'Hares Creek Shale Forest	LC	158.8	0.0	0.0	0.0	153.0	153.0	0.0	0.0	0.0	0.0	153.0	96.3	96.3
64. Sedgeland Heath Complex	LC	#	0.0	0.0	0.0	1332.9	1332.9	0.0	0.0	0.0	0.0	1332.9	#	#
67. Vegetation of Volcanic Substrates		16.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
103. Shale/Gravel Transition Forest	E	#	395.8	41.2	0.0	48.6	485.5	121.1	0.0	55.2	176.3	661.8	#	#
152. Blue Gum High Forest	CE	30.8	0.0	0.0	0.0	1.5	1.5	0.0	0.0	0.0	0.0	1.5	4.8	4.8
9999. Unclassified Vegetation		#	0.1	0.0	63.4	0.0	63.5	31.6	0.0	9.7	41.3	104.7	#	#
Total Vegetation		91970.9	5636.2	457.9	429.4	40246.4	46769.6	2240.3	309.2	2958.7	5508.1	52277.4	892.4	1023

E—Endangered; CE—Critically Endangered; LC—Least Concern; NT—Not threatened; V—Vulnerable; # Not calculable.

Table 69 Extent of the vegetation communities within existing reserves

Vegetation community	Status	Totals (ha) within reserves			Proportion of extant vegetation within reserves (%)		Proportion of pre-1750 vegetation within reserves (%)	
		A + B + C + S	Tx + Txr + Txu	All Classes	A+B+C+S Only	All Classes	A+B+C+S Only	All Classes
1. Shale/Sandstone Transition Forest (Low Sandstone)	E	0.7	0.0	0.7	0.1	0.1	0.0	0.0
2. Shale/Sandstone Transition Forest (High Sandstone)	E	0.0	3.0	3.0	0.0	0.2	0.0	0.1
3. Castlereagh Ironbark Forest (including 3a)	CE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3a. Cooks River Clay Plain Scrub Forest	CE	0.0	0.0	0.0	0.0	0.0	#	#
4. Castlereagh Swamp Woodland	CE	0.0	0.0	0.0	0.0	0.0	#	#
6. Castlereagh Scribbly Gum Woodland	V	0.0	0.0	0.0	0.0	0.0	#	#
8. Agnes Banks Woodland	CE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9. Shale Hills Woodland	E	228.0	12.4	240.5	14.6	15.4	3.3	3.5
10. Shale Plains Woodland	CE	178.3	34.5	212.8	6.7	8.1	1.1	1.4
11. Alluvial Woodland	CE	26.5	0.2	26.7	3.7	3.8	0.5	0.5
12. Riparian Forest	E	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13. Western Sydney Dry Rainforest	CE	2.1	0.0	2.1	100.0	100.0	4.3	4.3
14. Moist Shale Woodland	CE	27.5	0.3	27.8	41.0	41.5	21.8	22.0
15. Turpentine–Ironbark Forest	CE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31. Sandstone Ridgetop Woodland	LC	8022.7	0.0	8022.7	52.5	52.5	39.1	39.1
32. Upper Georges River Sandstone Woodland	NT	83.7	2.1	85.8	1.3	1.4	1.3	1.4
33. Western Sandstone Gully Forest	LC	538.6	14.1	552.7	6.8	7.0	6.3	6.5
34. Mangrove/Saltmarsh Complex	E	82.4	0.0	82.4	25.7	25.7	16.7	16.7
35. Riparian Scrub	LC	238.4	0.0	238.4	30.2	30.2	21.4	21.4
36. Freshwater Wetlands	NT	6.3	0.0	6.3	34.8	34.8	37.0	37.0
43. Turpentine–Ironbark Margin Forest	CE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61. Eastern Gully Forest	LC	5724.4	0.0	5724.4	61.1	61.1	50.0	50.0
62. Woodland/Heath Complex (north-east and central)	NT	70.6	1.6	72.2	3.1	3.2	2.5	2.6
63. O'Hares Creek Shale Forest	LC	115.6	0.0	115.6	75.6	75.6	72.8	72.8
64. Sedgeland Heath Complex	LC	1104.8	0.0	1104.8	82.9	82.9	#	#
67. Vegetation of Volcanic Substrates		0.0	0.0	0.0	0.0	0.0	0.0	0.0
103. Shale/Gravel Transition Forest	E	0.0	0.0	0.0	0.0	0.0	#	#
152. Blue Gum High Forest	CE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9999. Unclassified Vegetation		4.1	5.8	9.9	3.9	9.5	#	#
Total vegetation		16454.7	74	16528.8	544	553	278.1	279.3

E—Endangered; CE—Critically Endangered; LC—Least Concern; NT—Not threatened; V—Vulnerable; # Not calculable.

Table 70 Extent of the vegetation communities within land management classes

Vegetation community	Status	Core Area Total (ha)			Support Area Total (ha)			Enhancement Area Total (ha)			Proportion (%)—Extant vegetation in reserves, Core & Support Areas		Proportion (%)—pre-1750 vegetation present within reserves, Core & Support Areas	
		A+B+C+S	Tx+Txr+Txu	All classes	A+B+C+S	Tx+Txr+ Txu	All classes	A+B+C+S	Tx+Txr+Txu	All classes	A+B+C+S	All classes	A+B+C+S	All classes
1. Shale/Sandstone Transition Forest (LSI)	E	165.8	0.0	165.8	8.0	97.0	105.0	1.9	78.1	80.0	92.9	41.7	10.9	17.0
2. Shale/Sandstone Transition Forest (HSI)	E	537.6	0.0	537.6	4.0	111.2	115.1	0.0	124.1	124.1	94.3	49.4	23.9	28.9
3. Castlereagh Ironbark Forest (including 3a)	CE	129.3	41.9	171.2	0.0	9.5	9.5	0.0	1.7	1.7	100.0	62.0	2.2	3.1
3a. Cooks River Clay Plain Scrub Forest	CE	20.6	13.5	34.1	0.0	6.7	6.7	0.0	0.0	0.0	100.0	63.2	#	#
4. Castlereagh Swamp Woodland	CE	32.7	1.5	34.2	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	#	#
6. Castlereagh Scribbly Gum Woodland	V	204.2	0.0	204.2	0.0	1.0	1.0	0.0	0.0	0.0	97.5	79.7	#	#
8. Agnes Banks Woodland	CE	8.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	2.1	2.1
9. Shale Hills Woodland	E	193.8	0.0	193.8	42.1	125.1	167.1	44.0	153.0	197.0	71.0	38.6	6.8	8.8
10. Shale Plains Woodland	CE	446.6	0.0	446.6	45.8	332.6	378.4	171.9	331.7	503.6	70.1	39.3	4.3	6.6
11. Alluvial Woodland	CE	223.1	0.0	223.1	35.6	62.6	98.2	126.8	130.1	256.9	62.1	49.1	5.6	6.8
12. Riparian Forest	E	89.7	0.0	89.7	2.2	5.8	8.0	0.0	0.0	0.0	98.2	92.2	20.3	21.5
13. Western Sydney Dry Rainforest	CE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	4.3	4.3
14. Moist Shale Woodland	CE	24.3	14.8	39.2	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	41.1	53.1
15. Turpentine–Ironbark Forest	CE	1.2	2.4	3.6	0.0	1.8	1.8	0.0	0.0	0.0	100.0	12.8	0.1	0.6
31. Sandstone Ridgetop Woodland	LC	6439.3	0.0	6439.3	467.6	0.6	468.2	0.0	0.0	0.0	97.7	97.6	72.7	72.7
32. Upper Georges River Sandstone Woodland	NT	5242.9	0.0	5242.9	0.0	11.4	11.4	3.5	360.7	364.2	96.5	86.1	85.2	85.4
33. Western Sandstone Gully Forest	LC	6842.7	0.0	6842.7	4.7	0.4	5.1	0.0	5.8	5.8	94.0	93.2	86.2	86.4
34. Mangrove/Saltmarsh Complex	E	0.0	0.0	0.0	12.0	0.0	12.0	1.2	0.0	1.2	29.4	29.4	19.2	19.2
35. Riparian Scrub	LC	518.3	0.0	518.3	10.6	0.0	10.6	0.0	0.0	0.0	97.2	97.2	69.0	69.0
36. Freshwater Wetlands	NT	11.8	0.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	106.2	106.2
43. Turpentine–Ironbark Margin Forest	CE	53.4	0.0	53.4	0.0	0.0	0.0	0.0	0.0	0.0	100.0	76.0	4.3	4.3
61. Eastern Gully Forest	LC	2941.1	0.0	2941.1	427.1	0.0	427.1	0.0	0.0	0.0	97.1	97.1	79.4	79.4
62. Woodland/Heath Complex (NE and central)	NT	2062.7	2.6	2065.3	0.0	1.6	1.6	0.0	0.0	0.0	99.0	94.2	75.6	75.8
63. O'Hares Creek Shale Forest	LC	2.8	0.0	2.8	4.6	0.0	4.6	0.0	0.0	0.0	80.4	80.4	77.4	77.4
64. Sedgeland Heath Complex	LC	225.9	0.0	225.9	0.0	0.0	0.0	0.0	0.0	0.0	99.8	99.8	#	#
67. Vegetation of Volcanic Substrates		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
103. Shale/Gravel Transition Forest	E	441.4	5.6	447.0	15.7	52.1	67.8	3.5	6.8	10.2	94.1	77.8	#	#
152. Blue Gum High Forest	CE	1.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	4.8	4.8
9999. Unclassified Vegetation		9.1	0.0	9.1	8.3	8.1	16.4	0.6	6.8	7.4	33.8	33.8	#	#
Total Vegetation		26869.8	82.3	26952.2	1088.3	827.5	1915.6	353.4	1198.8	1552.1	2505.1	2090.6	801.6	833.4

E—Endangered; CE—Critically Endangered; LC—Least Concern; NT—Not threatened; V—Vulnerable; # Not calculable.

Table 71 Vegetation protection summary table (A, B, C & S Class vegetation only)

Vegetation community (conservation status indicated in brackets) ¹	Pre-1750 modelled area (ha)	Extant		Protected in reserves			Area within RMA Biodiversity Areas (ha)			Area in reserve system, Core & Support Areas	
		Area (ha)	% of Pre- 1750	Area (ha)	% of Extant	% of Pre-1750	Core	Support	Enhancement	% of Extant	% of pre-1750
1. Shale/Sandstone Transition Forest (Low Sandstone) (E)	1595.3	187.8	11.8	0.7	0.1	0.0	165.8	8.0	1.9	92.9	10.9
2. Shale/Sandstone Transition Forest (High Sandstone) (E)	2267.1	574.2	25.3	0.0	0.0	0.0	537.6	4.0	0.0	94.3	23.9
3. Castlereagh Ironbark Forest (including 3a) (CE)	5915.1	129.3	2.2	0.0	0.0	0.0	129.3	0.0	0.0	100.0	2.2
3a. Cooks River Clay Plain Scrub Forest (CE)	#	20.6	#	0.0	0.0	#	20.6	0.0	0.0	100.0	#
4. Castlereagh Swamp Woodland (CE)	#	32.7	#	0.0	0.0	#	32.7	0.0	0.0	100.0	#
6. Castlereagh Scribbly Gum Woodland (V)	#	209.4	#	0.0	0.0	#	204.2	0.0	0.0	97.5	#
8. Agnes Banks Woodland (CE)	375.0	8.0	2.1	0.0	0.0	0.0	8.0	0.0	0.0	100.0	2.1
9. Shale Hills Woodland (E)	6853.4	653.2	9.5	228.0	14.6	3.3	193.8	42.1	44.0	71.0	6.8
10. Shale Plains Woodland (CE)	15651.5	957.4	6.1	178.3	6.7	1.1	446.6	45.8	171.9	70.1	4.3
11. Alluvial Woodland (CE)	5080.0	459.5	9.0	26.5	3.7	0.5	223.1	35.6	126.8	62.1	5.6
12. Riparian Forest (E)	453.1	93.5	20.6	0.0	0.0	0.0	89.7	2.2	0.0	98.2	20.3
13. Western Sydney Dry Rainforest (CE)	48.4	2.1	4.3	2.1	100.0	4.3	0.0	0.0	0.0	100.0	4.3
14. Moist Shale Woodland (CE)	126.0	51.8	41.1	27.5	41.0	21.8	24.3	0.0	0.0	100.0	41.1
15. Turpentine–Ironbark Forest (CE)	928.9	1.2	0.1	0.0	0.0	0.0	1.2	0.0	0.0	100.0	0.1
31. Sandstone Ridgetop Woodland (LC)	20537.3	15277.2	74.4	8022.7	52.5	39.1	6439.3	467.6	0.0	97.7	72.7
32. Upper Georges River Sandstone Woodland (NT)	6250.3	5520.6	88.3	83.7	1.3	1.3	5242.9	0.0	3.5	96.5	85.2
33. Western Sandstone Gully Forest (LC)	8565.3	7854.1	91.7	538.6	6.8	6.3	6842.7	4.7	0.0	94.0	86.2
34. Mangrove/Saltmarsh Complex (E)	492.1	320.5	65.1	82.4	25.7	16.7	0.0	12.0	1.2	29.4	19.2
35. Riparian Scrub (LC)	1111.9	789.4	71.0	238.4	30.2	21.4	518.3	10.6	0.0	97.2	69.0
36. Freshwater Wetlands (NT)	17.1	18.2	106.2	6.3	34.8	37.0	11.8	0.0	0.0	100.0	106.2
43. Turpentine–Ironbark Margin Forest (CE)	1230.2	53.4	4.3	0.0	0.0	0.0	53.4	0.0	0.0	100.0	4.3
61. Eastern Gully Forest (LC)	11445.8	9364.0	81.8	5724.4	61.1	50.0	2941.1	427.1	0.0	97.1	79.4
62. Woodland/Heath Complex (north-east and central) (NT)	2821.3	2155.1	76.4	70.6	3.1	2.5	2062.7	0.0	0.0	99.0	75.6
63. O'Hares Creek Shale Forest (LC)	158.8	153.0	96.3	115.6	75.6	72.8	2.8	4.6	0.0	80.4	77.4
64. Sedgeland Heath Complex (LC)	#	1332.9	#	1104.8	82.9	#	225.9	0.0	0.0	99.8	#
67. Vegetation of Volcanic Substrates	16.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
103. Shale/Gravel Transition Forest (E)	#	485.5	#	0.0	0.0	#	441.4	15.7	3.5	94.1	#
152. Blue Gum High Forest (CE)	30.8	1.5	4.8	0.0	0.0	0.0	1.5	0.0	0.0	100.0	4.8
9999. Unclassified Vegetation	#	63.5	#	4.1	3.9	#	9.1	8.3	0.6	33.8	#
Total Vegetation	91970.9	46769.6	892.4	16454.7	544	278.1	26869.8	1088.3	353.4	2505.1	801.6

E—Endangered; CE—Critically Endangered; LC—Least Concern; NT—Not threatened; V—Vulnerable. # Not calculable.

One vegetation community, Mangrove/Saltmarsh Complex, is relatively poorly represented in the RMA Biodiversity Core and Support Areas. This community is classed as Endangered in and is the subject of further consideration in *Aquatic biodiversity of the Georges River catchment*.

Fauna and flora species

Table 72 indicates the extent to which the habitat for particular species is represented in the regional management areas. Two indicators are used to approximate the known habitat of these species—the habitat models derived in this study and species locality records. Both these indicators have their limitations. The habitat models only provide broad approximations of actual habitat and are limited in their accuracy by the number of records and the level of correlation between these records and the environmental data. On the other hand, known records indicate that species occupy or have occupied a particular location. The records however are limited by the level of search effort undertaken and may give bias towards easily accessible locations. As an example of this, the low number of Koala records in the Holsworthy Military Area may possibly reflect the restrictions on access to this area rather than a lower abundance of animals.

As an initial observation, it is evident from Table 72 that there are only a few records for many of the threatened and regionally significant species in the catchment. The number of records for most species is in the tens and twenties, with the notable exception being the Koala (due to intensive data collection by the University of Western Sydney). The low numbers reflect the cryptic nature of these species and the difficulty of detecting them in systematic surveying.

It is also apparent that the majority of the habitat for the targeted species is not protected within the current reserve system. Most species contain less than 50% of modelled high-quality habitat or known records within a reserve. The RMA network provides a substantial increase in the security of protection for most species, as approximated by their habitat models and records.

The Koala was a specifically targeted species in the assessment because of the state significance of the Georges River population. At present only 7.6% of the Koala's high-quality habitat and 2.5% of known records occur within land currently reserved. The inclusion of RMA (Biodiversity Core) and RMA (Biodiversity Support) land as areas managed for conservation purposes ensures that 98.3% of high-quality habitat and 64.6% of recorded locations of Koalas are afforded protection. The different outcome for high-quality habitat (98.3%) and records (64.6%) reflects the fact that many of the records occur in disturbed urban habitat that was not included in RMA (Biodiversity Core) and RMA (Biodiversity Support) land. This disturbed habitat is considered important for Koalas, however the management difficulties of conflicting land uses and small lot sizes in the urban areas made this area unsuitable for inclusion in RMA (Biodiversity Core) and RMA (Biodiversity Support) land. Landowner education and local actions to encourage tree retention and replanting may be the most appropriate conservation actions in these areas. The disturbed Koala habitat in urban areas has also been included as RMA (Biodiversity Enhancement) where it is sympathetically zoned (e.g. Environmental Protection, Open Space etc.).

Table 72 Representation of species features within the regional management areas

Group	Feature	Area of modelled habitat extant ¹ (ha)	No. of known records ²	Proportion (%) in reserves		Proportion (%) in reserves, Core & Support Areas	
				Modelled habitat	Known records	Modelled habitat	Known records
Amphibians	Giant Burrowing Frog (V)	40,023	29	38.0	48.3	96.7	96.6
	Red-crowned Toadlet (V)	7,746	61	40.1	44.3	96.9	88.5
	Brown Toadlet (P)	NA	11	#	54.5	#	72.7
	Green and Golden Bell Frog (E1)	NA	7	#	14.3	#	42.9
	Green Tree Frog (P)	NA	14	#	7.1	#	64.3
Reptiles	Heath Monitor (V)	NA	14	#	50.0	#	78.6
	Broad-headed Snake (E1)	22,738	5	54.2	40.0	98.3	80.0
Birds	Bush-stone Curlew (E1)	NA	6	#	16.7	#	16.7
	Glossy Black-Cockatoo (V)	NA	6	#	16.7	#	33.3
	Swift Parrot (E1)	NA	5	#	0.0	#	0.0
	Turquoise Parrot (V)	NA	0	#	#	#	#
	Barn Owl (P)	1,190	5	32.0	100.0	91.7	100.0
	Powerful Owl (V)	22,923	24	29.1	50.0	96.1	83.3
	Rock Warbler (P)	23,996	34	38.1	29.4	97.6	94.1
	Brown Treecreeper (V)	NA	3	#	0.0	#	33.3
	Regent Honeyeater (E1)	499	12	0.0	0.0	94.4	33.3
Mammals	Koala (V)	23,998	557	7.6	2.5	98.3	64.6
	Squirrel Glider (V)	NA	4	#	50.0	#	100.0

				Proportion (%) in reserves		Proportion (%) in reserves, Core & Support Areas	
	Eastern Horseshoe-bat (P)	7,717	3	39.9	100.0	98.7	100.0
	Eastern Freetail-bat (V)	1,183	20	32.2	45.0	91.8	75.0
	Unidentified Freetail-bat (P)	1,183	48	32.2	33.3	91.8	91.7
	Common Bentwing-bat (V)	NA	27	#	44.4	#	85.2
	Eastern False Pipistrelle (V)	1,183	22	32.2	45.5	91.8	90.9
	Large-footed Myotis (V)	19,895	19	34.1	15.8	94.3	84.2
Plants	<i>Pimelea spicata</i> (E1)	1,022	20	38.3	20.0	93.2	60.0
	<i>Persoonia nutans</i> (E1)	3,194	6	2.1	16.7	96.6	33.3
	<i>Pultenaea parviflora</i> (E1)	1,738	0	1.3	#	95.6	#
	<i>Pterostylis saxicola</i> (E1)	5,281	4	2.5	25.0	96.7	100.0
	<i>Pterostylis gibbosa</i> (E1)	NA	0	#	#	#	#
	<i>Cynanchum elegans</i> (E1)	40	1	35.3	100.0	98.7	100.0
	<i>Gyrostemon thesioides</i> (E1)	1,345	1	2.5	0.0	91.9	100.0

1. Model Habitat refers to the model of high-quality or potential habitat for the respective species.

2. Records refers to records held within the NPWS Wildlife Atlas as at February 2002

In the sandstone landform, the selection criteria for the RMAs particularly targeted species requiring large habitat areas and species vulnerable to habitat fragmentation. These species, such as the Heath Monitor, Powerful Owl and Broad-headed Snake, are only partially protected in the current reserve system. The implementation of the RMA (Biodiversity Core) and RMA (Biodiversity Support) areas will ensure that practically all habitat for these species is managed for conservation. Other threatened and common sandstone species will also benefit from the protection afforded. These species include the Red-crowned Toadlet, Giant Burrowing Frog, Rock Warbler, Glossy-black Cockatoo and a broad range of regionally significant and protected species listed for the catchment.

In the shale landform, the selection of core habitat for Cumberland Plain Woodland birds (Selection Criteria C2) also provides habitat for the diverse bat and reptile assemblages identified as occurring on the Cumberland Plain. The species that benefit from the selection of this habitat are discussed in the fauna section of this study.

The plant species targeted in this study occur in the shale landform (three species) and the shale–sandstone transition areas (three species). The habitat of these species is well represented within the RMA network. The only exception to this is *Persoonia nutans* where only two of the six known records of the species in the catchment are included.

Habitat linkages

The maintenance and enhancement of habitat linkages between areas of significant habitat is one of the biodiversity objectives developed in consultation with the Section 22 Committee. The RMA (Biodiversity Enhancement) classification enables such linkages to be developed by identifying land of strategic value in connecting significant areas of habitat. The strategic linkages are predominantly located on land zoned Environmental Protection, Open Space, Rural and Special Use where future revegetation could be achieved with minimal conflict with other land uses.

The following section provides a description of components of these linkages which are mapped as RMA (Biodiversity Enhancement). These corridors are identified according to the numbers below in Figure 48.

i) Cumberland Plain corridors

The regional management areas provide a network of regionally significant corridors across the Cumberland Plain. The principle functions of these corridors are to provide linkages and opportunities for rehabilitation of remnants of Cumberland Plain vegetation. Secondly, the corridor provides habitat linkage for the small, passerine birds of the Cumberland Plain that have been identified in Appendix H as a biodiversity indicator for the ecological functions of these communities. In respect to habitat requirements for the targeted assemblage of bird species, Appendix H notes that corridors for these species should not be less than 25 m wide and should have similar characteristics to those present in core habitat (i.e. well-developed understorey, presence of fallen logs and ground litter). Wider corridors of 40 to 50 m width with good understorey are occupied more permanently and by a wider range of species. An array of patches of habitat can be as or more useful as stepping stones between remnants for these species than linear corridors. Corridors in the order of 100 to 200 m should be considered for major regional corridors such as that proposed for the Prospect–Central Hills Corridor.

The strategic enhancement of existing habitat and revegetation within these corridors will assist in the long-term maintenance of these endangered shale-based ecological communities. The objectives for these corridor lands should be to increase the area of existing vegetation patches, improve the condition of these patches and to revegetate the corridor wherever feasible in order to provide stepping stones of habitat for the species of concern.

It is reiterated that the above identified habitat linkages are at a regional scale and constitute broad landscape corridors. In comparison, the Green Web developed by the Sydney Regional Organisation of Councils is at a considerably finer, local scale. The development of the RMAs is considered to complement the Green Web. Similarly, councils are encouraged to develop local habitat linkages and urban green fingers within their LGAs to compliment the network of corridors identified by the RMAs. Characteristics of this network are detailed in Table 73 below.

Table 73 Cumberland Plain corridors in the Georges River catchment

Corridor	Description
1. Prospect–Central Hills Corridor	This is a major north–south regional corridor across the Cumberland Plain. The corridor extends from Prospect Reservoir in the north through Western Sydney Regional Park to the DIPNR owned land (REP No. 31—Regional Open Space Corridor) between Wallgrove Road and Camden Valley Way, West Hoxton. The corridor then extends south through the Environment Protection zoned land of the Central Hills. This corridor has the potential for linkage outside the GRC to the Eastern Creek corridor in the north and to the Nepean River in the south through Mt Annan Botanic Gardens and the National Equestrian Sports Centre. Four of the following corridors provide east–west linkages from the Woronora Plateau to this major Prospect–Central Hills Corridor.
2. Lower Georges River Corridor	This corridor links vegetation predominantly on the south side of the Georges River and extends from Mill Creek in the east through Voyager Point and the Moorebank brickworks site to Mirrambeena Regional Park.
3. Prospect Creek Corridor	This links the contiguous vegetation of the Woronora Plateau and the Georges River to Prospect Reservoir via riparian lands.
4. Cabramatta Creek Corridor	This corridor links the contiguous vegetation of the Woronora Plateau and the Georges River to the DIPNR corridor lands at West Hoxton via riparian lands.
5. Glenfield Corridor	This is an east–west corridor of rural land linking the Woronora Plateau through Edmondson Park to the DIPNR lands at West Hoxton. The potential exists for urban land uses in this corridor that do not compromise the value of the land as habitat linkage.
6. Minto Corridor	This is an east–west corridor of Special Use zoned land containing a transmission line. The corridor extends from the Georges River to the Central Hills.

ii) Woronora Plateau corridors

While the Woronora Plateau is characterised by its broad area of contiguous vegetation, there are particular tracts of land which are likely to have additional value for the movement of fauna between the plateau and peripheral urban areas. Key corridors for species movement are detailed in Table 74.

Table 74 Woronora Plateau corridors in the Georges River catchment

Corridor	Description
7. Upper Georges River Corridor	This corridor extends from Appin north to Holsworthy. The Georges River gorge is likely to be of particular value for the movement of the Koala and other species with an indicated habitat preference for Upper Georges River Woodland and Western Gully Forest.
8. Williams Creek Corridor	This corridor extends along Williams Creek linking the Woronora Plateau with Voyager Point and the riparian corridors. The lower sections of Williams Creek contain a high diversity of vegetation communities and habitat types which warrant particular management. The area is also considered valuable for the movement of Koalas and other species with a habitat preference for Upper Georges River Woodland and Western Gully Forest.
9. Deadmans Creek Corridor	This extends along Deadmans Creek linking the Woronora Plateau with the commonwealth lands between Sandy Point and Pleasure Point. The area is also considered valuable for the movement of Koalas and other species with a habitat preference for Upper Georges River Woodland and Western Gully Forest.
10. Mill Creek Corridor	This corridor is likely to be of value for the movement of fauna species into the lower sections of the Georges River, including Georges River National Park. Species likely to utilise this corridor are wide-ranging forest dependent species and species with an indicated habitat preference for Upper Georges River Woodland and Western Gully Forest. The Corridor has two proposed linkages, one linking across New Illawarra Road to the Woronora River valley and the second linking across Heathcote Road to the Holsworthy Military Area.
11. Woronora River Corridor	This corridor extends along the vegetated gorges and foreshore lands of the Woronora River. Similar to Mill Creek, the Woronora valley is likely to be of particular value for the movement of fauna species into the lower sections of the Georges River. The Corridor has two proposed linkages, the dominant one being along the valley between the vicinity of the Woronora Dam and the lower portions of the River. A second potential linkage occurs through Fahey Creek at Loftus, across the Princes Highway, to Royal National Park.

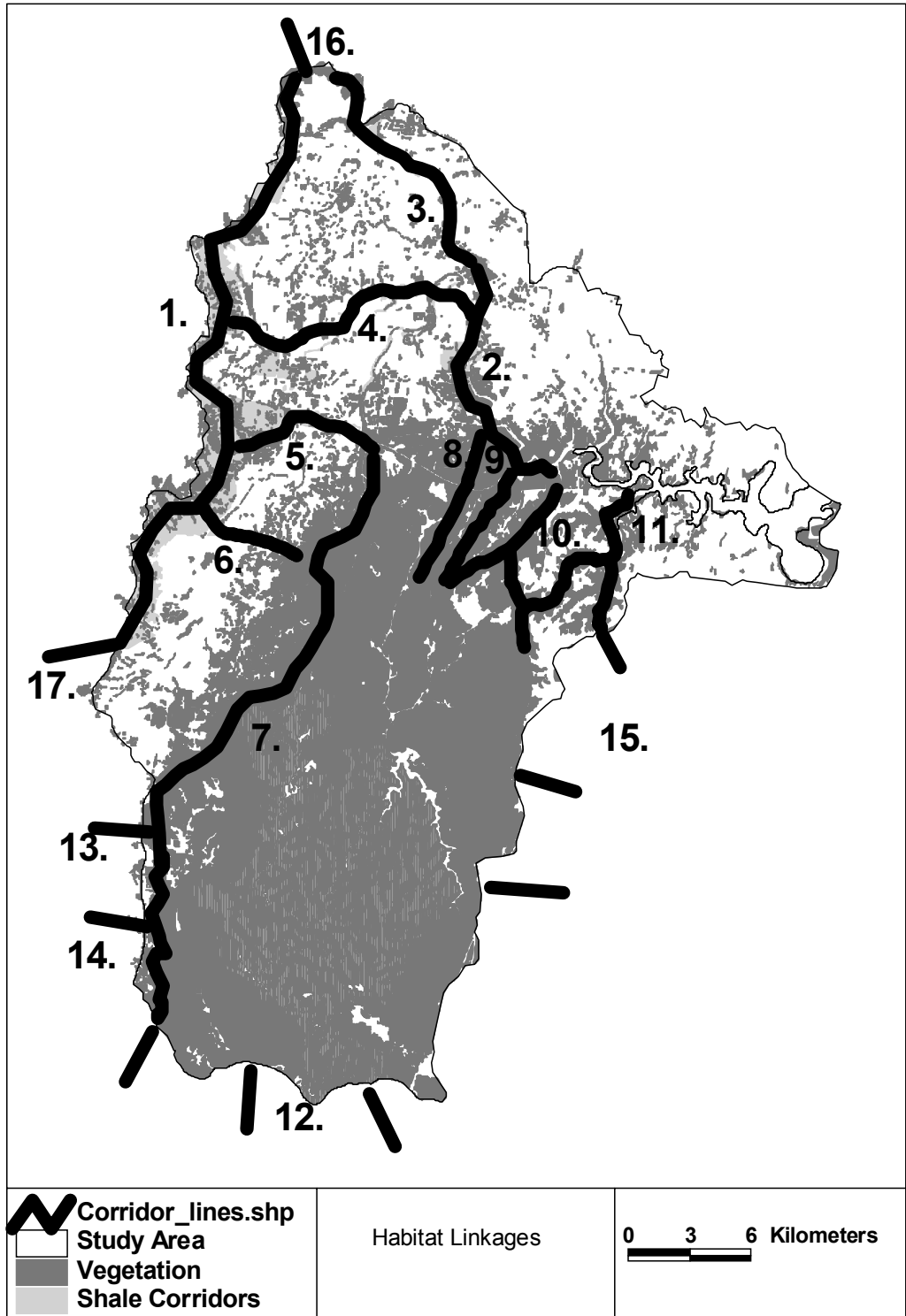
iii) Interregional Corridors

There are particular areas on the boundary of the Georges River catchment study area that may be sensitive because they provide connectivity to potential interregional corridors. These potential interregional corridors and areas of sensitivity are described in Table 75 below:

Table 75 Interregional corridors in the Georges River catchment

Corridor	Description
12. Illawarra Escarpment and Metropolitan Catchment Lands	The Woronora Plateau in itself provides a regionally significant corridor for fauna movement. Critical linkages in this interregional corridor extend south of the Plateau to the Illawarra Escarpment and the Metropolitan Catchment lands. The minimisation of habitat fragmentation along the Appin Road will assist in maintaining populations of species identified as requiring large habitat areas or that are vulnerable to habitat fragmentation (refer to Section D5d S3). The Georges River gorge south of Appin is likely to be of particular value for the movement of Koalas and other species with an indicated habitat preference for Upper Georges River Woodland and Western Gully Forest.
13. Woodhouse Creek Corridor	The potential exists to provide a habitat linkage from the Georges River in the vicinity of Wedderburn to the Nepean River. Native vegetation within the Georges River Catchment which links with the headwaters of Woodhouse Creek should be particularly targeted for retention and enhancement where possible.
14. Ousedale Creek Corridor	The potential exists to provide a habitat linkage from the Georges River north of Appin to the Nepean River. Once again, native vegetation within the Georges River Catchment which links with the headwaters of Ousedale Creek should be particularly targeted for retention and enhancement where possible.
15. Links to Royal National Park and Garrawarra State Recreation Area	The maintenance of vegetation links through Fahy Creek (Loftus), across the Princes Highway between Heathcote and Helensburgh and through the headwaters of the Hacking River are likely to be particularly valuable for the movement of wide ranging species into these reserves.
16. Prospect Reservoir–Eastern Creek Corridor	As noted above, the Prospect–Central Hills Corridor within the catchment has the potential for linkage to the north to Eastern Creek and the Hawkesbury River.
17. Central Hills–Mt Annan Corridor	As noted above, the Prospect–Central Hills Corridor within the catchment has the potential for linkage to the south to Mt Annan Botanic Gardens, to the National Equestrian Sports Centre and to the Nepean River.

Figure 48 Identified Regional Corridors



Areas of significant biodiversity value on the Woronora Plateau

Preliminary work for this study attempted to identify the areas of high conservation value in the landscape using C-Plan, a conservation planning software package. C-Plan was used to rank patches of vegetation according to the number of biodiversity indicator features present and the area of each feature, weighted by the conservation status of the feature. The results of this analysis were not utilised in the final assessment because of the limitations of the data and methodology.

Nonetheless, the use of C-Plan provided a number of inferences that are worth noting. The assessment indicated that two areas were consistently classified as having the highest biodiversity value for all features within the contiguous vegetation of the Woronora Plateau.

The first area was the Georges River Valley consisting of land surrounding the Georges River gorge from Appin to Holsworthy. The area's high biodiversity value is characterised by contiguous vegetation containing large areas of Endangered communities, notably Shale/Sandstone Transition Forest. The area also marks the transition between the shale and sandstone landforms resulting in its utilisation by species from both habitat preferences. The fauna study indicated a particularly high diversity of bat species in this area. The transition between the sandstone and shale has also resulted in a number of distinct intermediate ecological communities. These include the Shale/Sandstone Transition Forest and Upper Georges River Sandstone Woodland vegetation communities as well as distinctive fauna assemblages, notably for reptiles and birds.

The second area was the Holsworthy–Voyager Point area consisting of the vegetation contiguous with the Woronora Plateau at Holsworthy, Moorebank, Hammondville, Voyager Point and Pleasure Point. The southern boundary of this area is approximated by an east–west line that extends from the southern perimeter of Holsworthy Airfield to Deadmans Creek in the east and to the Georges River in the west. Deadmans Creek forms an eastern boundary of this area. The biodiversity value of this area is characterised by contiguous vegetation containing large areas of Endangered communities. It also represents the complex transitions between the shale, Tertiary Alluvium and sandstone landforms as well as riparian influences. At least eight vegetation communities occur within this area as a result of these influences. The intergrades between these communities are particularly complex on a local scale due to variations in substrate and drainage.

Land use implications of the selection of areas for management in RMAs

Table 76 indicates the area of each RMA represented in various land use zones. A large proportion of the land identified in the RMAs occurs in land zoned Environmental Protection, Open Space and Special Uses. This reflects in part the current zoning of the Woronora Plateau and the importance of the Plateau for inclusion in the RMAs.

Of particular note is the area of RMAs included within land zoned Urban as this is where the greatest land use conflicts are likely to occur. There are 260.2 ha of land zoned for urban uses which occur within the identified Core and Support areas. These areas predominantly occur within Liverpool, Holroyd and Campbelltown LGAs and contain endangered Cumberland Plain vegetation.

The achievement of the biodiversity goal and objectives was undertaken in a manner to avoid land use conflict where possible. Land zoned for Urban Use was not selected for inclusion within an RMA area unless this was compelled by the presence of particularly high conservation values. This generally occurred where Endangered communities were present and the condition and size of the vegetation was considered significant on a regional scale. The implementation of the necessary management objectives for these areas will require considerable negotiation with landowners to achieve a mutually acceptable outcome.

Table 76 Summary of the land types (zones) identified as RMA (Biodiversity Core), RMA (Biodiversity Support) or RMA (Biodiversity Enhancement)

Zoning class	Regional management areas (ha)			Total (ha)
	Core	Support	Enhancement	
Reserve (includes all land zoned National Park, Reservation—Sutherland LGA, Water catchment—Sutherland LGA, & Western Sydney Regional Park).	112.7	37.5	55.9	206.1
Environmental Protection	6993.6	496.1	2313.0	9802.7
Open Space (includes land zoned River in Hurstville LGA)	2555.8	261.3	2149.1	4966.2
Special Uses (includes land zoned Special Uses—Water Catchment—in Wollondilly LGA.)	13641.0	259.4	560.5	14460.9
Rural (includes land zoned Deferred in Wollongong LGA)	3401.9	711.5	2131.7	6245.1
Urban (includes all land zoned Residential, Commercial, Business, Mixed Uses and Industrial)	194.2	66.0	21.3	281.5
Roads (includes land zoned as roads in all LGAs and Proposed Road in Campbelltown LGA)	102.6	57.6	0.0	160.2
Total Area of land in RMA	27001.8	1889.4	7231.5	36122.7

Implementation of the conservation network

The RMAs identify a potential conservation network across the landscape. Identifying these areas however does not guarantee their protection or constitute a de facto reserve system. For instance, the high representation of Endangered communities within the RMAs does not mean that these important remnants are secure or protected. In many instances, the RMAs occur on private land and may be zoned for incompatible land uses. As stated above, the securing of these areas for conservation purposes will inevitably require negotiation with the landowners.

Subject to negotiation, the goal therefore exists of ensuring that land identified in the RMAs is securely managed for the objectives in the RMA. The term Secure Conservation Land is used to denote land that is effectively and permanently managed for conservation purposes in accordance with the RMA's objectives. Mechanisms to achieve this may include land reservation under the NP&W Act or as a Special Area under the *Sydney Water Catchment Management Act 1998*. It may also include land within a council reserve, in public or private ownership, which is managed for biodiversity protection in accordance with a conservation agreement and/or covenant on the title of the land and which is appropriately zoned.

The RMAs may be implemented into the planning process as a trigger for negotiation with the landowner to achieve a mutually acceptable outcome. Opportunities may arise through land use planning initiatives such as listing on the Urban Development Program, rezonings, DCPs, masterplans and DAs. They may also occur, for example, through consultation regarding the preparation of plans of management or land capability assessments for publicly owned land.

The RMAs may be utilised to monitor the effectiveness of actions in achieving the conservation goal. The goal of realising Secure Conservation Land can be quantitatively defined and the performance over the years towards achieving this goal can be measured. For instance, the area of RMA (Biodiversity Core) land that has been

negotiated with landowners and resulted in Secure Conservation Land can provide a performance measure for the region or for LGAs. Effectiveness in achieving secure conservation for the RMAs can subsequently be reported and compared over the years.

The RMAs also enable priorities to be selected for proactive effort. Priorities within the RMA (Biodiversity Core) land may be selected based on the conservation value of the land and level of imminent threat. Actions in these instances may include discussions with the landowner (and council) to ensure that they are aware of the values present and of the benefits of a negotiated outcome. The opportunity exists for a strategic approach to be taken to achieving conservation outcomes within the catchment or LGA. The following steps represent an approach to establish a biodiversity management framework in the Georges River catchment:

1. Establish a register of all land within the RMA network and the identification of which of these areas constitute Secure Conservation Land (refer to definition above).
2. Establish a reporting mechanism to monitor progress in securing conservation land within the RMAs. State of the Environment Reports or other performance measurement reports may be suitable for this purpose.
3. Prioritise sites that are of the highest conservation value and likely to be under imminent threat which require proactive measures. As indicated above, proactive measures may include discussions with the landowners and councils or in some instances may include negotiated acquisition.
4. Identify RMA land that can be easily secured, such as publicly owned land, and proceed to secure these lands. Mechanisms for security in these instances are likely to include conservation agreements and other forms of property agreement.
5. Respond to opportunities to negotiate and secure conservation land within the RMAs. Opportunities may arise through land use planning initiatives such as listing on the Urban Development Program, rezonings, DCPs, masterplans and DAs. They may also occur through consultation regarding the preparation of plans of management or land capability assessments etc. for publicly owned land.

These actions are relevant for both state government agencies and councils and a coordination of effort is essential.

4.5.6 Conclusions

The purpose of this conservation assessment is to identify land which achieves the biodiversity goal and objectives for the Georges River catchment. The methodology of the assessment consisted of firstly identifying biodiversity features that represented each of the five objectives. Secondly, the lands occupied by these features was assessed for their conservation value using standard criteria. Finally and as a result of this assessment, land occupied by the biodiversity features was assigned to one of the four land management classes. The overlaying of all land assigned to a particular land management class for the various features resulted in a final map for this land class.

Three of the land management classes have been termed regional management areas and consist of Core, Support and Biodiversity Enhancement areas. The fourth and lowest land class in this hierarchy is termed Other Land.

The conservation assessment resulted in a substantial area of the native vegetation, which is in good condition, being classed as RMA (Biodiversity Core). On the Cumberland Plain, the presence of endangered and regionally significant vegetation

communities drove this selection. In general, remnants of 10 ha or greater in size were included within the RMA (Biodiversity Core), with remnants of 0.5 ha selected where Critically Endangered communities were present.

The majority of the contiguous vegetation on the Woronora Plateau was included in the RMA (Biodiversity Core). The features that drove the selection of this area included high-quality Koala habitat, habitat for other species requiring large habitat areas or that are vulnerable to fragmentation, as well as the ecological value of the undisturbed catchments on the Plateau.

The RMA (Biodiversity Enhancement) land has been used to identify areas that provide a strategic opportunity for rehabilitation and habitat linkage with minimal land use conflict. Within the RMA (Biodiversity Enhancement) land, the study identified eleven regional corridors that provide benefits for the maintenance of vegetation and fauna populations within the catchment. Key components of this corridor network include a major north–south corridor from Prospect Reservoir through the Central Hills to Narellan Road in the south. The other nine corridors provide linkage from this north–south corridor to the Woronora Plateau using riparian lands and utility corridors. The study also identifies an additional six interregional corridors linking habitat within the catchment to habitat in other catchments.

The study has also identified two areas on the Woronora Plateau of likely high conservation value. These were the Georges River corridor from Appin to Holsworthy and secondly, the contiguous vegetation of the Holsworthy, Moorebank, Hammondville, Voyager Point and Pleasure Point area. Both these areas are characterised by large areas of contiguous vegetation containing Endangered communities. They also represent a likely high level of biodiversity associated with the transition between shale- and sandstone-influenced substrates. The Holsworthy area also contains alluvial and riparian influences which increase the diversity of communities and species present.

As envisaged by the aims and objectives for biodiversity management, the regional management areas incorporate the majority of modelled and known habitat for targeted species within the catchment. In most cases over 90% of the habitat and records of these species have been selected for inclusion within the RMA (Biodiversity Core) classification. Non-targeted and common species with similar habitat preferences as these species are also likely to benefit from this selection.

The majority of the land within the RMA network occurs within land zoned Environmental Protection, Open Space, Special Use and Rural. The achievement of the aims and objectives for biodiversity management was undertaken in a manner to avoid land use conflict where possible. Land zoned for urban use has not been selected for inclusion within an RMA area unless this was compelled by the presence of particularly high conservation values. This generally occurred where Endangered communities were present and the condition and size of the vegetation was considered significant on a regional scale. In all, 281.5 ha of land within the RMA network is also zoned for urban uses. The implementation of the necessary management objectives for these areas will require negotiation of a mutually acceptable outcome with landowners.

It is recognised that the identification of the RMA network will not in itself lead to the management of these lands for the recommended objectives. In practically all cases the negotiation of an outcome with the landowner will be essential. For the land of highest conservation priority, landowners may be approached directly as part of a strategic initiative. In other cases, the planning framework system provides for negotiation at the rezoning, DCP or DA stage. The goal of these negotiations is to provide Secure Conservation Land, i.e. land which is under long-term management for the recommended biodiversity objectives. The proposed benchmark for defining Secure Conservation Land is appropriate zoning and a conservation agreement on the title of the land.

The Regional Management Network also enables the measurement of progress in achieving the biodiversity objectives. The area of RMAs that meet the Secure Conservation Land benchmark can be monitored and reported on in State of Environment Reports etc. The option therefore exists to establish targets and time frames for quantifiable conservation outcomes to be achieved across the catchment or for individual LGAs.

Finally, it needs to be reiterated that the conservation assessment has been undertaken at a regional scale. Land not represented within the RMA network may still have biodiversity values of local and possibly regional significance, for instance as local habitat linkages, buffers or as habitat for threatened or regionally significant species. The study does not remove the need for site specific assessment when land use decisions are being made.