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Fauna study of Ettamogah Forest 1994-2000

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EXECUTIVE SUMMARY

This report presents the results of the first seven annual fauna surveys and 42 bi-monthly bird surveys conducted on two properties in and around Ettamogah Forest, north of Albury, NSW, from October 1994 to December 2000. These studies were conducted by researchers and students of the Johnstone Centre, Charles Sturt University, and employed sampling methodologies for terrestrial vertebrate fauna in the full range of environmental strata present. The suite of survey techniques used in this study are believed to have revealed the presence of most, if not all, vertebrate fauna species present on the properties and surrounds. Sampling methodologies specifically targeted birds because they are effective bio-indicators (sensitive to variations in landscape configurations) and because avian surveys are easily repeatable for future comparisons.

Combined, the two properties comprise five different ages of softwood plantation (*Pinus radiata*) planted in 1989, 1992, 1993, 1994 and 1995. Some areas of remnant vegetation on the northern side of the Norske Skog Papermill dominated by Red Box (*Eucalyptus polyanthemos*), White Box (*Eucalyptus albens*), River Red Gum (*Eucalyptus camaldulensis*) and Blakelys Red Gum (*Eucalyptus blakelyi*) were included in the surveys. The remainder of the site is dominated by introduced pasture species and weeds. Scattered remnants of native vegetation also exist along water courses, roadways and ridges, while some enrichment plantings of native trees and shrubs have also been established in areas along the perimeter of the pine plantations and water courses.

Pine plantations are sometimes referred to as biological deserts because of their inability to support native wildlife (Recher 1986). However, this study has revealed that pine plantations are capable of supporting a number of wildlife species. Coupled with strategic plantings of native vegetation and in the vicinity of large water-bodies, Ettamogah Forest and surrounds appears to provide the structural habitat requirements for a large array of terrestrial vertebrates. Indeed, this study recorded 22 species of mammals (including three arboreal and nine bat species), 184 bird species, 14 reptiles and 14 frogs in the area.

The native (mixed species) enrichment plantings present around the edges of some of the pine plantations within Ettamogah Forest provide a higher bird diversity than the pine plantations alone. Still, the pine plantations have a higher diversity of bird species than the cleared agricultural land, which the properties formerly comprised. The dams on the properties also support a high diversity of waterbird species. This study has revealed that the main dam may be the most important wetland for waterbirds in the Albury-Wodonga region, with 83 species recorded, only comparable to the newly-created Wonga Wetlands in West Albury.

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1. INTRODUCTION

As part of the commitment of Norske Skog Paper Mills (Australia) Ltd (formerly Fletcher Challenge Albury) to environmentally sensitive development of their properties, a long-term study of the terrestrial vertebrate fauna of Ettamogah Forest and surrounds commenced in October 1994. This report presents the results of the fauna studies completed up until December 2000, and discusses the changes in fauna populations that have occurred with the conversion of cleared agricultural land to pine plantations.

Large areas of cleared and previously uncleared land have been established with Monterey Pine (*Pinus radiata*) throughout Australia. Many studies have concluded that pine forests are structurally and floristically inferior to native vegetation (eg. Davidson 1976, Fisher *et al.* 1998, Gepp 1986 & Suckling *et al.* 1976). Pine forests do not provide nectar or suitable nesting hollows like native forests and the needle-like foliage is different to the broad-leaf, blade-like leaves of most native trees (Gepp 1986). Pine plantations are essentially a monoculture of single tree species, but native forests, consist of many species and many structural layers (Gepp 1986 authors).

However, there have been few studies of the functionality of pine plantations as ecosystems, and the diversity of fauna that can be supported under different planting regimes. Some studies have compared the biodiversity of pine plantations to that of native vegetation, but few have considered the possible benefits to biodiversity of pine plantations compared to cleared land.

This study documents the changes in biodiversity in pine forests and newly planted native vegetation over several years. This has allowed more thorough comparison to be made among different ages of plantations, as well as affording an opportunity to determine the habitat values of pine plantations over the longer term. This report includes and updates the data presented in earlier reports of the fauna of Ettamogah Forest (Klomp and Costello 1997). It is expected that this study will continue for ten years, to allow a thorough examination of long term changes in the faunal biodiversity supported by Ettamogah Forest.

2. STUDY AREA

The study area is located approximately 5 km north of Albury (off the Hume Highway), as shown in Figure 2.1. It is made up of two properties, both owned by Norske Skog Paper Mills (Australia) Ltd, as described below.

- The 'Maryvale property'; now known as Ettamogah Forest, is located to the east of the Hume Highway. It consists of approximately 290 ha of pine and 50 ha of native vegetation. This property contains all dam sites in the study area except one.
- The area of land on the northern side of the NSPM is situated west of the Hume Highway and consists of approximately 35 ha of pine, 6 ha of native enrichment planting and remnant vegetation. This area includes a public reserve largely consisting of remnant open woodland with some native enrichment plantings. It is also used as a travelling stock route from year to year.

Combined, the properties comprise of three main vegetation types: *Pinus radiata* plantations, remnant vegetation and enrichment plantings of native species. The pine plantations consist of five different ages of softwood plantation (*Pinus radiata*); they were planted in 1989, 1992, 1993, 1994 and 1995 (see Figure 2.2). The remnant vegetation contained within the public reserve is dominated by Red Box (*Eucalyptus polyanthemos*), White Box (*Eucalyptus albens*), River Red Gum (*Eucalyptus camaldulensis*) and Blakelys Red Gum (*Eucalyptus blakelyi*). The remainder of the site is dominated by introduced pasture species and weeds. Scattered remnants of native vegetation also exist along water courses, roadways and ridges, while some enrichment plantings of native trees and shrubs have also been established in areas along the perimeter of the pine plantations and water courses.

During the course of the study several of the study sites/vegetation types were modified, either directly as a result of management practices (eg thinning and harvesting of pine plantations) or indirectly as a result of weather conditions (eg wind storms and fire). Table 2.1 lists all the study sites/vegetation types and modifications that may have occurred during 1994-2000.

Rainfall data have also been included in this report (Table 2.2) to help elucidate the relationship between species presence and seasonal variations.

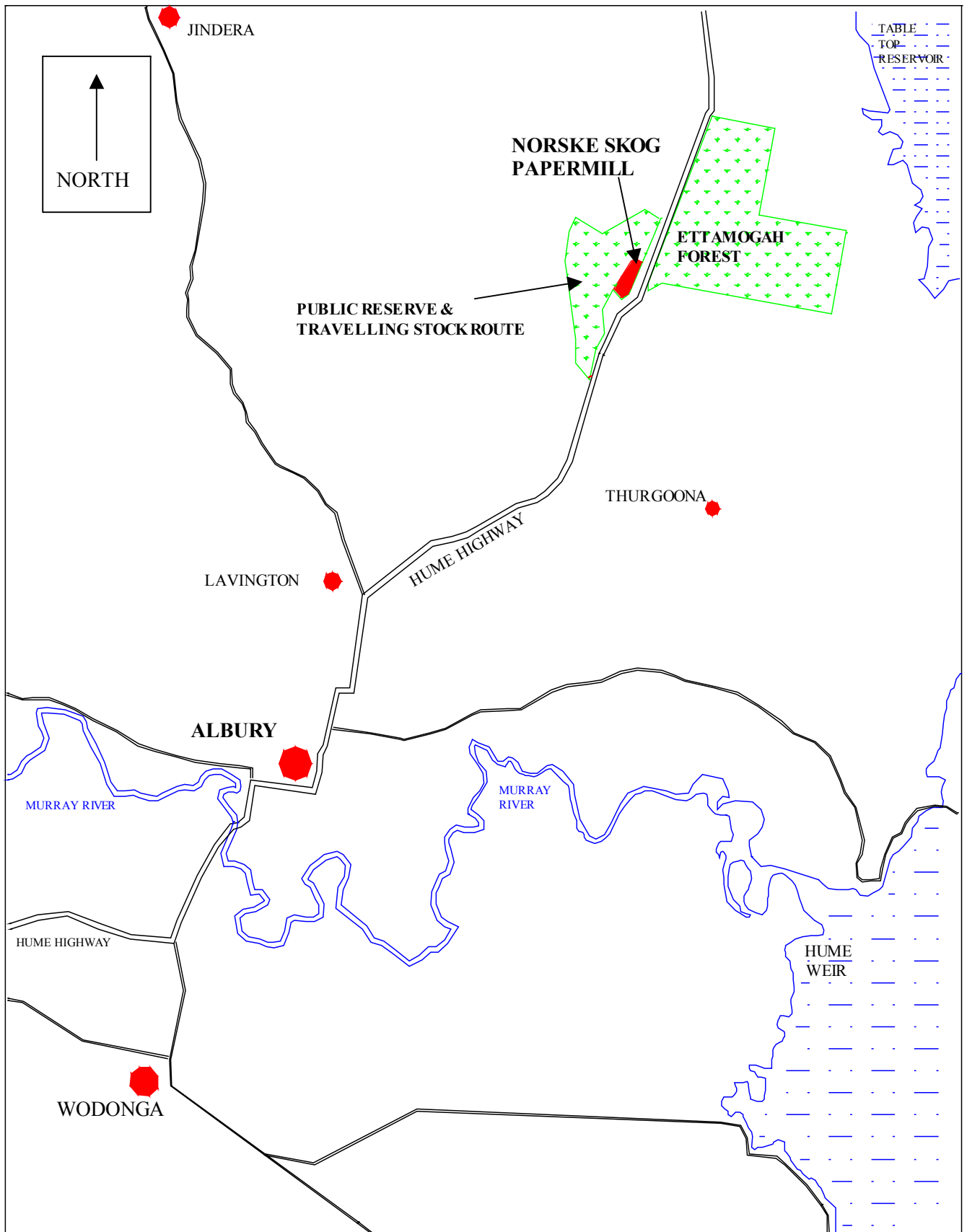


Figure 2.1. Locality map of Ettamogah Forests and surrounds

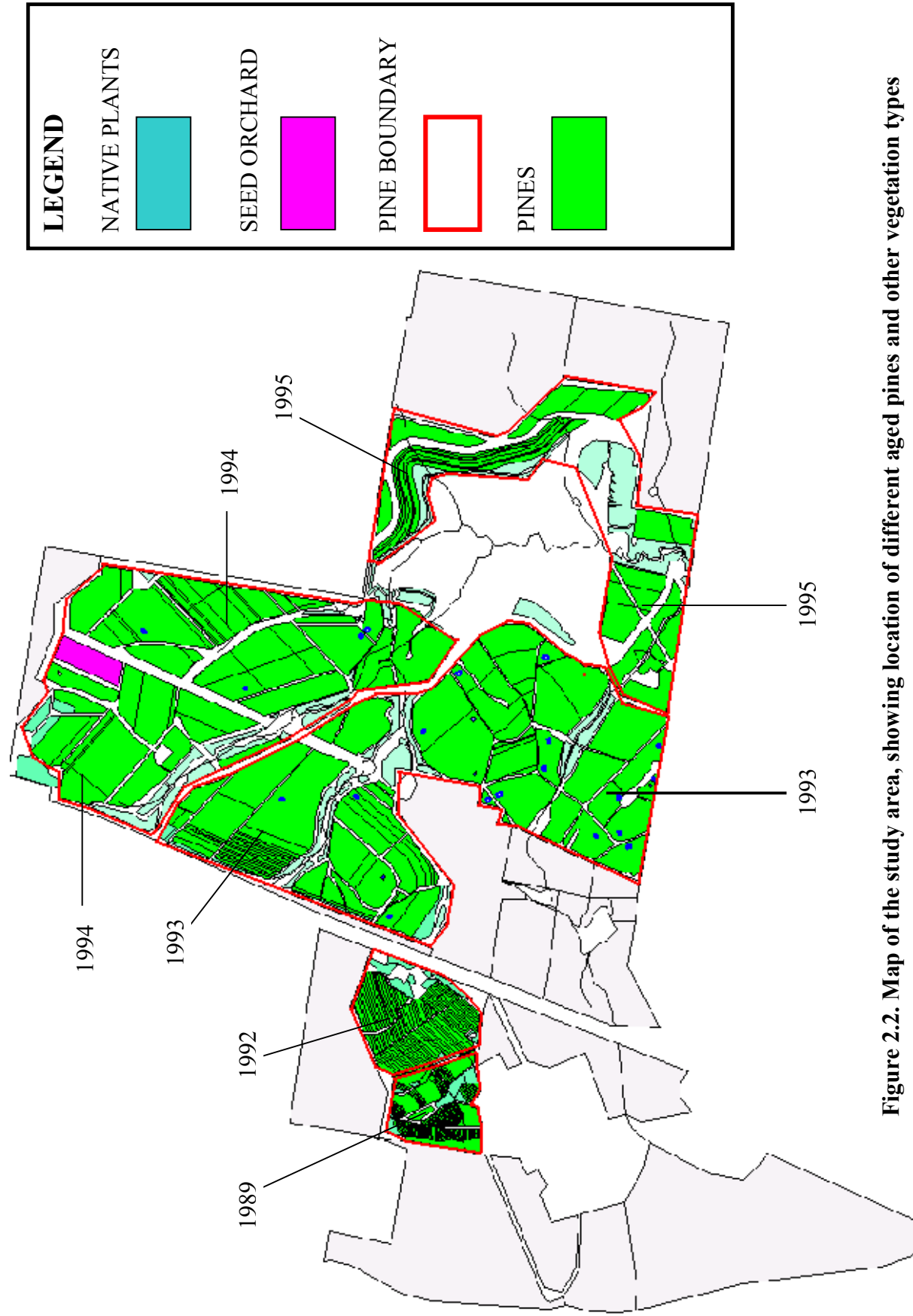


Figure 2.2. Map of the study area, showing location of different aged pines and other vegetation types

Table 2.1 Modifications to vegetation in the study area.

Code	Vegetation type/description	Year planted	Approximate height in 2000	Modifications/changes
P1 (both)	<i>Pinus radiata</i>	1994	8-10 m	No modifications
P2 (A,B,C)	P2 (A,B,C) <i>Pinus radiata</i>	1993	13-15 m	No modifications other than some pruning for access purposes
P3	P3 <i>Pinus radiata</i>	1992	15-17 m	Consists of irrigated and unirrigated pines All irrigated pines are pruned All unirrigated pines are unpruned These pines will be thinned every fifth row this coming autumn (2000)
P4	<i>Pinus radiata</i>	1989 original 1998/99 replanted	17-20 m 0.5-1 m	Consist of the original trial plantations and replantings as a result of wind damage in 1998. Original trials consist of irrigated and unirrigated areas. All were thinned in 1997.
C1	Cleared land, occasional remnant tree			No longer all cleared land, now consists also of enrichment plantings, Eucalyptus were planted in 1993, 1994 or 1995.
E1	Eucalyptus spp.	1994 approximately	N/A	Eucalyptus and mixed native species enrichment plantings
E2	Eucalyptus spp.	1986 approximately	15 m	Consist of mixed eucalypts and other natives planted by the Albury Wodonga Development Corporation and some remnant vegetation as well.
E3 mill site Ettamogah Forest	Remnant Eucalyptus	N/A Planted in 1993 1994 1995	Various 5-10 m	The mill site is a travelling stock reserve which is still used. It largely consists of remnant vegetation, in the form of open woodland with eucalypts and an understory of juveniles and Acacias. Ettamogah forest consists of a mix of native trees and shrubs, mainly concentrated in riparian zones. Much of this are was burnt by fire in 1998.
Dams D1	Lake Ettamogah	Built and planted 1994/95	5-10 m	Lake Ettamogah was fringe planted with Red Gums when built.
D2	Nine Mile Creek	1994		This dam was constructed as part of the effluent reuse scheme with <i>Phragmites</i> for habitat and erosion control.
D12	Dam Mill Site			This site has been modified from grazing to an extent as it is part of the travelling stock reserve.

Table 2.2 Rainfall (in mm) recorded at Ettamogah Forest gauge (1995-2000).

Year	Month												
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	TOTAL
1995	-	-	-	-	-	-	155.2	49.4	32.4	93.6	124.6	17.0	472.2
1996	97.0	54.5	39.5	25.0	61.0	102.0	101.5	88.5	99.0	43.0	71.0	37.5	819.5
1997	47.0	12.0	46.0	7.0	83.0	21.2	18.0	86.4	59.5	46.0	16.0	8.5	450.6
1998	4.8	20.5	0.0	78.5	10.0	65.0	84.0	58.5	131.5	38	82.5	17.1	590.4
1999	87.0	4.5	95.0	34.0	98.5	70.5	42.0	93.0	41.5	72.0	43.0	168.5	849.5
2000	8.0	56.5	53.5	69.3	142.0	85.0	65.5	95.0	114.0	79.0	34.2	14.5	816.5

(Source: Dahl 2001)

3. GENERAL METHODOLOGY

Eight terrestrial survey plots were selected (Figure 2.2), one in each of the four different ages of pine plantation and one in a 12 year-old native vegetation, one in a 14 year-old native vegetation corridor, one in remnant native vegetation and one in cleared farmland. These survey plots represent the range of ages, physical attributes, and habitat types that exist on the properties. Exact survey sites within each of these vegetation associations were determined by habitat characteristics, such as proximity to water, presence of fallen timber and mature trees, etc. The larger dams and water bodies were also studied to monitor the populations of waterbirds. Table 3.1 lists the specific faunal survey techniques used at each of the sites.

An annual fauna inventory was conducted in late spring every year since 1994. These annual fauna inventories involved a five day (four night) survey to determine the full array of terrestrial vertebrates present on the property. These data were then used to document the change in fauna populations from year to year.

In addition to the annual fauna surveys bird surveys were conducted every two months from October 1994. Birds were the focus of these surveys because they provide an indication of short term changes to faunal composition on the properties largely reflecting successional changes in vegetation structure.

The full fauna surveys and the bird surveys were conducted in the four different age stands of *Pinus radiata* (those planted in 1989, 1992, 1993 and 1994) as well as in remnant native vegetation, mixed species enrichment plantings, and on the dams and cleared farmland. All the sites listed in Table 3.1 were surveyed in the bimonthly bird surveys.

Specific methodologies used in this study are described in more detail in following sections. Standard survey techniques broadly follow Reardon & Stanely (1987), Swan (1990), Cronin (1991) and York *et al.* (1991).

Table 3.1. Techniques used at each survey site in the study area in the annual fauna surveys. All these sites were surveyed in the bimonthly bird surveys.

Site	Vegetation type	Survey techniques
Ettamogah Forest		
Site F	P1 (A)	Pitfall line, Elliott grid (4x4), cage trap, hair tubes (20), active reptile search, bird survey transects.
Site G	P3	Elliott grid (4x4), cage trap, bird survey transects.
Site H	P2	Elliott grid (4x4), cage trap, bird survey transects.
Site J	E1	Elliott grid (4x4), cage trap, bird survey transects.
Site D1	Dam	Bird survey transect.
Site D2	Dam	Frog survey transect, bird survey transect.
Site D3	Dam	Frog survey transect, bird survey transect.
Site D6	Dam	Frog survey transect.
Site K	E1	Spotlighting, bird survey transect.
Site L	C1	Active reptile search, bird survey transect.
Land on the northern side of the NSPM		
Site M	E3	Pitfall line, Elliott grid (4x4), cage trap, hair tubes (20), spotlighting, active reptile search, bird survey transects.
Site D12	Dam	Frog survey transect, bird survey transect.
Site N	E2 (A)	Harp trap, Elliott grid (4x4), cage trap, active reptile search, bird survey transect.
Site Q	P4	Harp trap, Elliot grid (4x4), cage trap, bird survey

4. MAMMALS, REPTILES AND AMPHIBIANS

4.1 Mammal survey techniques

In the annual fauna surveys, terrestrial mammals were surveyed using folding aluminium Elliott traps (33 x 10 x 9 cm). Grids of 4 x 4, with traps 10 m apart, were placed at seven survey sites (see Table 3.1). The traps were baited with a standard bait of rolled oats, peanut butter and honey wrapped in gauze. Large cage traps (75 x 40 x 40 cm) were also placed at each survey site and were baited the same way. The traps were used for a total of four trapping nights in each annual spring survey. Each trapping site was checked every morning for the duration of the survey.

Twenty baited hair tubes were placed 2 m apart in a line adjacent to the trapping grids on two sites, one within the remnant vegetation (site E3) and the other within a softwood plantation (P1). The hair tubes were left at each survey site for a period of five days prior to being retrieved and the contents analysed. The hair tubes were primarily used to detect animals that are known to be trap shy.

Bat surveys were conducted using harp-traps and ANABAT ultrasonic call equipment. The purpose of employing two methods to detect bat species within the study site was in order to determine, below canopy flyers using harp traps and above canopy flyers using ultrasonic detectors. Two harp traps were utilised, one within the remnant vegetation (site E2) and the other within a softwood plantation (P4). These traps were placed in specific areas likely to intercept free-flying bats. A total of four trapping nights were used in each annual spring survey. Recordings of the ultrasonic calls of free-flying bats were made annually at sites E3, P1 and P4.

Arboreal mammals and nocturnal birds were detected using spotlight transect surveys. Each transect was walked by two observers holding spotlights, at night, adjacent to transects or in areas of similar vegetation. Each spotlight transect was 300 m long and was completed within 30 minutes. Transects were conducted in all native vegetation types.

Records were kept of any incidental observations, as well as the presence of scats and other signs of the presence of vertebrate fauna, such as footprints, nests and burrows, tree scratchings, carcasses and bones.

4.2 Reptile and amphibian survey techniques

Areas were identified on the property as likely sites to yield the highest diversity of reptile species, based on slope, aspect and presence of ground cover such as rocks and debris. Most of these areas were adjacent to survey sites. The areas were surveyed for reptiles using standard active searching techniques ('rock rolling') and pitfall lines. The amount of effort for each of the surveys varied from year to year. Lines of pitfall traps were established at each site, consisting of five buckets dug into the ground five metres apart and connected by drift fencing.

A number of wet areas on the properties (eg. dam sites and water courses) were identified as providing suitable habitat for frog species. These were surveyed using the spotlighting triangulation method (with two people), actively searching, and by identification of frog calls using tape recorders at each of these areas over the four nights each year.

4.3 Summary of results

The total number of mammal, reptile and amphibian species recorded each year has gradually increased from 1994 to 2000 (Table 4.1). During the course of the six annual fauna surveys a total of 50 species were recorded in the study area. In 1998, for example, a total of 29 species were recorded, of which, 25 were native and four were introduced species. The numbers presented include all recordings taken as a result of the survey techniques employed during the annual fauna surveys, including incidental sightings. No mammals, reptiles or amphibians listed in the New South Wales *Threatened Species Conservation Act 1995* were recorded during the surveys.

Although the initial surveying did not start until October of 1994, this year has been included in the analyses because species diversity is at its peak at this time of the year, so the survey in 1994 was still representative. All tabulated results for the annual fauna surveys (1994-2000) can be found in Appendix 4-9 (CD inside back cover).

In addition to the nine bat species (Chiroptera), 13 mammal species, including seven introduced species were recorded (Table 4.1). The six native species were recorded only in native vegetation sites E1, E2 and E3, unlike the introduced species, which were recorded in both pine plantation (P1, P3 and P4) and native vegetation (E2 and E3). This can be seen in Figure 4.1. A full species list of all animals recorded in the study area is presented in Appendix 1.

Table 4.1 Number of mammals, reptiles and amphibians recorded during annual fauna survey (1994-2000).

Year	Number of species							
	Ground dwelling species	Arboreal mammal species	Bat species	Reptile species	Amphibian species	Introduced species	Native species	Total number of species recorded
1994	2	2	3	7	5	1	18	19
1995	2	2	5	4	7	2	18	20
1996	3	2	4	8	7	3	21	24
1997	5	3	6	6	6	3	23	26
1998	4	3	8	5	9	4	25	29
1999	5	3	5	6	5	2	22	24
2000	3	2	2	5	3	2	13	15
Total number of species	10	3	9	14	14	7	43	50

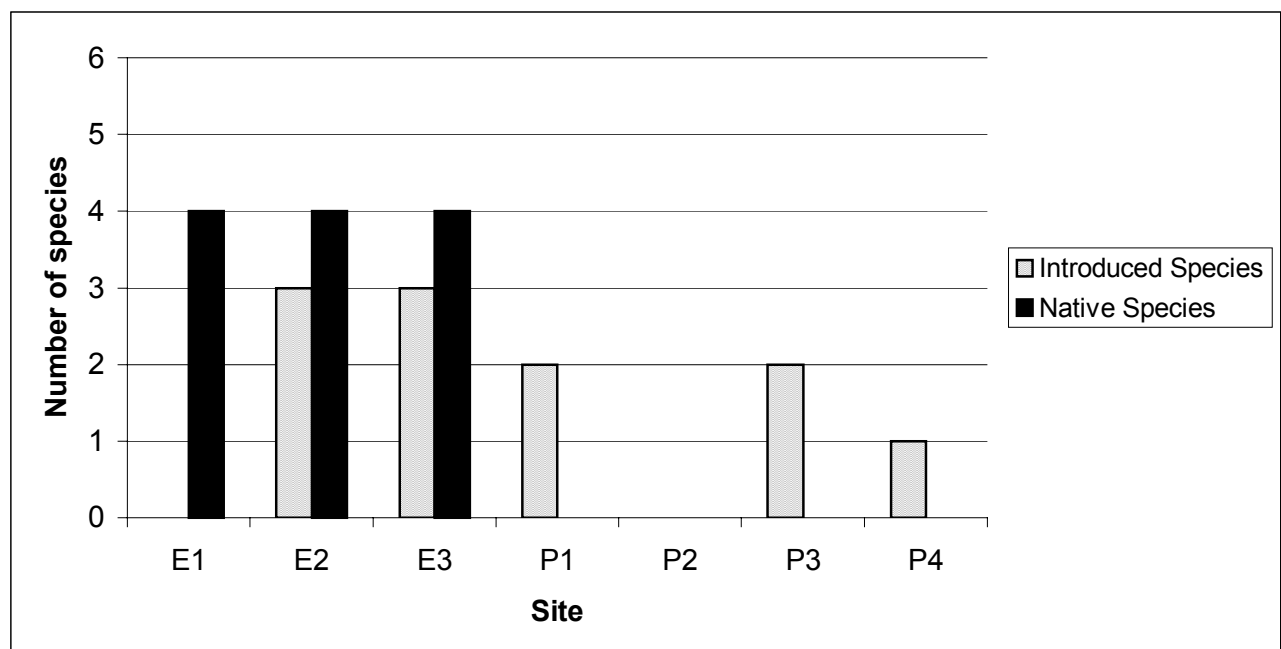


Figure 4.1. Number of mammal species (excluding bats) found within pines and native vegetation during the annual fauna surveys (1994-2000).

4.4 Mammals

A total of 22 mammal species were recorded at the properties including incidental sightings. All tabulated results of the terrestrial mammal, arboreal mammal, bat and hair tube surveys (1994-2000) can be found in Appendix 4-7 (CD inside back cover). Four small ground mammal species, nine bat species and three arboreal mammal species were recorded in the survey sites. Analysis of the recorded echolocation calls of free-flying bats yielded five distinguishable calls.

It can be seen from Figure 4.2 that the number of mammal species recorded during the course of the study has generally increased over time. In 1998, 15 mammal species were recorded, which represents the largest sample to date (Table 4.1). The majority of small ground dwelling mammals recorded were introduced species (Brown Rat, Black Rat and House Mouse). Although several native ground dwelling species were recorded (Kangaroo and Short-beaked Echidna), only one of these was a small ground dwelling species (Yellow-footed Antechinus). This species was recorded in 1997 1999 and 2000. All recordings were at the same site, E3 remnant vegetation. Native ground dwelling species were almost exclusively recorded in native vegetation, while introduced ground dwelling species were recorded in both pine plantation and native vegetation sites (Figures 4.1 and 4.2).

Of the nine bat species recorded, eight were recorded within the two pine plantations sites (P1 and P4). All nine were recorded within the two native vegetation sites (E2 and E3). Generally, the number of species recorded since the initial fauna survey has increased (see Figure 4.3). The largest sample of species was recorded in 1998 with eight species being recorded (Table 4.1). The majority of species were found within the native vegetation sites, yet six species were recorded between the two pine plantation sites.

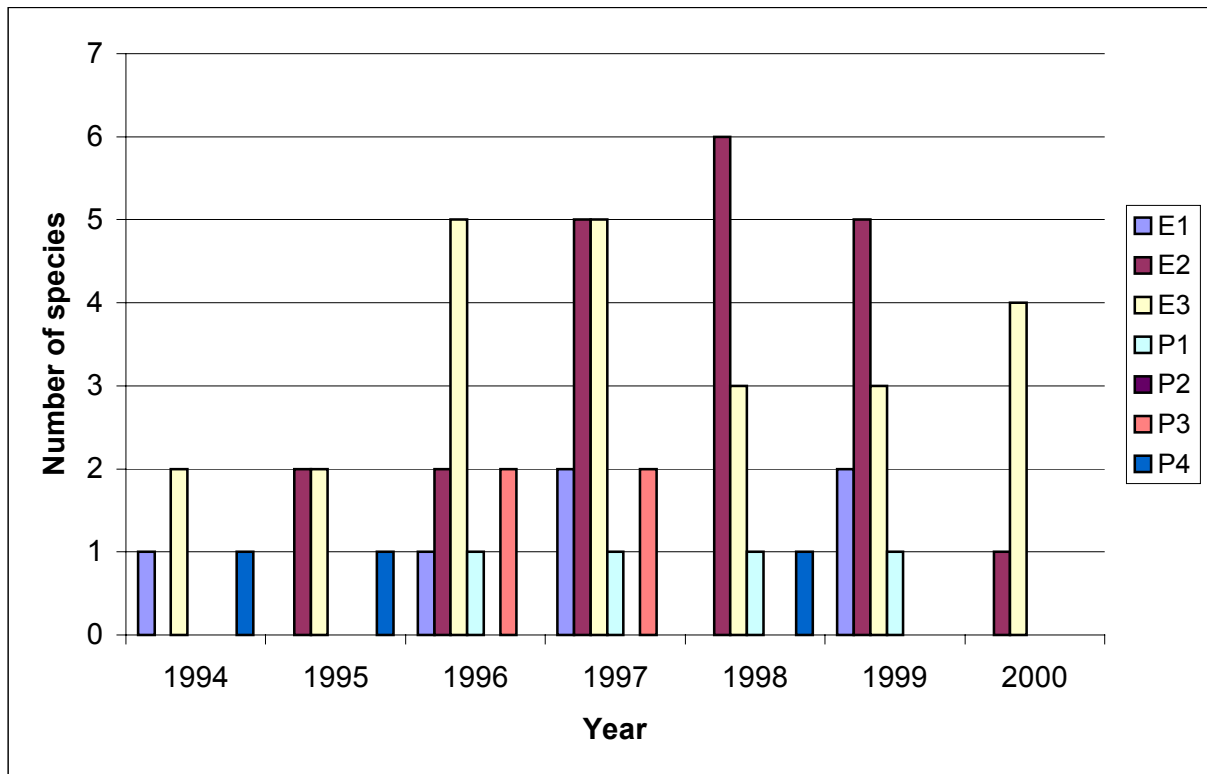


Figure 4.2. Number of mammal species (excluding bats) recorded at each site during the annual fauna surveys (1994-2000).

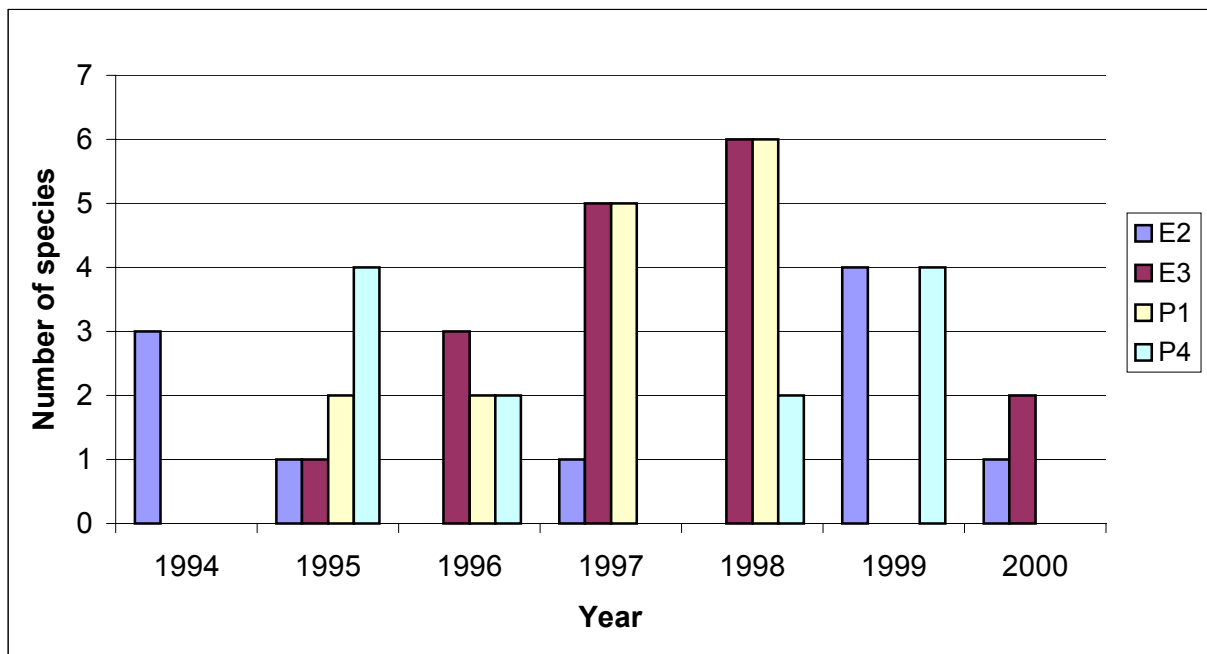


Figure 4.3. Number of bat species recorded at each site during the annual fauna surveys (1994-2000).

4.5 Amphibians and reptiles

The amphibian surveys have revealed the presence of 14 different species in Ettamogah Forest and surrounds (Table 4.1). All tabulated results of the reptile and amphibian surveys (1994-2000) can be found in Appendix 8 and 9 (CD inside back cover). Of the five dams surveyed in the study D12, located in the public reserve, north of the mill has yielded the largest sample of species. This site has consistently recorded the largest sample of species each year since the beginning of the study, apart from 1999 (Figure 4.4). This dam is located in close proximity to the remnant vegetation contained within the study area.

It can be seen from Table 4.1 that 14 reptile species were recorded in the study to date. The majority of species were present in remnant vegetation largely site E3, north of the mill. The largest sample of species was recorded 1996, with eight species (Figure 4.5). The pitfall traps proved to be unsuccessful in catching reptiles and mammals throughout the duration of the surveys, although several frog species have been captured using this technique. It is recommended that this method continue in future spring surveys. No reptile surveys were conducted in pine plantation sites.

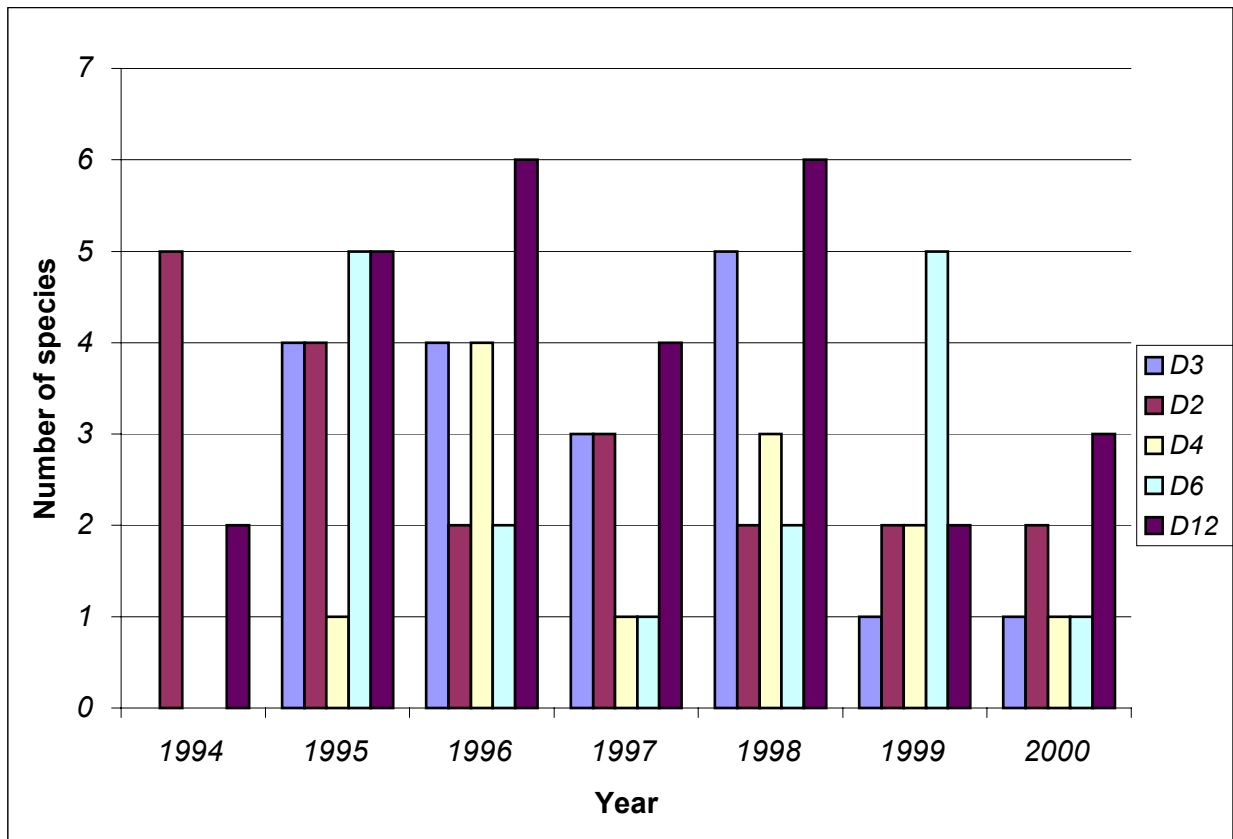


Figure 4.4 Number of amphibian species recorded at each site during the annual fauna surveys (1994-2000).

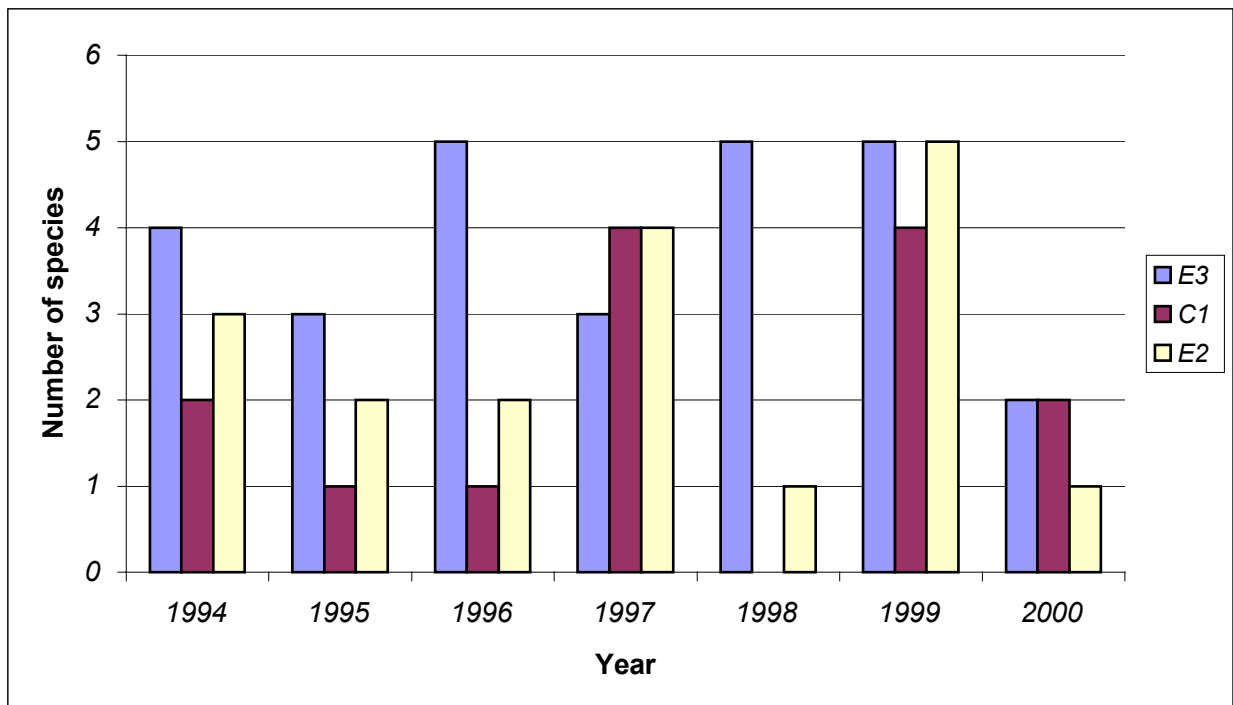


Figure 4.5 Number of reptile species recorded at each site during the annual fauna surveys (1994-2000).

5. BIRDS

5.1 Birds as biological indicators

Biological indicators (bioindicators) are those species which indicate the condition of the environment (Spellerberg, 1991). Ecological indicators are organisms used to indicate the state of some variable, or sets of such in the environment, where their direct measurement is too costly, difficult or time consuming. Physical changes and disturbances in environmental variables will result in a change in the species composition of the biotic community. These changes can then be used to monitor the state of the environment. Studying biological indicators will assist in documenting changes in faunal assemblages following an environmental change (in this case, altering habitat from cleared agricultural land to developing *Pinus radiata* plantations).

Birds are effective indicators and in this case the most suitable because of the following reasons (adapted from Chrome *et al.* 1993):

- Birds are easily detected and readily identifiable, so are cost effective bioindicators.
- Birds are sensitive to changes to the phenomenon being indicated (conversion of cleared agricultural land to pine plantations).
- Birds can indicate changes in populations of other species of interest, such as reptiles and invertebrates.
- Birds can reflect changes to the environment of populations, communities or the entire ecosystem; birds of prey are used as monitors of environmental pollution.
- Birds can also be used as monitoring agents to detect changes in the structure and function of biological communities (eg. hole dwelling species may indicate forest quality).
- Birds may be used as a conspicuous indicator to investigate whether some aspects of vegetation structure are adequate to support various other species (eg. persistence of certain understorey species may indicate habitat suitable for small ground dwelling mammals or reptiles, or a scarcity of feral predators).

Other examples of the use of birds as bioindicators are provided below:

- Birds with large home ranges may indicate that a reserved area is large enough for many species with small territories, though not necessarily adequate in other respects.
- Noisy minors may indicate disturbance or edge effects in habitat remnants.
- Waterbirds may indicate complex change to water quality. Colonial waterbirds such as cormorants and herons that feed in their breeding wetlands will be directly affected by the levels of fish and crustacean stocks in those wetlands. Studies of their productivity can be used to indicate changes in these lower levels of the food chain.
- Shore nesters may indicate levels of human disturbance.

In this study birds have been surveyed in each different age of pine plantation, as well as in remnant native vegetation, native vegetation plantations and cleared land, to determine the effect that the softwood plantations and the variation in plantation ages have on the diversity of species

and abundance of birds. They have also been monitored on dams and other wetlands in the study area.

5.2 Methods

Bird surveys were conducted bi-monthly (February, April, June, August, October and December) each year at 18 sites that represented all vegetation types and other physical features of the study area (including dams). It took approximately four hours from sunrise each morning for a team of at least four people to complete the entire survey. The sites were surveyed in random order and conducted within this time frame to avoid temporal biases, whilst maximising the number of species recorded at each site.

Two standard surveying methods were used to record the presence of birds. The first method involved walking a transect in the early morning, in the areas previously specified. Each transect was 300 metres long and took 20 minutes to complete. Birds were recorded if they were seen or heard within 25 metres on each side of the transect line. Hence, each transect recorded the birds present in a 1.5 hectare area.

The second method involved conducting concealed 10-minute spot transect surveys of the dams, cleared farmland and remnant vegetation, where the standard bird transect technique was inappropriate. In addition, nocturnal birds were noted and 'called up' during arboreal mammal transects at night, during the annual fauna surveys. All incidental observations of birds from anywhere on the property, were also recorded.

The main sources of error or variability to expected in counting bird populations by the methods used in this study are described below (after Davidson 1976).

- Observational errors and variations, including variability using the same person/s for all counts in the study, identification ability (both aural and visual), counting ability in flocking or fast moving groups of birds.
- Population derived errors as a result of the behavioural patterns of different populations and species. Population errors include emigration and immigration of species, flocking behaviour, habitat utilisation, seasonal changes and weather variability, and when the species is most active (i.e, nocturnal, dusk or dawn).
- Study plot variation errors can include, visibility throughout the plot (i.e, density of vegetation, size, shape of study plot, the proximity of the study plot to outside influences, the proximity of the study plot to internal influences, such as edge effects).

5.3 Results

A total of 184 species have been recorded in the study area during 1994-2000. This includes the combined results from each different age of pine plantation, the remnant native vegetation, native vegetation plantations, dams and cleared land (see Appendix 1 for full species list). The results from 1994-2000 20-minute and 10-minute bird surveys are contained in Appendix 10 (CD attached inside the back cover). The total number of species recorded each year is presented in Figure 5.1. Generally, the total number of bird species recorded each year has increased since the initial survey in 1994, where 84 species were recorded compared to 95 in 2000.

Six threatened species have been recorded in the study area: Swift Parrot (Schedule One, Part One of the *Threatened Species Conservation Act 1995*), Barking Owl, Blue-billed Duck, Freckled Duck and the Pink Robin, (Schedule Two of *Threatened Species Conservation Act 1995*). The Barking Owl was recorded during a spotlighting transect in 1998 in E3 vegetation, north of the paper mill and the Swift Parrot was recorded as an incidental sighting in 1996. Both the Blue-billed Duck and Freckled Duck have been sighted on the large dam (D1) on a number of occasions. A single sighting of the Freckled Duck was first recorded in February 1995, three sightings were recorded in December of 1996, four sightings in June of 1998 and then three additional sightings in December of 1999. The Blue-billed Duck was first recorded in 1996, two sightings were recorded in December of 1998, two more in December 1999 and a single sighting in October of 2000. The Turquoise Parrot (Schedule Two) was also recorded by staff of the paper mill.

The native vegetation sites support considerably greater bird diversity compared to the pine plantations (Figure 5.3 and Table 5.1). Of the 183 bird species recorded during the study, 78 were recorded amongst the pine plantation sites (P1,P2,P3 and P4), 138 were recorded in the native vegetation sites (E1,E2 and E3), 109 were recorded in the dam sites (D1,D2 and D12) and 51 were recorded at the cleared agricultural land site (Figure 5.3).

The most significant result from the bird surveys is that pine plantations have significantly greater species diversity than the cleared agricultural land (Table 5.1 and Figure 5.3). A total of 78 species were recorded in pine plantations (sites P1-P4), compared to 58 species recorded in cleared agricultural land (site C1).

It can be seen from Table 5.1 that the remnant native vegetation support a slightly greater species diversity than the eucalypts/mixed species enrichment plantings. The number of species recorded at the dam sites has been gradually increasing throughout the duration of the survey. The larger dam (D1), yielded a total of 83 species during 1994-2000.

The compilation and analysis of the bi-monthly bird surveys also reveals a number of seasonal variations in species diversity. Species diversity decreases during June-August and peaks in October-December (Figure 5.4 and 5.5). The majority of species are recorded during the October- February period, which is likely to be in response to the commencement of spring and

the warmer summer months. However, it was found that waterbird species diversity appears to fluctuate greatly throughout the year on the dams, which may be as a result of a combination of human induced pressures and seasonal variations.

Table 5.1. Total number of bird species recorded at each site in each year (1994-2000).

Year	Site											
	P1	P2	P3	P4	E1 20	E2	E3	C1	D1	D2	E1 10	D12
1994	6	8	12	2	18	21	21	6	27	21	11	0
1995	14	16	12	16	30	41	40	14	33	37	30	8
1996	23	15	13	16	38	38	35	14	39	30	36	19
1997	22	15	18	22	45	40	39	28	43	24	42	17
1998	20	23	14	12	39	28	31	16	48	21	30	18
1999	13	9	21	19	38	42	29	23	61	20	29	17
2000	6	13	13	15	25	29	41	16	42	20	29	17
Total	46	46	46	41	92	84	90	51	83	64	73	41

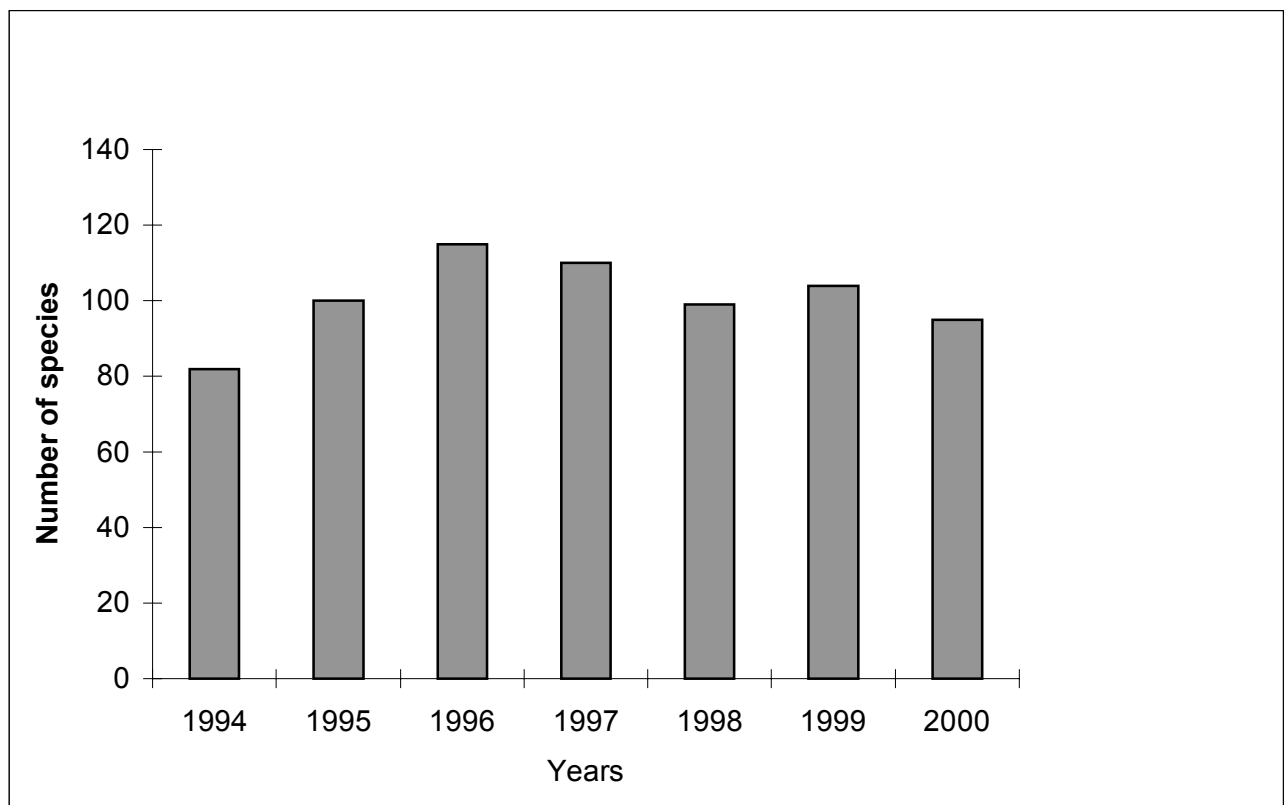


Figure 5.1. Number of bird species recorded in Ettamogah Forest in bimonthly surveys (1994-2000).

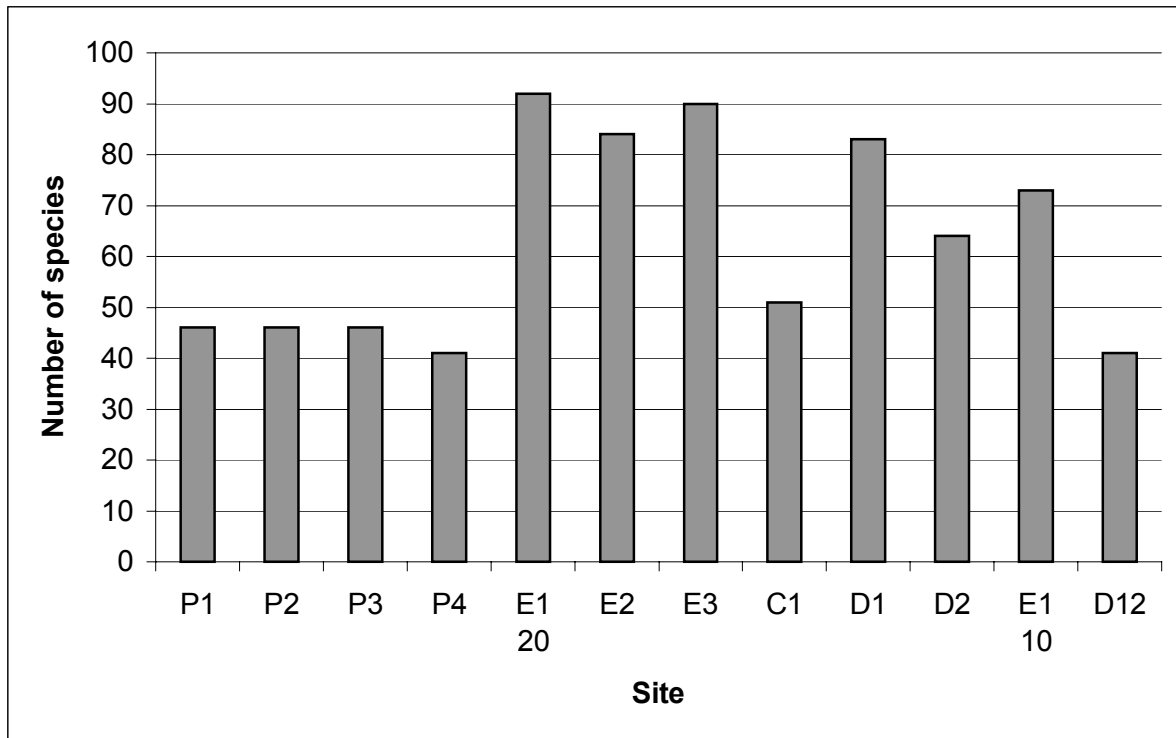


Figure 5.2. Number of bird species observed in each site during bimonthly surveys (1994–2000).

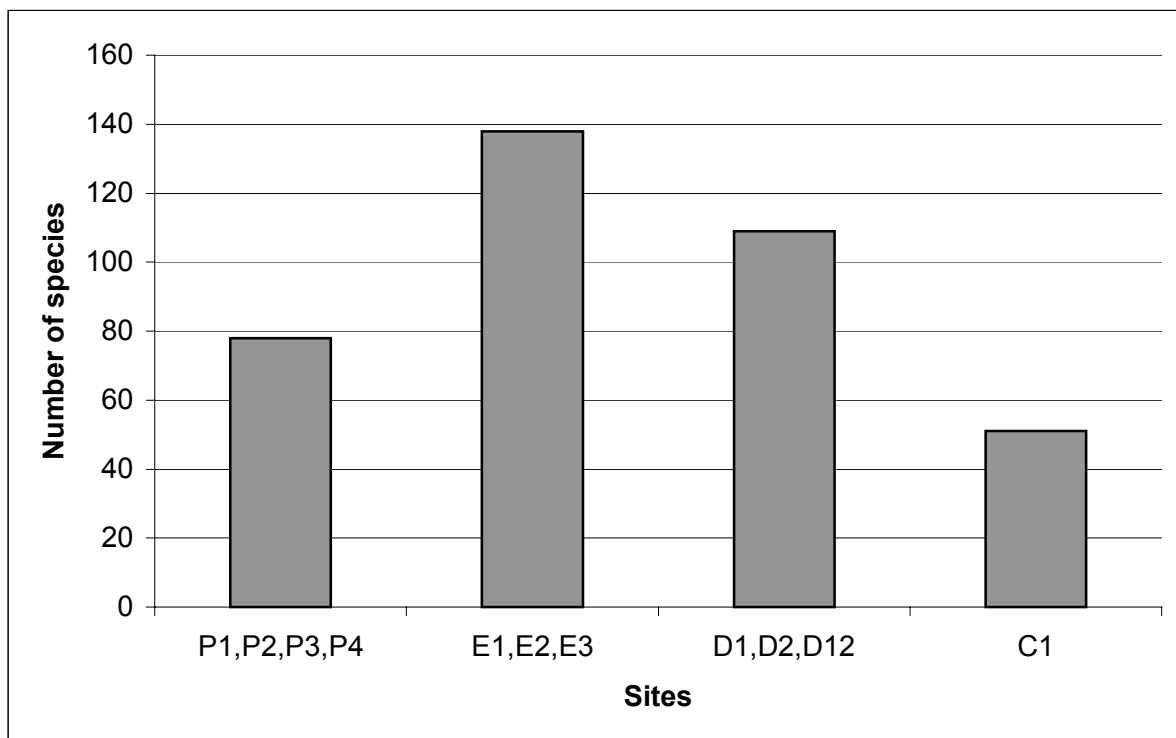


Figure 5.3. Number of bird species recorded in pines (sites P1-P4), eucalypts (sites E1-E3), dams (sites D1, D2, D12) and cleared land (site C1) in the bimonthly surveys (1994–2000).

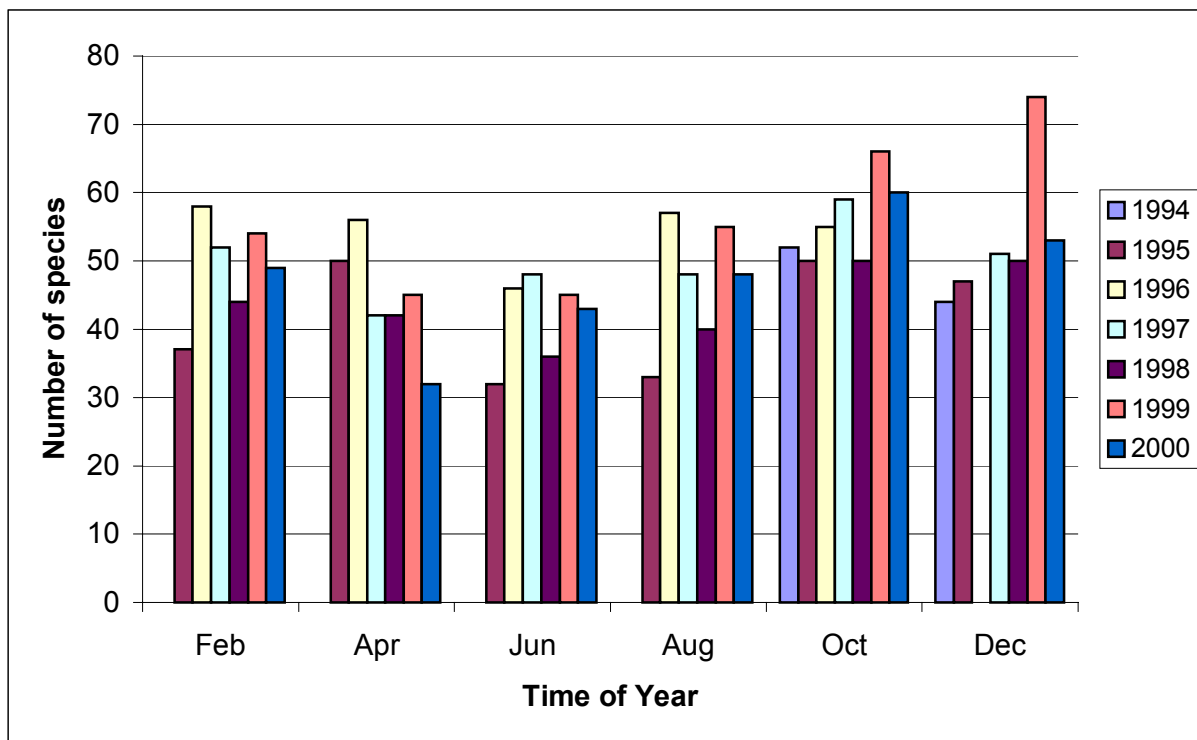


Figure 5.4. Effects of seasonality on bird species in each year (all sites combined).

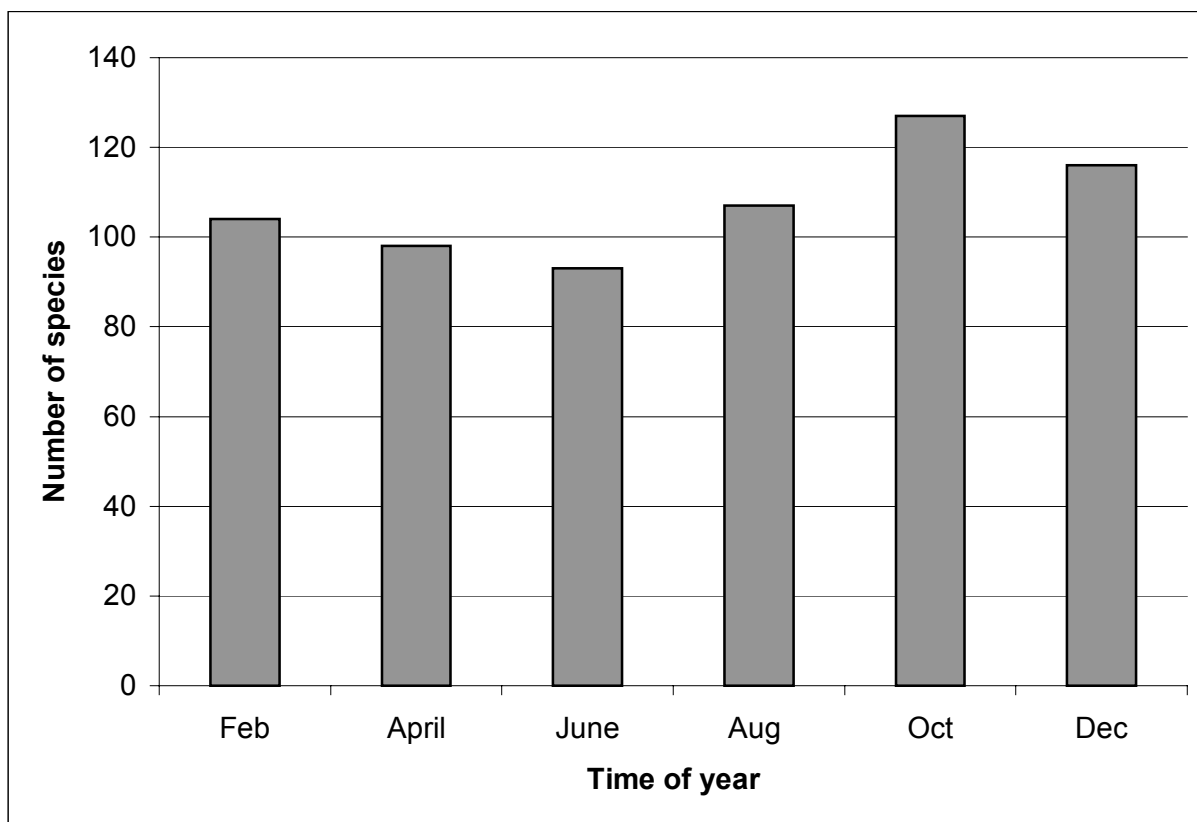


Figure 5.5. Effects of seasonality on bird species numbers (all sites and all years combined).

6. DISCUSSION

6.1 Mammals

It is likely that the suite of mammal survey techniques used in this study over the past seven years has revealed the presence of most or all mammal species present within the properties. The data from trapping of the small mammals are likely to reflect the differences in the presence of these animals within the study area, given that trapping regimes were systematic throughout the course of the study.

None of the species recorded in the mammal surveys are considered threatened. However, the Yellow-footed Antechinus, which was captured in 1997, 1999 and 2000 is not commonly recorded in this area. Nearly all other native mammals captured or observed throughout the course of the study were commonly recorded from spotlighting and incidental sightings in native vegetation and pine plantations (including the Eastern Grey Kangaroo). The Yellow-footed Antechinus is a small nocturnal, forest and woodland dwelling native marsupial, common in native forests of eastern Australia. It actively feeds on small rodents, birds and insects and also feeds on flowers and nectar (Strahan 1995). It appears that the remnant vegetation E3 site has the structural characteristics required by the Yellow-footed Antechinus. This species was still present at E3 the year after a small, low intensity fire at the site in 1998. Swamp Wallabies have also been observed by paper mill staff in the pine plantations.

Introduced species were frequently observed and trapped in both the pine plantations and native vegetation sites. However, the Black Rat and House Mouse were almost exclusively trapped amongst pine plantation sites. It has been found in previous studies that the House Mouse, is most abundant in mature pines and least abundant in mature eucalyptus forest (Suckling *et al* 1976). These introduced, small ground dwelling mammals may have existed only in pine plantation sites as a result of less competition through the absence of native species.

Arboreal mammals were completely absent from pine plantation sites. This is probably because of the lower structural diversity provided by the pines compared to the native vegetation. The pine plantation lacks suitable nesting hollows and nectar feeding trees that are provided in the native vegetation. Most recordings were in remnant vegetation E3 and eucalyptus/mixed native species plantings E2 north of the mill. The Sugar Glider *Petaurus breviceps* has been recorded for a few years in E2 vegetation adjacent to the public reserve. The Sugar Glider inhabits dry-sclerophyll forests and woodland in south-eastern Australia. It sleeps by day in a leaf-lined nest in a tree hole and mainly feeds upon gummy exudates from eucalypts and acacias (Strahan 1995). Ring-tailed Possums *Pseudocheirus peregrinus* and Brush-tailed Possums *Trichosurus vulpecula* have been recorded frequently each year for the duration of the study, almost exclusively in E3 and E2 vegetation in and adjacent to the public reserve. Both these native mammals are nocturnal and herbivorous and are widely distributed in eucalyptus forests where they utilize tree hollows for shelter.

Eight of the nine bat species discovered from the study were also recorded within the pine plantations. This may be attributed to the suitable flight corridors provided by the access roads into the pine plantations, as well as the retention of mature, native habitat trees along the perimeters of the plantations. These mature habitat trees would provide roosting areas and have been supplemented with eucalypt enrichment plantings in and around the pine plantations.

6.2 Amphibians and Reptiles

The reptile and amphibian survey techniques used in this study are believed to have revealed the presence of most reptile and amphibian species present within the properties. Although 14 species of reptiles have been recorded, none were recorded within any of the pine plantation sites during the surveys. The pine plantations provide poor reptile habitat and foraging opportunities for most reptile species. The dense pines reduce insulation levels, thus inhibiting the thermoregulation requirements of reptiles, yet snakes have been frequently observed in the very young pine plantations and older pines (93-94 age class) during warmer months of the year by paper mill staff.

The construction of several dams, channels and water courses to meet the water and drainage requirements of Ettamogah Forest has provided good frog habitat, as illustrated by the fourteen frog species recorded to date. Although not recorded during the study, turtles have been observed at Lake Ettamogah by paper mill staff.

6.3 Birds

The bird survey techniques used in this study are believed to have revealed the presence of most bird species present at the properties. Indeed the total bird count of 184 species to date is impressive for the area.

The results indicate a preference by bird species for the native vegetation habitats over to the pine plantations. As mentioned earlier, pine forests are structurally and floristically different from native vegetation. Pine forests do not provide nectar or suitable nesting hollows like native forests, and the needle-like foliage is different to the broad-leaf, blade-like leaves of most native trees (Gepp 1986). Pine plantations are normally a single-aged monoculture, where as native forests consist of many species of different ages providing many structural layers (Gepp 1986).

However, the results of this study suggest that the pine plantations support a greater species diversity than the cleared land on which they were established (78 species recorded in pines compared to 51 recorded at the cleared land site). Thus, it is likely that the conversion of the former 'Maryvale' property from cleared agricultural land into what is now known as Ettamogah Forest has had the effect of increasing bird numbers and species diversity. The lower species diversity found in cleared agricultural land can be largely attributed to the lack of structurally suitable habitat for most species. The high levels of faunal biodiversity present at Ettamogah

forest can be attributed largely to the diversity of habitats provided by the retention of native vegetation, the establishment of pine and native plantings and, more significantly, by the habitats provided by the large dam and its network of smaller wetlands.

The difference in biodiversity levels among the different aged pines is not as great as it was a few years ago. It is difficult to tell if any of the modifications to the pine plantations have had an impact upon species diversity. Generally, bird diversity appears to decrease with the increasing age of the pine plantations. Other studies have found that bird diversity tends to increase in pine plantations after a 10-15 year period, when pines have been thinned or pruned. These practices allow more light to penetrate to the forest floor and, in some cases, native vegetation is stimulated to re-emerge (Gepp 1986). Thinning of the pine plantations commenced in 2000 and as a result it is likely that changes in species diversity and composition will be seen at Ettamogah Forest in the next few years.

As mentioned previously, six threatened species (Swift Parrot, Barking Owl, Blue-billed Duck, Freckled Duck, Pink Robin and Turquoise Parrot) listed under the NSW *Threatened Species Conservation Act 1995* have been recorded throughout the duration of the study. The main dam provides a typical non-breeding, dry season refuge for Freckled Duck, with permanent open water and little emergent and aquatic vegetation; in contrast to the more inland, sheltered and vegetated sites required for breeding (Martindale 1986). The shallows of the dam provide foraging habitat as Freckled Duck are restricted to the top 70 cm of water, reached by up-ending (Frith 1982, cited in Marchant & Higgins 1990). Unlike the Blue-billed Duck, Freckled Duck never dive (Pizzey 1997) but both species need a range of microhabitats. The open shores surrounding the dam provide preferred day-loafing areas with nocturnal or crepuscular feeding typical (Marchant & Higgins 1990). The salinity of the water (1300-1400 PDS) is unlikely to deter this species because Freckled Duck are known to use lakes and reservoirs with salinities up to 34 ‰ (Marchant & Higgins 1990). At Ettamogah Forest, this species is protected from illegal shooting. Freckled Duck are reluctant to leave favoured wetlands even repeatedly circling low whilst under fire (Martindale 1986). Analysis of photographs taken by Peter Merritt at Ettamogah Forest confirms the presence of both male and female Freckled Duck.

The decline of birds in the temperate woodlands of southern Australia is not restricted to species listed in the NSW *Threatened Species Conservation Act 1995*, like the Barking Owl and Swift Parrot. Four woodland bird species recorded during the study (Brown Treecreeper, Speckled Warbler, Hooded Robin and Diamond Firetail) are listed nationally as *Near-Threatened* (Garnett & Crowley 2000). The persistence of Brown Treecreepers in remnant woodland patches is threatened by disrupted dispersal, because dispersing females are generally not replaced due to inadequate habitat connectivity (Walters *et al.* 1999). A whole suite of woodland birds are steadily disappearing from remnant patches in southern Australia, especially the more ecologically sensitive species, such as the four just mentioned and others recorded during this study like the Red-capped Robin, Scarlet Robin and Dusky Woodswallow (Robinson & Traill 1996, Ford *et al.* 2001). Ettamogah Forest supports most of the declining woodland birds of southern Australia, with revegetated drainage-lines and the retention of remnant vegetation facilitating the use of the pine plantations by some species.

Eleven species of wader (shorebird) have been recorded on and around the main dam, including five that have bred successfully: Black-winged Stilt, Masked Lapwing, Red-capped, Red-kneed and Black-fronted Dotteral. Four species are migratory, coming from Arctic Siberia and Japan (Common Sandpiper, Common Greenshank, Red-necked Stint and Latham's Snipe). The waders utilise the ephemeral mudflat edges, including those of the islands, for foraging and breeding. In over 30 years the Albury-Wodonga Field Naturalists Club and the Ovens and Murray Bird Observers Club have never before recorded Common Greenshank, Red-necked Stint, Red-capped Dotteral and White-fronted Chat in such proximity to Albury-Wodonga, although Red-necked Stints were seen in 1999 at the newly-created Wonga Wetlands in West Albury. The Pied Heron record (December 1999) is the first for NSW and some 2500 km from its nearest regular distribution. This record and the migratory and nomadic waders exemplify the increasing importance of this dam in facilitating avian movement through the Albury landscape.

7. CONCLUSION

This study has revealed the presence of a remarkable variety of terrestrial fauna in and around Ettamogah Forest. This level of biodiversity is a reflection of the different habitats provided in the area. There are five different ages of pine plantations, large and small water bodies with excellent wading habitat, a significant amount of remnant vegetation and a great deal of newly planted native vegetation. This approach to land management in the area, coupled with a genuine interest by staff of Norske Skog Paper Mills (Australia) Ltd in supporting and augmenting wildlife refugia, makes Ettamogah Forest an outstanding example of pine plantation and landscape management in Australia.

Bibliography

Cogger, H.G. (2000). *Reptiles and Amphibians of Australia*. Reed, Sydney.

Costermans, L.F. (1994). *Trees of Victoria and Adjoining Areas*. Costermans Publishing, Seaford, Victoria.

Chrome, F.H.J., Green, R., & Catterall, C.P. (1993). The use of birds as ecological indicators. **In:** Catterall, C.P., Driscoll, P.V., Hulsman, K., Muir, D. & Taplin (eds) *Birds and Their Habitats: Status and Conservation in Queensland*. A. Queensland Ornithological Society Inc.

Cronin, L. (1991). *Key Guide to Australian Mammals*. Reed, Sydney.

Davidson, P. M., (1976). *Birds in pine forests: A Brief Study of the Relationship Between Bird Populations and Pine Habitats at Kowen Forest, ACT*. Australian Government Publishing Services, Canberra.

Fisher, A.M., & Goldney, D.C. (1998). Native forest fragments as critical bird habitat in a softwood forest landscape. *Australian Forestry* **61**: 287-295.

Gepp, B.C., (1986). Birds in pine forests in South Australia. **In:** Ford, H.A. & Paton, D.C. (eds). *The Dynamic Partnership: Birds and Plants in South-eastern Australia*. Government Printer, Adelaide.

Kingsford, R. T. & Porter, J. L. (1994). Waterbirds on an adjacent freshwater lake and salt lake in arid Australia. *Biological Conservation* **69**: 219-228.

Marchant, S. & Higgins, P. J. (1990). *The Handbook of Australian, New Zealand and Antarctic Birds*. Oxford University Press, Melbourne.

Martindale, J. (1986). *The Freckled Duck - RAOU Conservation Statement*. RAOU Report No. 22. RAOU: Melbourne.

Parnaby, H. (1992). An interim guide to identification of insectivorous bats of south-eastern Australia. *Technical Reports of the Australian Museum* 8.

Pizzey, G. (1997). *The Grahame Pizzey and Frank Knight Field Guide*. Harper Collins: Sydney.

Reardon, T.B. & Stanley, C.F. (1987). *A Guide to the Bats of South Australia*. South Australian Museum, Adelaide.

Recher, H. F., (1986). So many kinds of animals: The study of communities, **In:** Recher, H.F., Lunney, D., Dunn, I. (eds). *A Natural Legacy - Ecology in Australia (2nd ed)*. Pergamon Press, Sydney.

Simpson, K. & Day, N. (1999). *Field Guide to the Birds of Australia*. Viking O'Neil, South Yarra, Victoria.

Spellerberg, I. F. (1991). *Monitoring Ecological Change*. Cambridge University Press. Cambridge.

Strahan, R. (ed) (1991). *The Australian Museum Complete Book of Australian Mammals*. Cornstalk Publications, North Ryde, NSW.

Suckling, G.C., Backen, E., Heislars. & Neumann, F.G. (1976) *The Flora and Fauna of Radiata Pine Plantations in North-Eastern Victoria*. Forest Commission, Victoria.

Swan, G. (1990). *A Field Guide to the Snakes and Lizards of New South Wales*. A Three Sisters Publication, NSW.

York, A., Binns, D. & Shields, J. (1991). *Procedures for Sampling Flora and Fauna for Environmental Impact Statements*. Forestry Commission of NSW, Sydney.

Appendix 1. Total species list. All terrestrial vertebrate species recorded in and around the Ettamogah Forest (1994-2000).

Introduced species are indicated with asterisks.

Amphibians

<i>Limnodynastes dumerilli</i>	Banjo Frog (Eastern Pobblebonk)
<i>Limnodynastes interioris</i>	Giant Pobblebonk Frog
<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog
<i>Limnodynastes peronii</i>	Brown –striped Frog
<i>Neobatrachus sudelli</i>	Painted Burrowing Frog
<i>Litoria paraewingi</i>	Plains Brown Tree Frog
<i>Litoria ewingi</i>	Southern Brown Tree Frog
<i>Litoria peronii</i>	Peron's Tree Frog
<i>Crinia signifera</i>	Common Froglet
<i>Crinia parinsignifera</i>	Plains Froglet
<i>Crinia sloanei</i>	Sloanes Froglet
<i>Uperoleia laevigata</i>	Smooth Toadlet
<i>Uperoleia rugosa</i>	Eastern Burrowing Toadlet
<i>Pseudophryne bibronii</i>	Bibron's Toadlet

Reptiles

<i>Carlia tetradactyla</i>	Southern Rainbow Skink
<i>Cryptoblepharus carnabyi</i>	
<i>Ctenotus robustus</i>	Large Striped Skink
<i>Egernia striolata</i>	Tree-crevice Skink
<i>Leiopisma coventryi</i>	Coventry's Skink
<i>Leiopisma delicata</i>	Grass Skink
<i>Lerista bougainvillii</i>	Bougainville's Skink
<i>Morethia boulengeri</i>	
<i>Phyllodactylus marmoratus</i>	Marbled Gecko
<i>Pseudemoia duperreyi</i>	Trunk-climbing Cool Skink
<i>Pseudonaja textilis</i>	Brown Snake
<i>Varinus varius</i>	Lace Monitor
<i>Teliqua scinioides</i>	Blue-tongue Lizard
<i>Pseudonaja textiles</i>	Red-bellied Black Snake

Birds

<i>Coturnix pectoralis</i>	Stubble Quail
<i>Coturnix ypsilophora</i>	Brown Quail
<i>Turnix varia</i>	Painted Button-quail
<i>Pelecanus conspicillatus</i>	Australian Pelican
<i>Anhinga melanogaster</i>	Darter
<i>Phalacrocorax varius</i>	Pied Cormorant
<i>Phalacrocorax melanoleucos</i>	Little Pied Cormorant
<i>Phalacrocorax carbo</i>	Great (Black) Cormorant
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant
<i>Podiceps cristatus</i>	Great-crested Grebe

Birds Appendix 1 (continued).

<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe
<i>Cygnus atratus</i>	Black Swan
<i>Tadorna tadornoides</i>	Australian Shelduck
<i>Anas superaliosa</i>	Pacific Black Duck
<i>Anas platyrhynchos</i>	Mallard
<i>Anas castanea</i>	Grey Teal
<i>Anas castanea</i>	Chestnut Teal
<i>Anas rhynchotis</i>	Australasian Shoveller
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck
<i>Aythya australis</i>	Hardhead
<i>Chenonetta jubata</i>	Maned Duck
<i>Stictonetta naevosa</i>	Freckled Duck
<i>Oxyura australis</i>	Blue-billed Duck
<i>Biziura lobata</i>	Musk Duck
<i>Porzana tabuensis</i>	Spotless Crake
<i>Gallinula ventralis</i>	Black-tailed Native Hen
<i>Gallinula tenebrosa</i>	Dusky Moorhen
<i>Porphyrio porphyrio</i>	Purple Swamphen
<i>Fulica atra</i>	Eurasian Coot
<i>Ardea pacifica</i>	Pacific Heron
<i>Ardea picata</i>	Pied Heron
<i>Ardea novaehollandiae</i>	White-faced Heron
<i>Ardea alba</i>	Great Egret
<i>Ardea intermedia</i>	Intermediate Egret
<i>Egretta garzetta</i>	Little Egret
<i>Threskiornis aethiopica</i>	Australian White Ibis
<i>Threskiornis spinicollis</i>	Straw-necked Ibis
<i>Platalea regia</i>	Royal Spoonbill
<i>Platalea flavipes</i>	Yellow-billed Spoonbill
<i>Actitis hypoleucos</i>	Common Sandpiper
<i>Tringa nebularia</i>	Common Greenshank
<i>Gallinago hardwickii</i>	Latham's Snipe
<i>Calidris ruficollis</i>	Red-necked Stint
<i>Vanellus miles</i>	Masked Lapwing
<i>Vanellus tricolour</i>	Banded Lapwing
<i>Erythrogonys cinctus</i>	Red-kneed Dotterel
<i>Charadrius ruficapillus</i>	Red-capped Plover
<i>Elseyornis melanops</i>	Black-fronted Dotterel
<i>Himantopus himantopus</i>	Black-winged Stilt
<i>Cladorhynchus leucocephalus</i>	Banded Stilt
<i>Larus novaehollandiae</i>	Silver Gull
<i>Elanus notatus</i>	Black-shouldered Kite
<i>Milvus migrans</i>	Black Kite
<i>Milvus sphenurus</i>	Whistling Kite
<i>Haliastur leucogaster</i>	White-bellied Sea Eagle
<i>Aquila audax</i>	Wedge-tailed Eagle
<i>Hieraaetus morphnoides</i>	Little Eagle
<i>Accipiter fasciatus</i>	Brown Goshawk
<i>Accipiter cirrhocephalus</i>	Collared Sparrowhawk

Birds Appendix 1 (continued).

<i>Circus assimilis</i>	Spotted Harrier
<i>Circus approximans</i>	Swamp Harrier
<i>Falco peregrinus</i>	Peregrine Falcon
<i>Falco longipennis</i>	Australian Hobby
<i>Falco berigora</i>	Brown Falcon
<i>Falco cenchroides</i>	Australian Kestrel
<i>Streptopelia chinensis</i>	Spotted Turtle-Dove*
<i>Geopelia placida</i>	Peaceful Dove
<i>Geopelia cuneata</i>	Diamond Dove
<i>Phaps chalcoptera</i>	Common Bronzewing
<i>Geophaps lophotes</i>	Crested Pigeon
<i>Cacatua roseicapilla</i>	Galah
<i>Cacatua pastinator</i>	Little Corella
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet
<i>Glossopsitta pusilla</i>	Little Lorikeet
<i>Alisterus scapularis</i>	Australian King-Parrot
<i>Nymphicus hollandicus</i>	Cockatiel
<i>Lathamus discolor</i>	Swift Parrot
<i>Platycercus elegans</i>	Crimson Rosella
<i>Platycercus eximus</i>	Eastern Rosella
<i>Psephotus haematonotus</i>	Red-rumped Parrot
<i>Cuculus pallidus</i>	Pallid Cuckoo
<i>Cuculus flabelliformis</i>	Fan-tailed Cuckoo
<i>Chrysococcyx osculans</i>	Black-eared Cuckoo
<i>Chrysococcyx basalis</i>	Horsefield's Bronze-Cuckoo
<i>Ninox connivens</i>	Barking Owl
<i>Ninox novaeseelandiae</i>	Southern Boobook
<i>Tyto alba</i>	Barn Owl
<i>Podargus strigoides</i>	Tawny Frogmouth
<i>Hirundapus caudacutus</i>	White-throated Needletail
<i>Aspus pacificus</i>	Fork-tailed Swift
<i>Dacelo novaguineae</i>	Laughing Kookaburra
<i>Todirhampus sancta</i>	Sacred Kingfisher
<i>Merops ornatus</i>	Rainbow Bee-eater
<i>Eurystomus orientalis</i>	Dollarbird
<i>Daphoenositta chrysoptera</i>	Varied Sittella
<i>Cormobates leucophaea</i>	White-throated Tree-creeper
<i>Climacteris picumnus</i>	Brown Treecreeper
<i>Malurus cyaneus</i>	Superb Fairy-wren
<i>Malurus splendens</i>	Splendid Fairy-wren
<i>Pardalotus punctatus</i>	Spotted Pardalote
<i>Paerdalotus striatus</i>	Striated Pardalote
<i>Sericornis frontalis</i>	White-browed Scrubwren
<i>Sericornis sagittatus</i>	Speckled Warbler
<i>Smicrornis brevirostris</i>	Weebill
<i>Gerygone fusca</i>	Western Gerygone
<i>Gerygone olivacea</i>	White-throated Gerygone
<i>Acanthiza pusilla</i>	Brown Thornbill

Birds Appendix 1 (continued).

<i>Acanthiza nana</i>	Yellow Thornbill
<i>Acanthiza lineata</i>	Striated Thornbill
<i>Acanthiza reguloides</i>	Buff-rumped Thornbill
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill
<i>Anthochaera carunculata</i>	Red Wattlebird
<i>Philemon corniculatus</i>	Noisy Friarbird
<i>Philemon citreogularis</i>	Little Friarbird
<i>Entomyzon cyanotis</i>	Blue-faced Honeyeater
<i>Manorina melanocephala</i>	Noisy Miner
<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater
<i>Lichenostomus leucotis</i>	White-eared Honeyeater
<i>Lichenostomus malanops</i>	Yellow-tufted Honeyeater
<i>Lichenostomus fuscus</i>	Fuscous Honeyeater
<i>Lichenostomus pencillatus</i>	White-plumed Honeyeater
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater
<i>Melithreptus lunatus</i>	White-naped honeyeater
<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill
<i>Certhionyx niger</i>	Black Honeyeater
<i>Epthainura albifrons</i>	White-fronted Chat
<i>Psophodes olivaceus</i>	Eastern Whipbird
<i>Petroica rodinogaster</i>	Pink Robin
<i>Petroica phoenica</i>	Flame Robin
<i>Petroica multicolor</i>	Scarlet Robin
<i>Petroica goodenovii</i>	Red-capped Robin
<i>Melanodryas cucullata</i>	Hooded Robin
<i>Eopsaltria australis</i>	Eastern Yellow Robin
<i>Microeca leucophaea</i>	Jacky Winter
<i>Falcunculus frontatus</i>	Crested Shrike-tit
<i>Colluricincla harmonica</i>	Grey Shrike-thrush
<i>Pachycephala pectoralis</i>	Golden Whistler
<i>Pachycephala rufiventris</i>	Rufous Whistler
<i>Rhipidura fuliginosa</i>	Grey Fantail
<i>Rhipidura rufifrons</i>	Rufous Fantail
<i>Rhipidura leucophrys</i>	Willie Wagtail
<i>Myiagra rubecula</i>	Leaden Flycatcher
<i>Myiagra inquieta</i>	Restless Flycatcher
<i>Grallina cyanoleuca</i>	Australian Magpie-lark
<i>Oriolus sagittatus</i>	Olive-backed Oriole
<i>Corancina novaehollandiae</i>	Black-faced Cuckoo-shrike
<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike
<i>Lalage tricolor</i>	White-winged Triller
<i>Artamus personatus</i>	Masked Woodswallow
<i>Artamua superciliosus</i>	White-browed Woodswallow
<i>Artamus cuanopterus</i>	Dusky Woodswallow
<i>Cracticus torquatus</i>	Grey Butcherbird
<i>Cracticus nigrogularis</i>	Pied Butcherbird
<i>Gymnorhina tibicen</i>	Australian Magpie
<i>Strepera graculina</i>	Pied Currawong
<i>Corvus coronoides</i>	Australian Raven
<i>Corvus mellori</i>	Little Raven

Birds Appendix 1 (continued).

<i>Corcorax melanorhamphos</i>	White-winged Chough
<i>Cheramoeca leucosternum</i>	White-backed Swallow
<i>Hirundo neoxena</i>	Welcome Swallow
<i>Hirundo nigricans</i>	Tree Martin
<i>Hirundo amel</i>	Fairy Martin
<i>Anthus novaeseelandiae</i>	Richard's Pipit
<i>Mirafra javanica</i>	Singing Bushlark
<i>Alauda arvensis</i>	Skylark*
<i>Cincolorhamphus crucialis</i>	Brown Songlark
<i>Cinclorhamphus mathewsi</i>	Rufous Songlark
<i>Acrocephalus stentoreus</i>	Clamorous Reed Warbler
<i>Cisticola exilis</i>	Golden-headed Cisticola
<i>Magalurus granineus</i>	Little Grassbird
<i>Passer montanus</i>	Tree Sparrow*
<i>Passer domesticus</i>	House Sparrow*
<i>Carduelis chloris</i>	European Greenfinch*
<i>Carduelis carduelis</i>	European Goldfinch*
<i>Taeniopygia bichenovii</i>	Double-Barred Finch
<i>Neochemia temporalis</i>	Red-browed Firetail
<i>Stagonopleura guttata</i>	Diamond Firetail
<i>Dicaeum hirundinaceum</i>	Mistletoebird
<i>Zosterops lateralis</i>	Silvereye
<i>Turdus merula</i>	Blackbird*
<i>Sturnus vulgaris</i>	Common Starling*
<i>Acridotheres tristis</i>	Common Mynah*

Mammals

<i>Nyctophilus geoffroyi</i>	Lesser Long Eared Bat
<i>Chalinolobus morio</i>	Chocolate Wattled Bat
<i>Chalinolobus gouldii</i>	Goulds Wattled Bat
<i>Vespardelus darlingtoni</i>	Large Forest Bat
<i>Vespardelus regulus</i>	Southern Forest Bat
<i>Vespardelus vultures</i>	Small Forest Bat
<i>Mormopterus planiceps (lpf)</i>	Southern Freetail Bat
<i>Scotorepens balstoni</i>	Inland Broad-nose Bat
<i>Nyctinomus australis</i>	White-striped Mastiff-Bat
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna
<i>Antechinus flavipes</i>	Yellow-footed Antechinus
<i>Petaurus breviceps</i>	Sugar Glider
<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum
<i>Trichosurus vulpecu</i>	Common Brushtail Possum.
<i>Macropus giganteus</i>	Eastern Grey Kangaroo
<i>Rattus rattus</i>	Black Rat*
<i>Rattus norvegicus</i>	Brown Rat*
<i>Mus domesticus</i>	House Mouse*
<i>Felis catus</i>	Feral Cat*
<i>Oryctolagus cuniculus</i>	Rabbit*
<i>Lepus capensis</i>	Brown Hare*
<i>Vulpes vulpes</i>	Red Fox*

Appendix 2. Bird species recorded in each year of the study (1994-2000).

Introduced species are indicated with asterisks.

Bird Species	1994	1995	1996	1997	1998	1999	2000
Stubble Quail	X	X	X				X
Brown Quail				X			
Painted Button-quail	X						
Australian Pelican	X	X	X	X	X	X	X
Darter	X	X	X			X	X
Pied Cormorant	X			X	X		
Little Pied Cormorant	X	X	X			X	X
Great (Black) Cormorant		X	X	X	X	X	X
Little Black Cormorant					X	X	X
Great-crested Grebe					X	X	X
Hoary-headed Grebe		X	X	X	X	X	X
Australasian Grebe	X	X	X	X	X	X	X
Black Swan	X	X	X	X	X	X	X
Australian Shelduck	X	X	X	X	X	X	X
Pacific Black Duck	X	X	X	X	X	X	X
Mallard*	X	X		X	X		
Grey Teal	X	X	X	X	X	X	X
Chestnut Teal		X	X		X	X	
Australasian Shoveller		X	X	X	X	X	X
Pink-eared Duck			X		X	X	X
Hardhead	X		X	X	X	X	X
Maned Duck	X	X	X	X	X	X	X
Freckled Duck		X			X	X	
Blue-billed Duck			X		X	X	X
Musk Duck		X	X	X	X	X	X
Spotless Crake	X						
Black-tailed Native Hen						X	
Purple Swamphen					X		
Dusky Moorhen		X	X	X	X	X	
Eurasian Coot	X	X	X	X	X	X	X
Pacific Heron	X		X				
Pied Heron						X	
White-faced Heron	X	X	X	X	X	X	X
Great Egret	X	X	X		X	X	X
Little Egret		X		X			X
Intermediate Egret			X	X	X	X	
Australian White Ibis	X	X	X	X	X	X	X
Straw-necked Ibis	X	X	X	X		X	
Royal Spoonbill	X			X		X	
Yellow-billed Spoonbill			X	X			
Common Sandpiper			X				
Common Greenshank						X	
Latham's Snipe						X	
Red-necked Stint						X	
Masked Lapwing		X	X	X	X	X	X

Bird Species	1994	1995	1996	1997	1998	1999	2000
Banded Lapwing		X					
Red-kneed Dotterel				X		X	
Red-capped Plover						X	
Black-fronted Dotterel	X	X	X	X	X	X	X
Black-winged Stilt			X	X	X	X	X
Banded Stilt	X						
Silver Gull	X		X	X	X	X	X
Black-shouldered Kite	X	X	X	X	X	X	X
Black Kite		X					
Whistling Kite		X	X	X	X	X	X
White-bellied Sea Eagle						X	
Wedge-tailed Eagle	X	X		X	X		
Little Eagle	X	X	X	X	X	X	
Brown Goshawk	X		X	X		X	
Collared Sparrowhawk	X						X
Spotted Harrier		X	X				
Swamp Harrier				X		X	X
Peregrine Falcon		X		X			
Australian Hobby		X	X		X		
Brown Falcon	X	X	X	X	X	X	X
Australian Kestrel	X	X	X	X	X	X	X
Spotted Turtle Dove*						X	X
Peaceful Dove			X	X	X	X	X
Diamond Dove							X
Common Bronzewing		X	X	X			
Crested Pigeon		X	X	X	X	X	X
Galah	X	X	X	X	X	X	X
Little Corella	X		X			X	
Sulphur-crested Cockatoo	X	X	X	X	X	X	X
Rainbow Lorikeet				X			
Little Lorikeet						X	X
Australian King-Parrot							X
Cockatiel			X				
Swift Parrot			X				
Crimson Rosella	X	X	X	X	X	X	X
Eastern Rosella	X	X	X	X	X	X	X
Red-rumped Parrot	X	X	X	X	X	X	X
Pallid Cuckoo		X		X	X		
Fan-tailed Cuckoo	X		X			X	X
Black-eared Cuckoo			X				
Horsefield's Bronze-Cuckoo			X			X	
Barking Owl					X		
Southern Boobook Owl	X		X				
Barn Owl	X	X					
Tawny Frogmouth			X				
White-throated Needletail				X			
Fork-tailed Swift					X		
Laughing Kookaburra	X	X	X	X	X	X	X
Sacred Kingfisher	X		X	X	X	X	X

Bird Species	1994	1995	1996	1997	1998	1999	2000
Rainbow Bee-eater	X	X	X	X	X	X	X
Dollarbird				X			
Varied Sitella				X			
White-throated Tree-creeper	X	X	X	X	X	X	
Brown Treecreeper		X	X	X		X	X
Superb Fairy-wren	X	X	X	X	X	X	X
Splendid Fairy-wren				X			
Spotted Pardalote		X	X	X	X	X	X
Striated Pardalote		X	X	X	X	X	X
White-browed Scrubwren	X	X	X		X		
Speckled Warbler				X			
Weebill		X			X	X	X
Western Gerygone						X	X
White-throated Gerygone			X			X	X
Brown Thornbill		X	X	X	X	X	X
Yellow Thornbill	X		X	X	X	X	X
Striated Thornbill		X	X		X		
Buff-rumped Thornbill		X	X	X			X
Yellow-rumped Thornbill	X	X	X	X	X	X	X
Red Wattlebird			X	X	X	X	
Noisy Friarbird			X		X		X
Little Friarbird		X	X			X	X
Blue-faced Honeyeater				X			
Noisy Miner		X	X	X	X	X	X
Yellow-faced Honeyeater					X		
White-eared Honeyeater	X	X					
Yellow-tufted Honeyeater		X					
Fuscous Honeyeater	X	X			X		
White-plumed Honeyeater	X	X	X	X	X	X	X
Brown-headed Honeyeater			X				
White-naped Honeyeater				X	X		
Eastern Spinebill				X			
Black Honeyeater			X				
White-fronted Chat	X		X		X	X	X
Eastern Whipbird				X			
Pink Robin				X			
Flame Robin	X	X	X	X	X	X	X
Scarlet Robin		X	X	X			
Red-capped Robin		X	X	X	X	X	
Hooded Robin	X		X				
Eastern Yellow Robin	X		X		X		X
Jacky Winter		X	X	X	X	X	
Crested Shrike-tit	X	X	X	X	X	X	
Grey Shrike-thrush	X	X	X	X	X	X	X
Golden Whistler		X	X	X			
Rufous Whistler	X	X	X	X	X	X	X
Grey Fantail	X	X	X	X	X	X	X
Rufous Fantail					X		
Willie Wagtail	X	X	X	X	X	X	X

Bird Species	1994	1995	1996	1997	1998	1999	2000
Leaden Flycatcher				X	X	X	
Restless Flycatcher		X	X	X	X		X
Australian Magpie-lark	X	X	X	X	X	X	X
Olive-backed Oriole			X				X
Black-faced Cuckoo-shrike	X	X	X	X	X	X	X
White-bellied Cuckoo-shrike				X			
White-winged Triller	X						X
Masked Woodswallow	X	X		X			
White-browed woodswallow	X			X		X	
Dusky Woodswallow			X	X	X	X	X
Grey Butcherbird		X					
Pied Buthcherbird					X		
Australian Magpie	X	X	X	X	X	X	X
Pied Currawong	X		X	X	X	X	X
Australian Raven	X	X	X	X	X	X	X
Little Raven		X	X	X	X		
White-winged Chough		X	X	X	X		X
White-backed Swallow	X	X					
Welcome Swallow	X	X	X	X	X	X	X
Tree Martin		X	X			X	X
Fairy Martin	X		X	X		X	X
Richard's Pipit	X	X	X	X	X	X	X
Singing Bushlark			X	X			
Skylark*		X	X				
Brown Songlark	X	X	X				
Rufous Songlark		X	X	X			X
Clamorous Reed Warbler					X		
Golden-headed Cisticola	X					X	X
Little Grassbird				X			
Tree Sparrow*		X			X		
House Sparrow*	X	X	X	X	X		X
European Goldfinch*	X	X	X	X	X	X	X
European Greenfinch*							X
Double-Barred Finch	X	X		X		X	X
Red-browed Firetail	X	X	X	X	X	X	X
Diamond Firetail		X	X	X			
Blackbird*	X	X	X	X	X		X
Mistletoebird		X			X		
Silvereeye		X	X	X	X	X	X
Common Starling*	X	X	X	X	X	X	X
Common Mynah*	X						
TOTAL (184)	82	100	115	110	99	104	95

Appendix 3. Additional species observed by staff of Norske Skog Paper Mill at Ettamogah Forest (1994-2000).

Reptiles

Chelodina longicollis Eastern Long-necked Turtle

Birds

<i>Gallirallus philippensis</i>	Buff-banded Rail
<i>Porzana tabuensis</i>	Australian Spotless Crake
<i>Area ibis</i>	Cattle Egret
<i>Nycticorax caledonicus</i>	Rufous Night Heron
<i>Plegadis falcinellus</i>	Glossy Ibis
<i>Chiladonias hybridus</i>	Whiskered Tern
<i>Sterna caspia</i>	Caspian tern
<i>Callocephalon fimbriatum</i>	Gang Gang Cockatoo
<i>Melopsittacus undulatus</i>	Budgerigar
<i>Neophema pulchella</i>	Turquoise Parrot
<i>Alcedo azurea</i>	Azure Kingfisher
<i>Epthianura tricolor</i>	Crimson Chat
<i>Monarcha melanopsis</i>	Black-faced Monarch

Mammals

Wallabia bicolor Swamp Wallaby