2 METHODS

2.1 EXISTING FAUNA DATA

Prior to 2003-04, knowledge of the terrestrial vertebrate fauna in Kanangra-Boyd NP was limited, particularly in more remote sections of the park. Kanangra-Boyd NP was subject to limited investigation during the NSW Comprehensive Regional Assessment (CRA) program, which sought to provide a broad regional overview of biodiversity patterns. Limited systematic fauna surveys were undertaken on the Boyd Plateau in 1997 as part of this program. In 2001 DEC was commissioned by the SCA to undertake a comprehensive fauna survey of the entire Warragamba Special Area. Systematic flora and fauna surveys were undertaken within the park between 2002 and 2004 as part of this program (NPWS 2003a, DEC in prep.).

The Atlas of NSW Wildlife (DEC 2004a) was the primary resource used to access existing data on the fauna of the park. The majority of records within the Atlas prior to the summer of 2003-04 derive from the DEC systematic surveys described above. The bulk of the remaining records derive from the licensed data sets of Birds Australia (Blakers *et al.* 1984 and Barrett *et al*. 2003) and the specimen register of the Australian Museum. Blakers *et al.* (1984) sightings involved designating a ten-minute spatial grid, based on easting and northing lines. All birds recorded from within this grid are then assigned to AMG co-ordinates at the centre of the grid, such that the data is not spatially accurate on a fine scale. This process was also used by some observers included in Barrett *et al.* (2003) though others provided information at a finer scale. The Australian Museum data derives from specimens submitted to the museum by members of the public, as well as from field trips undertaken by Museum staff specifically to collect fauna specimens. Early specimens in the register often have a low level of spatial and temporal reliability. For this reason, records from the Australian Museum prior to 1950 have been excluded from discussion in this report.

Remaining records within the Atlas of NSW Wildlife derive from observations made by: park rangers and field officers; catchment officers; bushwalkers and naturalists; scientific researchers working in the area; and other visitors to the park. These records have various levels of reliability depending on the type of observation, as well as the certainty and identification experience of the observer.

2.2 SURVEY STRATIFICATION AND SITE SELECTION

Between 1997 and 1999 CRA fauna surveys were undertaken within the park, primarily along roads on the Boyd Plateau and Black Range. Twenty-nine sites were established, at which a variety of systematic survey techniques were undertaken. In 2002 an extensive program was commenced to comprehensively and systematically survey fauna within the Warragamba Special Area. Thirty-three sites were established within Kanangra-Boyd NP over the summer of 2002-2003 as part of this program.

Gap analyses undertaken as part of the survey stratification and site selection for the 2003-04 survey season incorporated the above systematic surveys, to ensure that the data collected during 2003-04 would complement, rather than replicate, work that has previously been undertaken within the park. A total of four weeks of field survey was undertaken within Kanangra-Boyd NP over the summer of 2003-04.

The primary stratum used for site selection was vegetation type. Kanangra-Boyd NP is covered by a number of vegetation maps, of which two were used in the selection of fauna survey sites. For the area of park within the SCA Special Area boundary (eastern side of the park) the vegetation map and descriptions produced by the Central Conservation Assessment and Data Unit (NPWS 2003a) was used; for the remainder of the park, the vegetation map and descriptions produced by Southern Directorate CRA (NPWS 2000a). Each specific vegetation community within the park was placed into a broader flora group; vegetation communities that shared significant similarities in floristic composition, structure, topographic position and substrata were grouped together. Fauna survey site stratification was based on these broad flora groups, while aiming to sample the full variation of vegetation communities within each group as much as possible.

The preferable sampling strategy would have aimed to sample the mapped vegetation communities proportionately according to the mapped area of each community within the reserve *and* have included enough repeat sampling within each vegetation community to provide reasonable reliability

that potential variations within widespread stratum were captured. Such replication of sites serves to strengthen the reliability of patterns derived from collected data. The pre-trip site selection process aimed to fulfil this goal as much as possible. An analysis identified the previous systematic fauna survey effort undertaken within each vegetation community and broad flora group within the park. Vegetation communities that had not previously been sampled or had been under-sampled (where the amount of previous survey effort was less than that predicted by the proportional size of the community) were prioritised for sampling.

Sites were initially selected using ArcView, with information gained from topographic maps, vegetation maps, access trails, and location of previous survey effort. Sites were positioned primarily on or close to access trails to facilitate conduct of spotlighting and harp trapping surveys and to maximise the number of sites that could be accessed during the limited survey period. Due to time and budgetary constraints, broad flora groups that occupied less than 300 hectares of land within the park were not targeted for systematic replicated sampling (though some sites were established in some of these communities where possible). In the field, the proposed site locations were ground-truthed to ensure that they were representative of the mapped vegetation community, had not been significantly affected by recent burning or other habitat modification, and comprised a single vegetation community. If these criteria were not met, an alternative location was selected for the site. Systematic survey sites were 100 metres by 200 metres in area, and spaced a minimum of one kilometre from each other (two kilometres apart for nocturnal call playback surveys).

Selection of survey sites was extremely limited, at both stages of the process, by the steep and dramatic terrain of the park, the location of access trails, and the large amount of travelling time between areas. Consequently, considerable difficulties were met in locating survey sites that sampled the range of vegetation communities, maintained sufficient distance between sites to ensure they were independent from one another and could be accessed with a reasonable degree of efficiency. For these reasons, and because fauna survey is very labour intensive, not all communities within the park could be sampled to the desired extent. Vegetation communities that were restricted in extent and/or extremely difficult to access received comparatively fewer sites in proportion to their area. In particular, problems were encountered in surveying Grassy Red Gum-Box-Ironbark Woodlands, Montane Slopes Dry Forests and Dry Gorge Slopes Forest. Table 1 presents the area of each broad flora group (greater than 100 hectares in area) within the park and the corresponding survey effort for each fauna survey technique. Maps 2a and 2b show the location of fauna survey sites and the pattern of broad flora groups within the park. Appendix A provides the specific AMG, vegetation type and survey techniques of each survey site. The tables and figures include all systematic surveys undertaken within the park by DEC between 1997 and 2004.

2.3 SURVEY METHODS

The systematic fauna survey methods used were based on those developed by the NPWS Biodiversity Survey Coordination Unit (NPWS 1997). The systematic techniques described below were used to sample the following vertebrate fauna groups: diurnal and nocturnal birds, reptiles, bats, arboreal mammals, amphibians, and terrestrial mammals. Consistency in the use of these techniques allows comparison between fauna species detected across different vegetation types and environments within the park. Furthermore, it will allow future comparisons with consistent surveys of environments elsewhere.

Field survey teams were supplied with field proformas to facilitate comprehensive, consistent recording of field data and to increase accuracy and efficiency of data entry into the DEC Biodiversity Sub-system (BSS) of the Atlas of NSW Wildlife computer database. The names of observers and recorders were noted on every data sheet to aid data verification and entry.

2.3.1 Systematic site-based methods

Diurnal bird survey

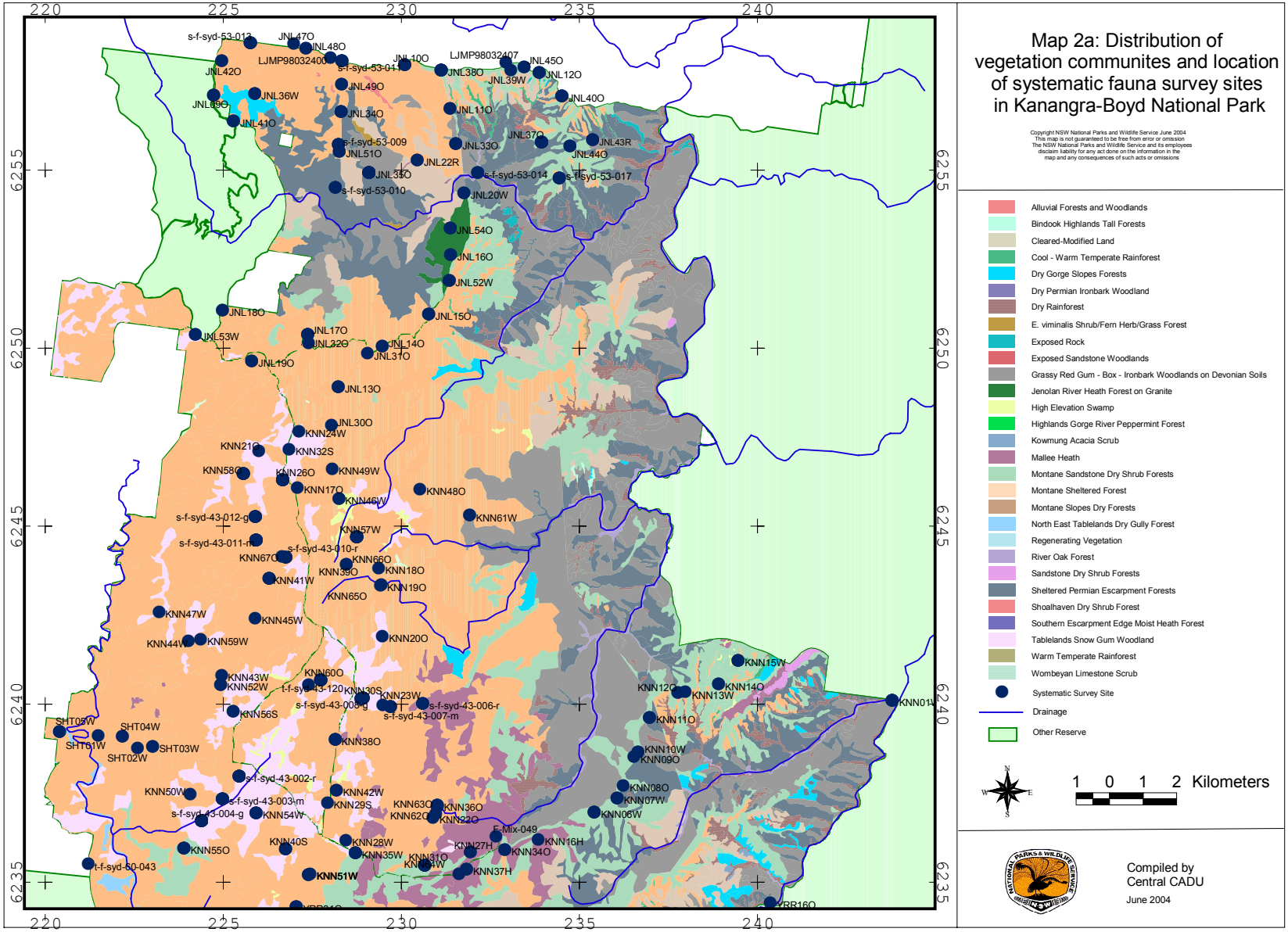
Diurnal bird censuses comprised a twenty minute observation and listening search within a two hectare (100 by 200 metre) area, conducted by an experienced bird surveyor. Censuses were conducted only during periods of relatively high bird activity (in the early morning) and reasonable detectability (eg. low wind and cicada activity). All bird species and abundance of individuals seen or heard were recorded. Individuals were scored as on-site if they were detected within the two hectare plot. Individuals recorded outside the plot, in adjacent vegetation types or flying overhead were recorded as off-site.

Table 1: Area of each broad flora group within Kanangra-Boyd National Park and corresponding allocation of systematic survey methods (includes systematic survey sites from CRA, SCA and Biodiversity Survey Priorities projects).

Broad Flora Group	Mapped area of vegetation community in park[1]	Proportion of park occupied by group (%)	No. of diurnal bird surveys	No. of diurnal reptile surveys	No. of site spotlight surveys*	No. of harp trapping bat sites	No. of ultrasonic bat detector sites	No. of nocturnal streamside searches for frogs	No. of owl call broadcast sites	No. of Elliott trap sites	No. of hairtube transects
Montane Sheltered Forest	23391	35.7	30	27	21	24	12	5	11	4	1
Grassy Red Gum - Box - Ironbark Woodlands on Devonian Soils	8263	12.6	4	4	2	1	0	0	0	0	0
Montane Slopes Dry Forests	7628	11.7	6	1	2	0	1	0	1	0	0
Montane Sandstone Dry Shrub Forests	7296	11.1	13	15	10	4	1	0	1	0	0
Sheltered Permian Escarpment Forests	5509	8.4	6	5	4	0	2	0	0	0	0
Dry Gorge Slopes Forests	4300	6.6	2	0	1	0	0	0	0	0	0
Tablelands Snow Gum Woodland	2553	3.9	6	5	2	11	4	1	4	0	2
Dry Rainforest	2335	3.6	3	4	1	1	2	1	0	0	0
Mallee Heath	1655	2.6	5	4	3	0	2	1	2	1	0
River Oak Forest	685	1.1	2	2	1	0	1	0	0	0	0
North East Tablelands Dry Gully Forest	262	0.4	0	0	0	0	0	0	0	0	0
Kowmung Acacia Scrub	254	0.4	0	0	0	0	0	0	0	0	0
High Elevation Swamp	215	0.3	0	1	0	0	1	0	0	0	0
Jenolan River Heath Forest on Granite	189	0.3	2	1	0	0	0	0	0	0	0
Sandstone Dry Shrub Forests	185	0.3	0	0	0	0	0	0	0	0	0
Bindook Highlands Tall Forests	182	0.3	0	0	0	0	0	0	0	0	0
Cool-Warm Temperate Rainforest	113	0.2	4	3	0	0	0	0	0	0	0
Vegetation Communities <100 hectares	478	0.7	0	0	0	0	0	0	0	0	0
Total	**65496**	100	**83**	**72**	**47**	**41**	**26**	**8**	**19**	**5**	**3**

[1] area based on GIS data layers, does not equal gazetted area of reserve

* Transect-based surveys are not included in table as these transverse a variety of vegetation communities. Seven spotlighting transects (range from 300 metres to eight kilometres) and four cage trapping transects have been undertaken within the park.


Map 2a: Distribution of vegetation communites and location of systematic fauna survey sites in Kanangra-Boyd National Park
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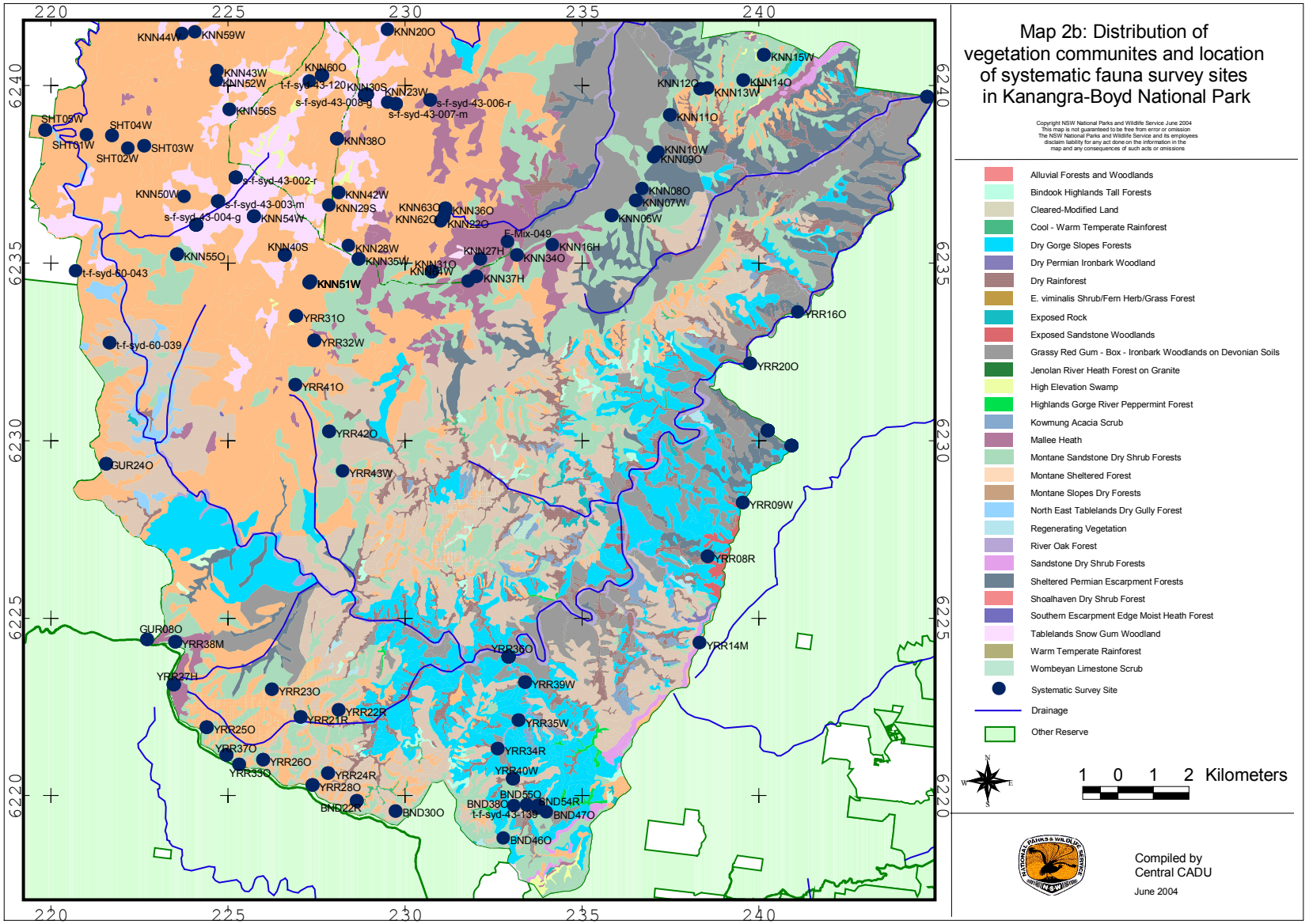
The NSW National Parks and Wildlife Service and its employees disclaim liability for any act done on the information in the map and any consequences of such acts or omissions
Alluvial Forests and Woodlands
Bindook Highlands Tall Forests
Cleared-Modified Land
Cool - Warm Temperate Rainforest
Dry Gorge Slopes Forests
Dry Permian Ironbark Woodland
Dry Rainforest
E. viminalis Shrub/Fern Herb/Grass Forest
Exposed Rock
Exposed Sandstone Woodlands
Grassy Red Gum - Box - Ironbark Woodlands on Devonian Soils
Jenolan River Heath Forest on Granite
High Elevation Swamp
Highlands Gorge River Peppermint Forest
Kowmung Acacia Scrub
Mallee Heath
Montane Sandstone Dry Shrub Forests
Montane Sheltered Forest
Montane Slopes Dry Forests
North East Tablelands Dry Gully Forest
Regenerating Vegetation
River Oak Forest
Sandstone Dry Shrub Forests
Sheltered Permian Escarpment Forests
Shoalhaven Dry Shrub Forest
Southern Escarpment Edge Moist Heath Forest
Tablelands Snow Gum Woodland
Warm Temperate Rainforest
Wombeyan Limestone Scrub
Systematic Survey Site
Drainage
Other Reserve
1 0 1 2 Kilometers
Compiled by
Central CADU
June 2004


Map 2b: Distribution of vegetation communites and location of systematic fauna survey sites in Kanangra-Boyd National Park
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Jenolan River Heath Forest on Granite
High Elevation Swamp
Highlands Gorge River Peppermint Forest
Kowmung Acacia Scrub
Mallee Heath
Montane Sandstone Dry Shrub Forests
Montane Sheltered Forest
Montane Slopes Dry Forests
North East Tablelands Dry Gully Forest
Regenerating Vegetation
River Oak Forest
Sandstone Dry Shrub Forests
Sheltered Permian Escarpment Forests
Shoalhaven Dry Shrub Forest
Southern Escarpment Edge Moist Heath Forest
Tablelands Snow Gum Woodland
Warm Temperate Rainforest
Wombeyan Limestone Scrub
Systematic Survey Site
Drainage
Other Reserve
1 0 1 2 Kilometers
Compiled by Central CADU
June 2004

Diurnal herpetofauna search

A standard half-hectare area subplot (50 by 100 metres) within a two hectare standard site was searched for one person-hour (standardised regardless of the number of persons searching). Censuses were restricted to the period between mid-morning to late afternoon, when temperature and insolation are sufficient to ensure maximum reptile activity. Surveying was not conducted on overcast or rainy days.

This census technique entailed active searching of potential reptile and frog microhabitats within the half-hectare area. Active or basking reptiles were identified by sight or captured and identified by the use of keys. Sheltering or cryptic species were detected by searching around, under and within fallen logs, litter, decorticating and fallen bark, rock outcrops and other likely shelter sites. Incidental observations of other fauna were also recorded.

Nocturnal site spotlighting survey

This census comprised searching for arboreal mammals along a 200 metre transect within a site for half a person hour. Fifty-watt spotlights were used to scan the vegetation for animals and enable detection of reflected eye shine. Surveyors also listen intently for fauna calls during the survey period. All fauna observed within the census period were recorded, noting whether they were on or off site.

Harp trapping

While ultrasonic recorders were used principally to detect high flying bat species, collapsible bat traps, known as harp traps (Tidemann and Woodside 1978), captured low flying species. Two nights of trapping were conducted at each bat trap site. Sites were selected for their perceived potential to interrupt bats along their flight paths, and were usually along tracks or in gaps between trees where adjacent vegetation might force bats to fly.

Traps were checked each morning. Captured bats were identified by external morphology, forearm measurement and body weight, and keyed out where necessary using Parnaby (1992a) and Churchill (1998). Animals were released on the following night at the point of capture.

Bat ultrasonic ('Anabat') call recording

Ultrasonic recorders (Corben 1989) are particularly useful for detection of high-flying species, which often comprise more than one third of an area's bat species (Parnaby 1992b), yet are under sampled by harp trapping (Richards 1992). The method requires the recording and identification of high frequency, echolocation "calls" made by bats, which, except for one or two species, are ultrasonic, that is, inaudible to humans.

<u>1997-2002 surveys</u>
The recording equipment for the surveys consisted of an Anabat II® detector and a tape recorder. Census duration was 30 minutes. Censuses began at or soon after dusk, and were conducted between then and up to two hours after dusk, a peak activity period for microchiropteran bats. A 40-kilohertz calibration tone was recorded for a few seconds at the start and end of each recording session and sometimes at intervals during the recording period.

<u>Current surveys</u>
The recording equipment for the surveys consisted of an Anabat II® detector and digital flash card recorder, housed within a tupperware box for weather protection. The box was set up in locations where bats were expected to fly, such as over water bodies, at cave entrances and along tracks. The Anabat was set to commence detection at dusk and turn off at dawn. During the night, a delay switch operated to turn on the recording device when bat activity was detected and then de-activate the device while no bat activity was occurring. The equipment was left in each location for one night only, then moved elsewhere.

Anabat recordings were transferred onto computer and analysed by Narawan Williams, a recognised expert in this field. Identification was designated as either definite, probable or possible, following the methodology of Parnaby (1992b). Calls that proved difficult to identify were also assessed by Michael Pennay (DEC Western Regional Assessments Unit) using the techniques described in Pennay *et al.* (2004).

Nocturnal streamside search

Streamside searches for frogs were undertaken for half a person hour in one of two ways: in stream or gully habitats a 200 metre stretch was searched; at standing water bodies a half-hectare (50 by 100 metre) area was surveyed. The searches were only conducted on warm, dark, humid and wet nights within two days of rain. All frogs, and other animals, identified visually or by call within the time period were recorded, together with the weather conditions at the time of the survey.

Nocturnal call playback

Nocturnal birds and mammals are often detected only when they vocalise for territory or social contact, behaviour which can be elicited by broadcasting specific calls. A standard survey census involved broadcasting the calls of each of the four large forest owls - Powerful (*Ninox strenua*), Masked (*Tyto novaehollandiae*), Sooty (*T. tenebricosa*) and Barking (*N. connivens*) - from the centre of a site. Prior to call broadcasts, on arrival at the site, the surrounding area was searched by spotlight for five minutes to detect any fauna in the immediate vicinity and then a ten-minute period of listening was undertaken.

A pre-recorded compact disc of each species' call series was played, amplified through a megaphone. Calls of each species were played for five minutes, followed by a five minute listening period. The surrounding area was again searched by spotlight after a final ten minute listening period. After the census, the response or presence of any fauna, date and time that response occurred, and weather details such as amount of cloud cover was recorded. Very windy and rainy periods were avoided where possible. Censuses conducted in poor weather were noted.

Elliott trapping

This technique involved setting Elliott B traps at twenty metre intervals along a 200 metre transect through a site. Traps were baited with a mixture of peanut butter, oats and honey. Traps were left in place for four nights, checked and emptied every morning soon after dawn. Any animals captured within the traps were identified, sexed if possible, and released.

Hair-sampling tubes

Ten large hair-sampling tubes (nine centimetre diameter, after Scotts and Craig 1988) were placed in transects at approximately twenty metre intervals along a 200 metre transect. Alternative tubes were baited with meat or a mixture of peanut butter, honey and rolled oats. Each tube was fitted with adhesive paper to collect hairs of small and medium sized mammals that were attracted to the bait. Tubes were left on site for ten nights. Hair samples were identified by specialists using the techniques described by Brunner and Coman (1974) by an expert in the field, Barbara Triggs. Identifications were classified into three levels of reliability: definite, probable and possible.

2.3.2 Transect-based methods

Transect spotlighting survey

The method employed varied on a site by site basis, and was only undertaken during the CRA surveys. A team of two surveyors walked or drove along a transect, varying between 300 metres and eight kilometres in length, searching for arboreal mammals with 50 watt spotlights. An AMG was calculated for each sighting along the transect and entered into the data sheet.

Cage trapping

This technique involved setting large cage traps at 200 metre intervals along a two kilometre transect. The technique is designed to target medium-sized ground mammals, particularly Spotted-tailed Quolls (*Dasyurus maculatus*). Locations were selected to maximise the number of habitat types sampled and increase the chance of intersecting a Spotted-tailed Quoll home ranges. Traps were alternately baited with chicken and fish. Traps were left in place for four nights, checked and emptied every morning soon after dawn. Any animals captured within the traps were identified, sexed if possible, and released. This technique was only undertaken in June 2004 on the Boyd Plateau.

2.3.3 Targeted survey for Eastern Bent-wing Bat at Colong Caves

In January 2004 a targeted survey was undertaken at Colong Caves in order to: determine whether the system contains a maternity roost for the Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*); locate important roost areas within the cave; and identify important sites within the system in order to guide future management decisions.

The survey was undertaken using four different methods: harp trapping; searching each accessible cave for roosting bats or evidence of bat activity; fly-out counts; and bat ultrasonic ('Anabat') call recording. Harp traps were erected in the Grand Arch and in the first chamber of C3 (the upper passageway) on the 12th January 2004 and left in place overnight. An Anabat detector was set at the entrance of C2 overnight on the 12th January, in order to confirm the identification of bat species using that section of the cave system. On the 13th January the cave system was investigated by walking through and recording every location where bats were observed or where guano was present. Most of the chambers that bats were likely to use or be able to fly through were examined, including High Cave, Lizard Cave, King Solomon's Temple, Dripping Cave, Landslide Cave, Amber Cave, Crystal Pool, C1 and C2. The limit of this investigation was Pulsating River, which is approximately 320 metres from C3 cave entrance. Finally, on the evening of the 13th January the entrances of C1 and C2 were watched, and a visual fly-out count of Eastern Bent-wing Bats and Eastern Horseshoe-bats (*Rhinolophus megaphyllus*) was undertaken.

2.3.4 Targeted surveys for Brush-tailed Rock-wallaby

Staff from DEC Oberon Office are currently undertaking a program of targeted Brush-tailed Rock-wallaby (*Petrogale penicillata*) surveys. The surveys involve visiting potential Brush-tailed Rock-wallaby habitat on foot and by helicopter, searching for individuals, scats or other traces of the animals. The first survey was conducted in autumn 2000, at Ironmonger Spur, Scrubbers Hump, lower Jenolan Gorge and Gubba Gully. This was followed by a survey in mid 2002 in the areas of Grand Bluffs, Goolara Peak, and Quartpot Gully (M. Jones pers. comm.). The latest survey was undertaken in December 2003, within the area roughly bounded by Goolara Peak, Black Creek, Scrubbers Hump and Ironmonger Gully (M. Jones pers. comm.).

2.3.5 Opportunistic methods

Predator and herbivore scat collection

The large numbers of hairs, and occasionally skeletal remains, in predator scats and pellets results in a high level of confidence in identifications of prey species and is hence an efficient sampling technique for prey animals. In addition, the recording of predator or non-predator scats constitutes records for the species that deposits the scat, providing locality records for species such as the Spotted-tailed Quoll, Fox (*Vulpes vulpes*), Dingo (*Canis lupus dingo*), Dog (*Canis lupus familiaris*) and Pig (*Sus scrofa*). Due to the unmeasurable time delay between prey ingestion and defecation, the location in which the prey animals lived cannot be accurately known, so this technique is useful only for detecting the species presence within a general area. Lunney *et al.* (2002) showed that on average Dogs and Foxes defecate within a two kilometre radius of the site of prey ingestion.

Predator scats were collected, placed in paper envelopes, labelled and sent to specialist Barbara Triggs for analysis, using the methods described previously for hair tube samples.

The location of herbivore scats was also noted on an opportunistic basis to indicate the presence of an animal. If there was any doubt in herbivore scat identification in the field, samples were brought back for identification by an expert.

Incidental records

Surveyors driving or walking through the park recorded the location of interesting fauna when it was seen or heard. Particular animals targeted by this technique were those undersampled by systematic surveys, including large ground mammals, non-vocalising birds, and secretive, shy and/or rare animals. The date, time, map grid location (usually obtained from a GPS) and microhabitat of the animal were recorded on a data sheet.

2.4 SURVEY TIMING

As indicated above, systematic field surveys have been undertaken within Kanangra-Boyd NP over a number of years. Table 2 summarises the timing of these surveys and the techniques that were undertaken in each season.

Table 2: Timing of DEC systematic fauna surveys within Kanangra-Boyd National Park.

Survey program	Timing	Techniques employed
Comprehensive Regional Assessment (CRA)	February – March 1997 and February 1998	Bird census, reptile search, transect spotlighting, harp trapping, 30 minute bat call detection, streamside search, hair tubes, nocturnal call playback, opportunistic methods
	September 1998	Nocturnal call playback
Warragamba Special Area Surveys – Year 1	December 2002 – March 2003	Bird census, reptile search, site spotlighting, opportunistic methods
	April – June 2003	Nocturnal call playback
Biodiversity Survey Priorities Fauna Surveys	December 2003 – January 2004	Bird census, reptile search, site spotlighting, harp trapping, overnight bat call detection, streamside search, Elliott trapping, targeted survey for Quoll, targeted survey for bats at Colong Caves, opportunistic methods
	June 2004	Cage trapping, Elliott trapping, nocturnal call playback
Warragamba Special Area Surveys – Year 2	January 2004	Bird census, reptile search, site spotlighting, harp trapping, overnight bat call detection, streamside search, Elliott trapping, opportunistic methods