

1.1 Survey methods

Flora and Vegetation

Vegetation sampling for ecological assessments generally has several aims, these being:

- to map vegetation;
- identify habitats for significant species, populations or communities;
- produce a list of species; and
- identify ecological conditions onsite, such as weeds, and disturbance.

Typically this involves nine (9) stages before a final product is presented:

1. Review of mapping resources for the site, such as, LHCCRM mapping (2003);
2. The mapping of the site prior to field surveys to establish the area (ha) of units, and the typing of vegetation communities;
3. Determination of the survey effort based on LHCCREMS survey guidelines;
4. Onsite walking transect surveys;
5. Redraft of vegetation mapping using transect data;
6. Redrafting of vegetation maps, comparing results with resources and initial maps;
7. Determination of field survey effort from new mapping results using logic shown in Table 2, including targeted survey requirements;
8. Conduct quantitative plots and targeted surveys; and,
9. Prepare final vegetation community maps, threatened species habitat maps and condition maps.

The above process was followed for the preparation of vegetation data and maps for this assessment. For simplicity, only the field survey methods are detailed below, the remaining techniques follow common, logical process.

Table 2. LHCCREMS survey guideline survey requirements for flora and vegetation community descriptions. Point 2 of the above list determines how many transects are initially used onsite. Point 7 determines the final level of survey required. That is unless during this final survey important habitat or significant species are located. When this occurs additional surveys are included that target the locations and habitats for the sub-population recorded onsite

Area	Structure	Survey requirements		
		Transects	Plot (per community)	Replicates
0-1ha	Simple	1-2	1	1 If there is evidence of management history i.e. grazing.
	Complex	1-2	1	1 If there is evidence of management history i.e. grazing.
1-10	Simple	3	1	1 per community @ 5ha
	Complex	3	2	1 per community @ 5ha
11-50ha	Simple	4-6	1	1 per community @ 5ha
	Complex	4-6	2	1 per community @ 5ha
>50ha	Simple	7-10	2	1 per community @ 10ha
	Complex	7-10	2	1 per community @ 10ha

Vegetation sampling included all fundamental environmental parameters required to describe vegetation communities, these included:

- Vegetation structure
- Floristic composition
- Topography
- Soils type
- Geology
- Slope
- Aspect
- Disturbance history
- Successional Change
- Connectivity To other bush land areas
- Distance from water sources

Transects

Two transects running the length of the site were run parallel from the lowest to the highest point of the site. One transect was within the subject site, the other on adjoining land to the north, See **Figure 1**. Transects are used to establish major vegetation parameters onsite and collect data on disturbance history and management issues. In effect these surveys influence the design of quantitative plot surveys (see below), therefore they are the first data collected onsite, and frequently are used to produce draft community and condition maps that are used to determine the number of plots and assist in designing targeted surveys. Data is collected whilst walking on the transects this includes; communities present, the boundaries between communities, species present, identifying locations for plot-based surveys, and data on the potential for disturbance of threatened species.

Plots

Quantitative survey plots (or Quadrats) are taken within 400m² (20mx20m) defined and measured survey plots. In total two plots were sampled (following the logic of **Table 2**). The locations of the plots were established using coordinates (MGA 94) generated using a random number algorithm (RNGP) and plotted in the Mapinfo GIS software (v10.5). In addition to the vegetation parameters detailed in section 2.2.1 structural, floristic, cover abundance and threatened and significant data was also collected. For simplicity, the fine details of these survey methods are withheld here and shown in Appendix A for those interested.

Where these RNGP's landed in cleared or developed areas they were excluded from the survey. When the quota of required plots is reached, pursuant to the recommendations in the LHCCR Flora and Fauna survey guidelines 2002 the survey design was complete and additional sites ignored.

Targeted Searches

Haphazard searches or transects are usually the first methods to be employed, and are the main methods for compiling species lists and qualitatively describing the vegetation. Other more detailed methods are then usually implemented based on this first data collection, particularly for determining potential habitat for threatened and cryptic flora species.

Once areas of potential threatened species habitat have been identified, these target areas can be systematically searched depending on the size. The methods comprise systematically placed transects and/or haphazard searches as the primary methods for locating cryptic and threatened species. Areas considered as optimal habitat within target areas can be searched very intensively depending upon the targeted threatened species. For example methods for locating *Tetratheca juncea* outside of its flowering period would require very detailed ground searches to locate this small grass-like threatened species, however locating a threatened shrub species such as *Callistemon linearifolius* is much easier to find and doesn't require extensive searching of the ground layer.

Reference Sites

Reference sites can be used to help locate cryptic or threatened species, or diminish the possibility of a threatened species being present. For example cryptic species that can only be easily located when flowering, a reference site where the species is known to occur can be assessed for flowering individuals, so it can

reasonably be assumed that any species present within the study area would also be flowering. The reference site obviously needs to be similar habitat to the study area habitat (i.e. soils, aspect, moisture), a similar vegetation association and it should be as close to the local area as possible.

Plant Identification

Plant identification follows Harden (2000, 2002, 1992 and 1993) *Flora of New South Wales Volumes 1, 2, 3 & 4*, where a plant can not be identified to species level it is sent to the Australian Herbarium for verification or identification. A number of other resources are also used including CD-ROM plant identification keys such as *Euclid* (2001) and *Ausgrass* (2002), other identification guides (see Bibliography) and the Internet has a number of resources useful for plant identification including PlantNET and EucaLink.

Vegetation Mapping

Vegetation mapping is usually undertaken through aerial photograph interpretation (API), which involves identification of areas of vegetation which appear to be more or less internally homogenous on the aerial photograph (i.e. similar texture, colour, etc.). Mapping may seek to define areas (or polygons) based on vegetation structure (dominant growth form, height, density), or floristics (constituent plant species) or both. The API is supported by ground-truthing (i.e. checking aerial photograph interpretations on the ground). The quality of a vegetation map is proportional to the amount of ground-truthing, especially where floristics is used to define polygons. Ground-truthing may be targeted (i.e. investigating specific areas of API interest) or use some form of systematic sampling (e.g. transects).

Survey methods used for this mapping project comprise haphazard transects and survey points. The surveys are explained above, however, all flora species were recorded, along with any relevant notes concerning the dominance of certain species and the vegetation structure. A handheld GPS was used to record survey points and any significant changes in the vegetation. A map delineating vegetation associations was then produced from the survey results.

The definition and delineation of vegetation polygons is subjective. A map of the vegetation of any area seeks to describe the distribution of plant species in that area by defining a number of vegetation map units (floristic assemblages or 'communities') which are relatively internally homogeneous with sharp boundaries between adjoining 'communities'. Whilst such mapping is a convenient tool, it greatly oversimplifies the real situation. A plant 'community' is essentially an artificial device developed to simplify our interpretation of the real world. Plants rarely occur in well defined 'communities', although the distribution of some species may consistently partially overlap due to broadly similar environmental requirements. The 'communities' of any vegetation map are generally intuitively defined to reflect broad similarities in environmental requirements of species, but it is important to remember that in many situations the 'communities' could just have easily been defined in some other manner. Accordingly, vegetation units used for any map should be viewed as generalised plant species assemblages rather than distinct 'communities'.

In addition, plant 'communities', no matter how they are defined, rarely have sharp boundaries but gradually merge into each other. Any mapped boundary is as arbitrary as the definition of the 'communities'. The boundaries shown on a vegetation map should therefore be viewed as being indicative of the extent of the defined 'communities' rather than being precise edges.

Thus a vegetation map is not a 'photograph' of the vegetation of the site but rather a model of the distribution of plant species designed to demonstrate some inferred ecological relationships between plant species as well as the generalised distribution of major species. Care should therefore be exercised in using the map for any other purpose.

1. 5.3 Fauna Survey Methodology

The general fauna investigation conducted for the preparation of this report had the objective of:

- Identifying the fauna assemblage of the study area;
- Identifying the habitat qualities of the study area;
- Locating important habitat in the study area;
- Identifying significant species habitat;
- Identifying fauna movement corridors and habitat connectivity; and
- Identifying conservation areas.

The review of the general fauna assemblage of the study area was conducted through scoping of fauna records and the correlation of habitat requirements of significant species with the vegetation units contained in the study area. The vegetation units were then examined based on their habitat characteristics in order to determine which of the significant species would be likely to inhabit those vegetation units, based on their habitat requirements.

3. 5.3.1 Flying Mammals

Temporal variation in microchiropteran bat activity can make the estimation of diversity at a site difficult, particularly when undertaking snap shot surveys (such as most ecological assessments) difficult. Table 2 shows the range of activity levels of microchiropteran species during a typical season. This variation makes it hard to eliminate the presence of a species from a site. Surveys conducted for this site occurred during periods of moderate activity.

Table 2: Seasonal Activity levels of Threatened Microchiropteran Bats

Species	Summer	Autumn	Winter	Spring	Hibernate or Migrate
<i>Miniopterus australis</i>					Hibernate
<i>Miniopterus schreibersii</i>					Hibernate
<i>Myotis adversus</i>					Hibernate
<i>Mormopterus nfolkensis</i>	Unknown				Unknown
<i>Saccolaimus flaviventris</i>					Migrate
<i>Falsistrellus tasmaniensis</i>					Hibernate
<i>Scoteanax rueppellii</i>					Hibernate
<i>Kerivoula papuensis</i>					Unknown
<i>Chalinolobus dwyeri</i>					Hibernate

Key:

	Most activity
	Moderate activity
	Most active

The minimum survey effort required to sample flying mammals within Newcastle City Council is shown in Table 3 which is derived from LHCCREMS guidelines which have been adopted by this council.

Table 3: LHCCREMS Guidelines for flying mammals

Time of Survey	Survey Technique	Survey Period	Survey Effort per Community
Microchiropteran Bats	Harp traps	All year, limited captures in winter	2 harp trap nights per broad habitat type
	Echolocation	All year, limited results in winter	45 minute continuous recording plus call activated all night
	<i>optional</i> Triplining	All year	3 hours commencing from dusk
	<i>optional</i> Mistnetting	All year	3 hours commencing from dusk
Megachiropteran Bats	Spotlighting & listening	All year	Walking rate 1km hour per person
<i>optional</i>	Mistnetting	All year	3 hours commencing from dusk

Recent scientific publications (Richards 2001; Milne *et al.* 2004) have raised concerns regarding the effectiveness of short duration echolocation surveys and the accuracy of different media used (White and Gehrt 1999; Milne *et al.* 2004). Recommendations suggested to improve achieve the greatest results were a two (2) hour walking transect, all night recording and the use digital Anabat recorders.

It was determined that the most appropriate manner of surveying microchiropteran bats was too use random transects targeting periods of high bat activity (i.e. jus prior to and after dusk) and establish 'all night' Anabat stations (Figure 4).

Targeted transects of open flyways were undertaken just prior to and after dusk using a digital Anabat Detector. If a species was opportunistically observed or heard, searching ceased for 5' minutes (or longer) in order to record a high quality call on the Anabat. Spotlighting for megachiropteran bats was conducted concurrently with Anabat detection. Flowering myrtaceous vegetation and other potential foraging resources were targeted during these searches.

Permanent Anabat stations were also established across the site to capture temporal variation in microchiropteran bat species. Station 1 was located next to a farm dam in the south eastern section of the subject site with the detector aimed over the dam at a 45° angle to the horizontal. Station 2 was located within an open flyway on the northern edge of the vegetation within the south western section of the study area with the detector aimed along the flyway at a 45° angle to the horizontal (Figure 4)

4. 5.3.2 Non-flying Mammals

Non-flying mammals can be divided into two broad categories, terrestrial mammals and arboreal mammals. Table 4 identifies the minimum survey effort and survey methods required to be undertaken by Newcastle City Council.

Table 4 – LHCCREMS survey guidelines for non-flying mammals

Fauna Group		Survey Technique	Survey Period	Survey Effort per Community
Small mammals	terrestrial	Small mammal traps	All year	10 trap nights over 3-4 consecutive nights
	<i>optional</i>	Hair tubes	All year	5-10 consecutive trap nights per site
	<i>optional</i>	Pitfall trapping	All year	5-10 consecutive trap nights per site
Medium mammals	Terrestrial	Cage/B Elliot traps	All year	5-10 consecutive trap nights per site
	<i>optional</i>	Hair tubes	All year	5-10 consecutive trap nights per site
Arboreal Mammals		B Elliot traps	All year	Trapping grid 1 ha sampling in each major habitat, with 10 traps per grid for 3-4 consecutive nights
		Faecal pellet counts	All year	Minimum of 1 plot per 1,000 m ²
		Spotlighting	All year	Walking rate 1km hour per person
	<i>optional</i>	Hair tubes	All year	5-10 consecutive trap nights per site

"A type" Elliott traps, cage traps and arboreal Glider traps were used to sample non-flying mammals within the study area.

Arboreal traps were sprayed with an attractant, a 50:50 mixture of honey and water with a splash of vanilla and any animal captured was given a unique tag using non-toxic/non-permanent hair dye and released at point of capture.

Terrestrial Elliott traps were baited with either meat or rolled oats with peanut butter and honey. In inclement weather traps are put in plastic bags to prevent rain entering trap.

Cage traps usually baited with meat or other attractant with similar affect. Cage traps covered with hession bags and plastic (in inclement weather) to provide protection for any trapped animal.

5. 5.3.3 *Avifauna*

Recent research has shown that inventory-based studies such as transects recommended in several survey guidelines (e.g. LHCCREMS 2002) can generate data of less completeness than other bird survey methods, such as a "standardised search" approach (Watson 2003). In comparative studies of bird survey techniques fixed transects were shown to record only 38.9% species completeness, compared to the stopping rule based search which peaked at 75% completeness (Watson 2004). In short, Watson (2004) believes that fixed area sampling efforts of only 20 minutes may only be suitable for the smallest of sites or sites with limited complexity.

Birds were surveyed across the study area by random transects targeting periods of high bird activity, predominantly between the hours of 6 am and 9 am. As a minimum the surveys followed the following:

Estimating the area of search

Generally, for smaller patches (<50 hectares) one moves freely throughout the patch in every sample period. In comparison, larger patches (>50 hectares) can be broken into sub-sets and these sampled as independent (i.e. not overlap samples). A variation of methods was used across the study area dependent on patch size. All species are recorded by ear and unknown species are keyed out on site with the use of a digital recorder.

Interval time

An appropriate interval time ranges from 15 min – 60 min based on patch size and habitat density. Again this was scaled across the sites.

Stopping rule

A compound stopping rule in which "surveying was stopped after three sequential periods in which in total two new or fewer species were encountered" was applied.

Line transects

In total two fixed area transects (400m² each) were erected and surveyed on five occasions over a one week period for a 20 minute survey period at each site (n=10). Surveys were conducted between 0700 and 1000 hours or between 1700 and 1900 hours, windy or rainy days were avoided. Assumptions that were met included, that all birds exactly in the transect were all detected, that birds do not move before detection, distances are measured accurately, and individual birds are detected independently.

2.0 *Terrestrial Mammals*

Trapping for non-flying mammals was undertaken over four consecutive nights between 11 December 2010 and 14 December 2010 using both terrestrial "A type" Elliott traps and cage traps and arboreal HWR Glider traps. Traps were baited with a mixture of honey, oats, peanut butter and vanilla essence. As an attractant, each arboreal trap was sprayed with a 50:50 mixture of honey and water with a splash of vanilla. Each animal captured was given a unique tag using non-toxic/non-permanent hair dye and released at point of capture.

One arboreal trapping stations was established in the survey area during containing ten glider traps. Traps were attached to trees approximately four metres above the ground and were placed between 5 and 20 metres apart depending on availability of trees.

One terrestrial transect was established within the subject site, containing ten (10) "A Type" Elliott traps and was situated along centre of the subject site running in a north-south direction. All terrestrial traps were placed at approximately 5 metre intervals.

One cage trap was placed in the rear of the site, where it was baited with meat and was set in dense understory vegetation suitable for medium sized terrestrial mammals. This trap was set for five nights and checked every morning.

6. 5.3.4 Amphibians

Relevant literature relating to survey methods for amphibians was reviewed to determine the most appropriate approach for surveying the amphibian assemblages within the study area (Table 6). The most common approach to amphibian surveys involved a listening period followed by an active search of that area (Hazell 2001; Lemckert 1999).

Table 6 – Literature search results for amphibian survey methods

Study	Method	Method Details
Hazell <i>et al.</i> (2001)	1. Listening	5 minute listening period away from edge to determine assemblage followed by a 10 minute survey period at edge to determine abundance.
	2. Spotlight search area	5 minute active search in a 2m wide strip of riparian vegetation and shallow water to identify non-calling frogs.
Lemckert (1999)	1. Listening	5 minute listening period
	2. Spotlight inspection	Spotlight search of waters edge and adjacent vegetation.
NSW NPWS & National Parks Association (2004)	1. Transect	Survey sample point every 50m
	2. Diurnal targeted search	Active search of targeted habitat
	3. Call recognition	Call and listen for 30 minutes

The minimum survey effort and survey methods required to be undertaken for amphibians by Newcastle City Council are shown in Table 7.

Table 7 – LHCCREMS survey guidelines for amphibians

Survey Group	Survey Technique	Survey Period	Survey Effort per Community
Diurnal searches	Systematic searches	Sep-Mar	1 ha search for 1 person hour per habitat
Nocturnal searches	Spotlight searches	Sep-Mar	30 minutes on 2 separate nights
	Playback of recorded calls	Sep-Mar	Once on each of 2 separate nights
	Specific habitat searches	Sep-Mar	2hrs per 200m of waterbody edge
	optional Pitfall trapping	Sep-Mar	

Surveys for amphibians were undertaken during June which was outside the optimal period for undertaking surveys when the majority of amphibian species are considered to be active. Therefore, the number of amphibians identified on the site may be an underestimate of the total number of species that actually utilise the study area and subject site.

Due to the timing of the surveys the assessment for this species was, therefore, largely based on knowledge of its distribution in the local area and the likelihood of it occurring within or utilising habitats within the study area.

7. 5.3.5 Reptiles

A review of relevant literature was undertaken to determine the most appropriate methods for surveying reptiles within the study area (Table 8). The most common approach to reptile surveys involves a transect search in combination with an active search of a predetermined unit size (MacNally and Brown 2001; NSW National Parks Wildlife Service and National Parks Association 2004). In general all surveys for reptiles should target periods of high activity (dawn or dusk) and be undertaken in sunny weather with high temperatures (18 – 34°C) (MacNally and Brown 2001).

Table 8 – Review of reptile survey methodology

Study	Method	Method Details
MacNally and Brown (2001)	1. Timed transects	50m long x 10m wide
	2. Active search plot	250m ² Both searched for 10 minutes.
NPWS & NPA (2004)	1. Transect	100m long x 50m wide
	2. Active search plot	500m ²
Loyn <i>et al.</i> (2004)	1. Passive (auditory, visual)	Area determined by searcher
	2. Active search of area	Area determined by searcher
	3. Active search of subplot	250m ²
Klomp <i>et al.</i> (2001)	1. Identify likely habitat	Determined by habitat features
	2. Active search of area	Extent of habitat identified
	3. Pitfall trapping	5 pitfalls 5m apart connected with drift fence
Singh <i>et al.</i> (2002)	1. Pitfall trapping	20 traps per plot randomly placed
	2. Time-constrained searches	15 minute search of each plot

The minimum survey effort and survey methods required to be undertaken for amphibians by Newcastle City Council are shown in Table 9.

Table 9 – LHCCREMS survey guidelines for amphibians

Survey Group	Survey Technique	Survey Period	Survey Effort per Community
Diurnal searches	Habitat searches	Sep-Mar	1 ha search for one person hour on 2 separate days per habitat
Nocturnal searches	Habitat searches	Sep-Mar	Walking rate 1km hour per person on 2 separate nights
Specific habitats	Diurnal & nocturnal searches	Sep-Mar	1 person hour diurnal + 1 person hour per ha nocturnal
<i>optional</i>	Pitfall trapping	Sep-Mar	

Reptiles were surveyed across the study area on the 18 June 2008 using a variety of methods including passive and active search methods along random transects and subplots (Figure 4). In addition targeted searches of likely reptile habitat (e.g. rocks, hollows, rubbish) were conducted throughout the subject site.

Two (2) randomly located transects were conducted on the 18 June 2008 following the dimensions recommended by MacNally and Brown (2001) (50m long and 10m wide). The transects were surveyed

diurnally over a timed period (10 minutes) searching for auditory and visual cues of reptile species. Where a species was observed an opportunistic active search of that particular location was undertaken.

Five (5) randomly located subplots (5m x 10m) were placed along the transects and actively searched once the timed transect survey had been completed. Active searches within these subplots employed destructive sampling techniques, such as the raking of leaf litter, 'rock rolling' (overturning of rocks) and the turning and destruction of logs and log hollows to determine the presence of reptile species. The data gathered for each pseudoreplicated quadrat was then pooled together to produce a result for an active search area of a combined 250m².

Haphazard searches (active) of likely reptile habitat were conducted during field surveys when suitable habitat was randomly encountered. This was to provide any additional information on reptile assemblages in the subject site.

