EFFECTS of the EDEN WOODCHIP INDUSTRY on TERRESTRIAL VERTEBRATES with Recommendations for Management

AUTHORS:
Harry F. Recher
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FORESTRY COMMISSION OF N.S.W.
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FOREWORD

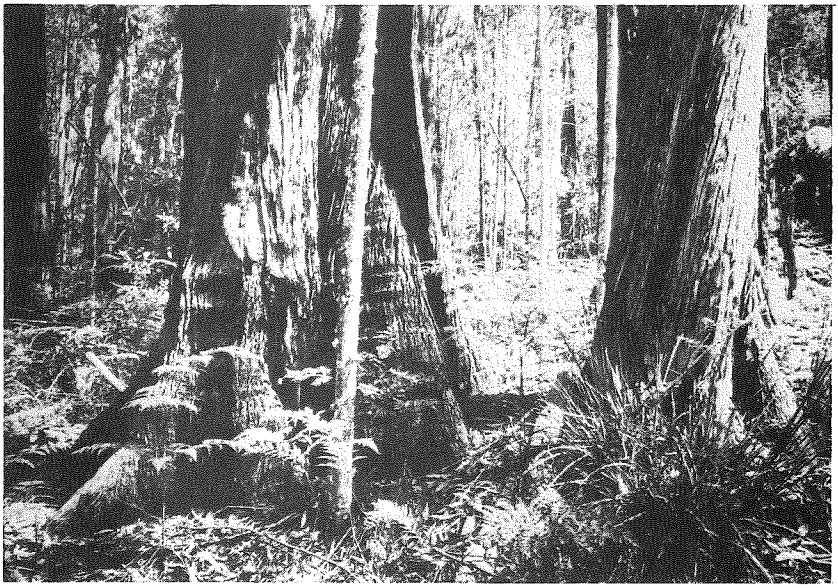
In 1975 the Forestry Commission appointed its first wildlife biologist. This was an important step in ensuring that all aspects of forest ecology were considered in planning the management of the forest resources of New South Wales. Since 1975 the Commission's involvement in the study of forest wildlife has expanded rapidly. This report presents an overview of research initiated in 1975 and carried out by the Commission in co-operation with the Australian Museum on the effects of logging on native fauna in the South East Forestry District. The report discusses options for the management of wildlife in the context of an intensive forestry operation and is an indication of the Commission's commitment to the conservation of the State's forests and the need for public discussion of management recommendations.

J.L. Henry,
Commissioner for Forests

July, 1980.

PLATE 1—PLATE 2

Plates 1 and 2 illustrate the forest along the Coast Range Road, Victoria. A tall, moist formation with *Eucalyptus fastigata — E. obliqua* and an abundance of gliding possums. Elevation approximately 900 m above sea level.
(Photo — Australian Museum — H.F. Recher)



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SUMMARY

This report reviews research into the effects of integrated logging or clearfelling on populations of forest birds and mammals in the Eden District in southeastern New South Wales, Australia. Studies commenced in 1975 and have been conducted cooperatively by the Forestry Commission of N.S.W. and the Australian Museum. Initial emphasis has been on the distribution and abundance of fauna in mature forest and on the identification of those species most likely to be affected adversely by logging operations. Census plots for birds, small ground mammals and arboreal mammals were established along an altitudinal transect from near sea level in the Nadgee State Forest to about 900m above sea level in the Bondi State Forest. These plots were compared with similar plots in the Bega Sub-district.

Data for birds are most extensive and are available from 69 plots censused during the spring breeding season with seasonal data available for 15 plots and monthly data obtained from two 10 ha grids during 1978. Seven plots have been censused for birds each year since 1975 and a further eight each year since 1976. In addition to data on fauna, the vegetation on each transect has been measured in a variety of ways and the species composition of the canopy, and taller understorey layers determined.

From the vegetation data, six forest habitats are represented on our study plots; moist gully, spotted gum, tablelands, dry ridge, low rainforest and coast forest with Banksia. Of these, the first three and the Banksia forest have the richest faunas. Within these forests the birds and mammals most likely to be sensitive to integrated logging operations are species which require tree hollows for nesting or as dens. This includes nearly 10 per cent of the avifauna (15 species), all gliding possums (4 species) and some forest bats. The Koala, Pygmy Possum, Short-eared Possum and Common Dunnart are also likely to be sensitive. Clearfelling will also adversely affect nectar feeding birds including honeyeaters, lorikeets and silvereyes.

The immediate effect of clearfelling is the replacement of the mature forest fauna by species typical of shrub habitats. Most of these inhabit mature forest where they use shrub and ground vegetation layers. As regeneration proceeds, the young forest is recolonized by mature forest fauna, but it appears that forest which is 40 to 45 years old is too young for some species which depend upon mature forest for refuge, nest sites or foraging.

Despite the effects of integrated logging on wildlife, it is considered possible to manage wildlife so as to ensure the survival of all species within the Eden District and continue integrated logging operations. Various management options are proposed based on existing procedures of small coupe logging and retention of buffer strips along water courses. It is also recommended that the logging rotation system be diversified further through space and time and that forest with particular value for wildlife be reserved from clearfelling or cut on a much longer cycle than the proposed 40 to 45 year cutting rotation. It is considered that the existing National Parks and Nature Reserves in the Eden District are inadequate by themselves to ensure the survival of the region's wildlife. It is strongly recommended that the management of wildlife be made an integral part of the management of the State Forests in the Eden District.

INTRODUCTION

The State Forests in the southeastern corner of New South Wales fall within the Eden Woodchip Concession (Figure 1) (Scott & Co., 1975). As such, they are managed intensively for the production of pulpwood (woodchips) and sawlogs. The forestry operation is known as 'integrated logging' or 'clearfelling' and results in the removal of all or almost all trees with a diameter greater than 20cm at breast height (1.3m). Although these forests have been harvested for more than a century, integrated logging is a major change in forest management and has been the subject of controversy since the establishment of the woodchip industry in 1968 (Routley & Routley, 1975; Scott & Co., 1975). Environmental groups have been particularly vocal in their objections and have pressed for the reservation of additional forest lands as national park, e.g. the Wallagaraugh Wilderness proposal (Helman *et al.* 1976 &. Bell 1978). Among the adverse environmental effects attributed to integrated logging are increased erosion, destruction of wildlife habitat, decreased recreational opportunities, and the spread of forest disease (Routley & Routley, 1975). In opposition it is argued that the woodchip industry has boosted the local economy, provided a tax base for new services, and that the regenerating forest will be healthier and more productive than the existing forest which has been adversely affected by fire and poor logging practices in the past (Scott & Co., 1975).

In response to this controversy, the Australian Museum initiated studies during 1975 on the effect of integrated logging on wildlife in the forests of the Eden District (Recher *et al.,* 1975a; Recher, 1976). Investigations were extended in 1977 to forests near Bega and coordinated with work at Kendall on the north coast of New South Wales (see Milledge, 1979). These studies have been designed to resolve questions on the impact of clearfelling on forest vertebrates and to provide guidelines for the management of wildlife in the context of an intensive forestry operation. Since 1976 the Museum has conducted its forest research programme in cooperation with the Forestry Commission of New South Wales. In 1979 this cooperative programme was extended to include the National Parks and Wildlife Service of New South Wales.

Although two previous reports have been issued (Recher *et al.,* 1975a; Recher, 1976), in this paper we review our work from 1975 through 1978. To assess the impact of integrated logging on wildlife we have sought to determine the distribution and abundance of terrestrial vertebrates, their biology and habitat requirements, and the relation between habitat and species diversity. Basic to this work has been a survey of the vertebrate fauna of southeastern New South Wales with emphasis on the fauna of mature forest. In this report we outline the results of our research and make recommendations for the management of birds and mammals in forests affected by integrated logging.

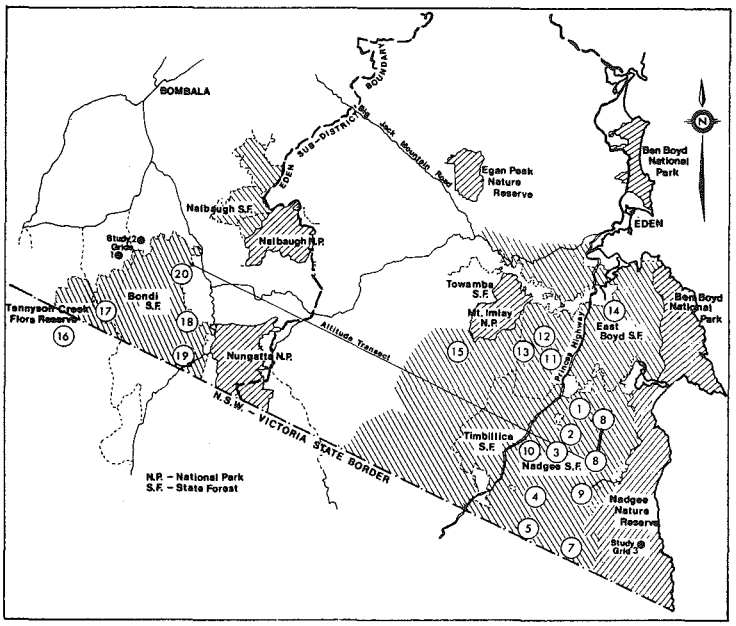

FIGURE 1
Map of southeastern New South Wales showing Eden Woodchip Concession and spotlight transects used in the arboreal mammal studies.

OBJECTIVES

Our studies have been designed to obtain data needed to integrate fauna management with forestry practices. Implicit are two assumptions. We assume that clearfelling will continue in the Eden District for at least another 30 years or until one logging cycle has been completed. We also assume that Forestry Commission policy has, as an objective of forest management, the conservation of wildlife. The responsibility of the Forestry Commission for wildlife conservation is stated in the Commission's indigenous forest policy statement[1] and required under its Act[2]. We personally view the State Forests of New South Wales as part of a conservation spectrum extending from wilderness preserves to forest plantations.

In the design of our research, two sets of questions have been asked. One set is biological and is concerned with the ecology and behaviour of the animals studied. The second set is specifically related to existing forest management practices and the effects of these on wildlife. The two are not independent and an understanding of the relation between forestry and wildlife requires both to be answered.

---

1. The Forestry Commission's Indigenous Forest Policy (1976) states: 5.3.8 *Wildlife Conservation*
   .....
   Wherever practicable management of State Forests should be designed to protect wildlife habitats and to minimise adverse effects from commercial operations, construction and fire protection activities, or from activities of human visitors.

2. The Forestry Act, 1916, states, under the heading: Objects of the commission
   8A (1) The objects of the commission shall be —
   .....
   (e) consistent with the use of State Forests for the purposes of forestry and of flora reserves for the preservation of the native flora thereon —
   (i) to promote and encourage their use as a recreation; and
   (ii) to conserve the birds and animals thereon.

   (2) In the attainment of its objectives ..... the commission shall take all practicable steps that it considers necessary or desirable to ensure the preservation and enhancement of the quality of the environment.

The Biological Questions

A major objective has been to determine the distribution and abundance of the forest animals of south eastern New South Wales and their association with the forest vegetation. Because they are easy to study and have considerable social value, we concentrated on birds and mammals. During 1979, our research was extended to include reptiles, amphibians, and invertebrates, but results are too preliminary to report here.

A more ambitious goal has been to reach an understanding of the mature forest ecosystem. We have been particularly interested in the relation between various habitat parameters (e.g. foliage structure, plant species diversity) and animal species diversity, the foraging ecology of birds and arboreal mammals, and the role of fire. This part of our research will assume increasing importance during 1980. An immediate goal is to determine the relation between the abundance of birds and the abundance of their food resources (e.g. insects, nectar-rich flowers).

In studying the forest fauna, we have attempted to identify those birds and mammals which depend on mature forest and which can reasonably be expected to be affected by integrated logging. The biology of these species, their resource requirements (e.g. food, nest or den sites) and the effect of logging on these resources are therefore of particular importance to the forest manager. In our work, we have selected a few of these dependent species for intensive study: Yellow-bellied Glider *Petaurus australis,* Greater Glider *Schoinobates volans,* White-throated Tree-creeper *Climacteris leucophaea* and Red-browed Tree-creeper *C. erythrops.* Data have been obtained on other dependent species, but these species were selected for detailed work because of their easy accessability on our study areas.

The Forest Management Questions

What is the effect of integrated logging on wildlife? There is no simple answer to this question. The management of forests in the Eden District is complex. There are differences in logging and regeneration procedures according to forest type, soil, topography and altitude. There has also been a tendency for management prescription to change as more is learned of the response of the forest to logging. We have therefore taken the major features of existing forest management procedures and asked how each of these affects the forest fauna. These questions interlock, but the approach to each is designed to provide guidelines in the management of wildlife for a specific part of the forest management plan.

Length of Logging Cycle

It is expected that the State Forests forming the Eden Woodchip Concession will be logged once in the first 40 years (i.e. by the year 2010), but the nature of the logging cycle can not be predicted past that point (G.R. Dobbyns, personal communication). It is therefore important for wildlife management to know "at what age will the regenerating forest be colonized by animals which depend on mature forest?" If it is more than 40 years, it may require variations in a second logging cycle to allow some forest to mature so as to provide the needs of dependent species (Recher *et al.,* 1975a).

Buffer Strips

In the normal course of logging, mature forest on very steep or rocky areas, along main roads, reserves along major waterways, and filtration or buffer strips along smaller water courses is retained. It has been estimated that in the Eden Sub-district (Fig. 1) 25 per cent of State Forest will not be logged for these reasons (G.R. Dobbyns, personal communication). Reserves and buffer strips along water courses which will form a net of mature forest throughout the Eden District may be especially important for wildlife. We need to know "are strips of mature forest an adequate refuge for dependent wildlife?" What resources do they provide and how is their value to wildlife affected by the width of the strip, fire and logging? Are there significant benefits to be gained from locating the borders of buffer strips along "ecological boundaries" (e.g. the edge of a floodplain) as opposed to a constant width as now practised?

PLATE 3

Goanna Creek, East Boyd State Forest. Two transects are located at this point. Pictured here is an open dry ridge forest of *Eucalyptus sieberi* mid-way up the slope. The second transect parallels the creek through a *E. cypellocarpa* flat. The open forest has few birds or mammals, but the *E. cypellocarpa* flat is one of the richest areas sampled.

(Photo — Australian Museum — H.F. Recher)

Movement Corridors

In addition to unlogged patches, reserves and strips, 22 per cent (88 000 ha.) of forested crown lands are reserved as National Park and Nature Reserve within the Eden District. However, the parks and nature reserves are individually small and separated by intervening State Forest (Figure 1). Allowing for the movement of wildlife between these separate areas is therefore an important consideration in managing wildlife in the State Forests. Buffer strips and creek reserves provide an existing base for wildlife movements, but "should buffer strips be extended across ridges to create a 'web' of mature forest along which organisms can move between catchments?" Also, "are corridors of mature forest needed along ridgelines for wildlife which might be restricted to the drier forest types?"

Habitat Trees

Tree hollows are a critical resource for arboreal mammals and some forest birds (as den and nest sites). Virtually all forms of logging reduce the number of hollow, or, as they are called, habitat trees (Recher & Rohan-Jones, 1978) and retention or provision of hollows in intensively managed forest is an important part of any wildlife management program (Thomas, 1979). For a variety of reasons, including cost, it is probably best to retain naturally occurring hollows within the managed forest. Even under the most favourable circumstances, the number of hollows available to wildlife will be reduced and effective management requires the answers to several questions. What is a habitat tree? Which species of trees and at what age and size do they provide hollows for mammals and hole-nesting birds? Is it adequate to provide habitat trees solely within buffer strips or must they be located throughout the regenerating forest? If dispersed, at what density? If confined to buffer strips, are special measures needed to protect them from logging and buffer against abnormal environmental stress?

Size of Logging Coupes

The pattern of logging is to alternate logged with unlogged coupes. The size of the area cleared in any one patch has changed from large (in excess of 4000 ha.) in 1969/70 to the present pattern of logging from alternate dump sites (landing stages) with coupes averaging less than 40 ha. Because different species of animals have different requirements for space, the size (and perhaps the shape) of logged and unlogged coupes may have important effects on wildlife. For example, an animal which disperses slowly may find it difficult to fully recolonize a large patch of regeneration and an animal which requires a large territory may not be able to use very small patches of forest. In order to determine the best balance between the needs of wildlife and the constraints imposed on logging by typography, roading and efficient use of equipment, we need to understand "what effect the size (and shape) of logged and unlogged areas has on animal populations?".

Habitat Patterning

We know that wildlife is not uniformly distributed throughout the forests of southeastern New South Wales. Species abundances and the composition of communities change with soil, aspect and altitude. It may be desirable to reserve some particularly rich habitats from clearfelling or to log them differently from other less productive forest (Recher *et al.*, 1975a). If this is to be done, then we need to know "What varieties or special types of habitat should be preseved? How much of each type is a viable unit? What are suitable methods for recognising these habitats in the field?"

In the preceding, we have outlined some of the broader questions which must be answered in developing an effective program of wildlife management within the context of an intensive forest industry which affects a large area of Crown Forest (405 000 ha.). There are many other management questions; some relate to the conservation of the individual species and others to the forest as a whole. Those that we have asked form a base on which to develop what must be a continuously changing (evolving) plan of management for the Eden Woodchip Concession.

THE STUDY AREA

The Eden Woodchip Concession occupies the extreme southeastern corner of New South Wales (Figure 1). The region has a generally rugged topography with slopes predominantly greater than 15° (Heyligers, 1975). Elevations range from sea level to 1200 m (Brown Mountain), but are mostly between 600 m and 900 m in the western half of the concession and less than 300 m in the eastern half. Yearly rainfall increases from the coast (750 mm at Nadgee) inland (920 mm at Bondi) and with elevation (e.g. in excess of 1100 mm on Mount Imlay and Brown Mountain.)

Kelly & Turner (1978) recognize six main geological types in the Eden area (roughly the eastern half of the concession), but soils derived from Devonian Bega Granite (45 per cent of area) and Ordovician marine sediments (33 per cent of area) are most important. These soils are moderately rich in nutrients (e.g. NPK). Soils in the western half of the study area are derived from the same major geological types (Heyligers, 1975).

The study area is mostly forested with forest types changing with soil fertility, elevation, aspect and slope (Turner *et al.*, 1978). We have examined three parts of the region:

1. State Forests in the Eden sub-district: East Boyd, Nadgee, Timbillica and Yambulla. These lie between latitudes 37°10′S and 37°25′ and longitudes 149°30′E and 149°55′E. Altitudes vary from sea-level to 886 m (Mount Imlay) but are mostly in the range 50 m to 600 m.
2. Bondi State Forest west of the Cann Valley Highway in the Bombala Sub-district, and the adjacent Victorian forest. The latitudinal range here is 37°05′S to 37°15′S and the longitudinal range is 149°05′E to 149°20′E. Altitudes range from about 500 m to 1057 m (Mount Tennyson) but are mostly below 900 m.
3. Five State Forests in the Bega Sub-district: Tanja, Tanja West, Mumbulla, Murrah and Bermagui.[1] These lie between latitudes 36°25′S and 36°45′S and longitudes 149°50′E and 150°05′E. Altitudes range from sea-level on the coast to 774 m (Mumbulla Mountain) but are mostly below 300 m.

In addition, the Australian Museum has been involved since 1969 in forest ecology studies in Nadgee Nature Reserve which lies on the coast to the east of the Nadgee State Forest (Figure 1). Data are also available from studies of forest ecology by the Australian Museum and the Forestry Commission in the Blue Mountains (latitude 33°20′S) and at Kendall (latitude 31°40′S). Data have thus been obtained along an altitudinal transect from Nadgee Nature Reserve west to Bondi State Forest and along a latitudinal transect from Nadgee Nature Reserve north to Kendall. This report presents data only from the southeastern forests.

1. Most of Tanja and Tanja West State Forests and some of Mumbulla State Forest are to be dedicated as part of Mimosa Rocks National Park.

VEGETATION

Birds were surveyed on 45 plots in mature, relatively undisturbed forest. Many of these plots were also used to survey small mammals. The plots were selected to sample the range of forest types along the altitudinal transect from Nadgee to Bondi and in the State Forests near Bega. On each plot, we determined the species composition of the canopy and taller understorey vegetation and estimated the density of foliage on a vertical profile through the vegetation. These data were necessary for understanding the distribution and abundance of birds and mammals in relation to their habitat. As described later, arboreal mammals were surveyed differently from birds and small mammals but, as the bird study plots coincided with the larger areas sampled for arboreal mammals, they are representative of the vegetation in which arboreal mammals were studied.

Our data from mature forest plots provide a baseline from which changes arising from forest management can be identified. Nineteen plots are in the Eden sub-district State Forests, fourteen are in the western part of the Bondi State Forest and adjacent Victoria, and twelve are in the Bega sub-district. A smaller number of plots from clearfelled forests of different ages have been surveyed.

Based on the dominant tree species, our plots sample thirteen forest-types (Appendix A). Common names for tree species are presented in Appendix B. Although the forests of the three regions differ in tree species and forest-types (Tables 1 and 2; Figure 2) (also see Heyligers, 1975; Turner *et al.*, 1978), for the analysis of faunal distributions, it is convenient to group them into six broad types:

1. **Dry open forest of the ridges.** The most common and characteristic species is *Eucalpytus sieberi* but a variety of other species occur in different areas and in various combinations (see Appendix A). The understorey is mainly xeromorphic shrubs.
2. **Tall, moist open-forest of the gullies.** The most common and characteristic species here is *E. cypellocarpa,* but again a variety of other species occur. The understorey mainly consists of mesomorphic shrubs and ferns.
3. **Tall open-forest dominated by** *E. maculata.* Occurs at low altitudes in the Bega sub-district on ridges and slopes with fertile soils. The understorey is mainly moderately mesomorphic shrubs.
4. **Open-forest and woodland of the tablelands.** Occurs in Bondi State Forest. Characteristic species are *E. dives*[1], *E. dalrympleana, E. pauciflora* and *E. stellulata.* The understorey is grassy and may include xeromorphic shrubs.
5. **Low open-forest and woodland with *Banksia serrata/integrifolia* in the understorey.** The ground layer consists of xeromorphic shrubs, sedges, and Bracken *(Pteridium esculentum).* Two types occur: a community on coastal headlands and stabilised sand-dunes dominated by *E. botryoides* and *E. globoidea;* and a community on poorly-drained sites dominated by *E. consideniana* and *E. globoidea.* The former is more common in the Bega sub-district, the latter more common in the Eden sub-district.
6. **Low rainforest.** Occurs in gullies at low altitudes in the Bega sub-district and is mostly dominated by *Acmena smithii.* Similar vegetation occurs in patches or as an understorey in eucalypt gully forest elsewhere in the study area.

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1. The taxonomy of the peppermints (*E. dives, E. robertsonii* and *E. radiata*) is unresolved. There are known intermediate forms within the peppermint group and between them and other species. For the purposes of our work we have used the species name for which the specimen exhibits the most characteristics. Further taxonomic work may prove the *E. dives* population referred to here, to be composed of several variants.

TABLE 1
MAJOR FOREST TYPES IN THE STUDY AREA

(C – common, U – uncommon)

Forest Types	Bega Sub-district	Eden Sub-district	Western Bondi State Forest.
1. *Acmena smithii* low rainforest	C	U	
2. *Eucalyptus cypellocarpa – E. muellerana – E. obliqua* tall open-forest	C	C	C
3. *E. longifolia – E. muellerana – E. smithii* tall open-forest	C		
4. *E. fastigata* tall open-forest	U	U	C
5. *E. sieberi – E. globoidea – E. agglomerata* open-forest	C	C	
6. *E. sieberi – E. globoidea – E. gummifera* open-forest	U	U	
7. *E. sieberi – E. obliqua – E. dives* open-forest			C
8. *E. longifolia – E. muellerana – E. sideroxylon* open-forest	C	U	
9. *E. maculata* tall open-forest	C		
10. *E. dives – E. dalrympleana* open-forest			C
11. *E. pauciflora – E. stellulata* open-forest/woodland			U
12. *E. consideniana – E. globoidea* open-forest/woodland	U	C	
13. *E. botryoides – E. globoidea* low open-forest/low woodland	U	U	

TABLE 2

EUCALYPTUS AND ANGOPHORA SPECIES PRESENT ON THE STUDY PLOTS

Bega-Bermagui State Forests	Eden-Nungatta State Forests	Western Bondi State Forest
E. cypellocarpa	*E. cypellocarpa*	*E. cypellocarpa*
E. fastigata	*E. fastigata*	*E. fastigata*
E. globoidea	*E. globoidea*	*E. globoidea*
E. muellerana	*E. muellerana*	*E. muellerana*
E. obliqua	*E. obliqua*	*E. obliqua*
E. sieberi	*E. sieberi*	*E. sieberi*
A. floribunda	*A. floribunda*	*E. ovata*
E. agglomerata	*E. agglomerata*	*E. viminalis*
E. elata	*E. elata*	*E. dalrympleana*
E. longifolia	*E. longifolia*	*E. dives*
E. smithii	*E. smithii*	*E. nitens*
E. bosistoana	*E. ovata*	*E. rubida*
E. botryoides	*E. viminalis*	*E. pauciflora*
E. gummifera	*E. consideniana*	*E. stellulata*
E. maculata	*E. fraxinoides*	
E. maidenii	*E. radiata*	
E. paniculata		
E. sideroxylon		

FIGURE 2

RELATIONSHIP OF FOREST-TYPES TO LATITUDE, ALTITUDE AND ASPECT

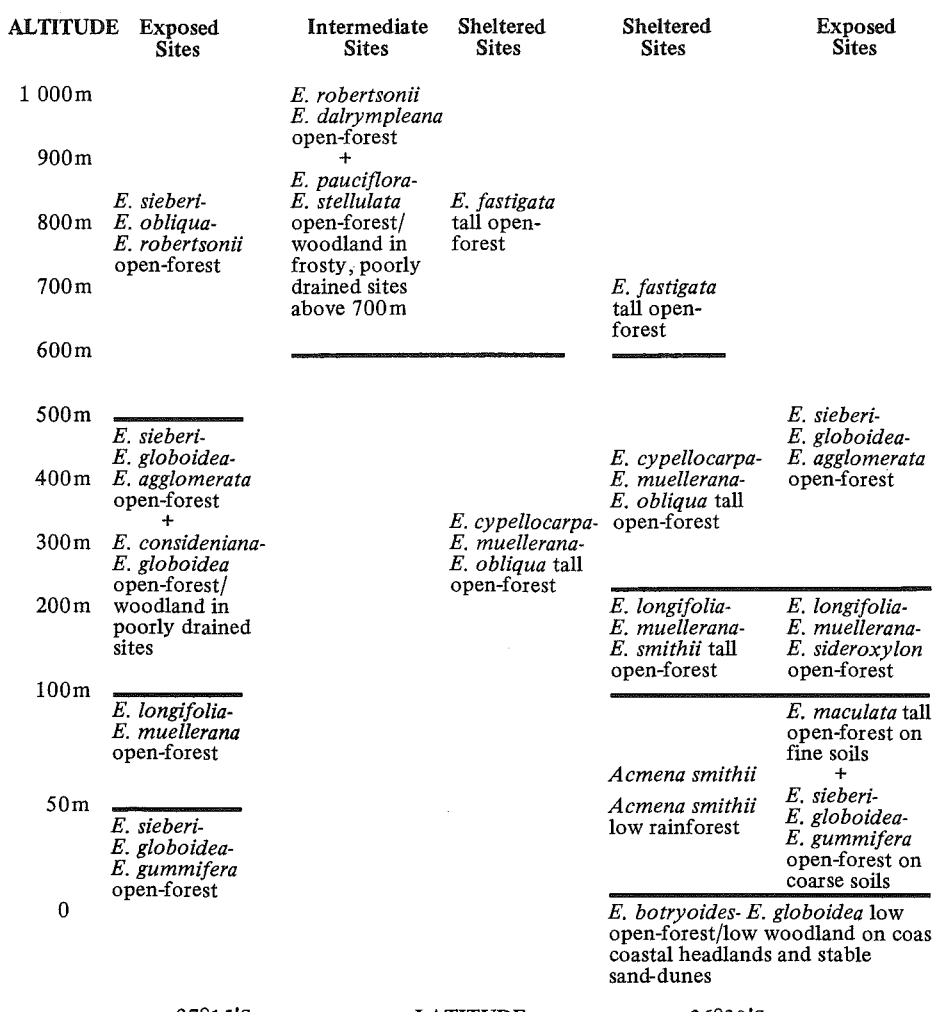

PLATE 4

Eucalypt forest along Imlay Road Approximately 300 m above sea level. This site is dominated by *Eucalyptus radiata* and *Eucalyptus obliqua* and has a moderately rich fauna.

MAMMALS

Excluding bats, twenty-six species of native mammals have been confirmed as occurring in the forest of the Eden District (Appendix B) (Recher *et al.,* 1975a; unpublished data). The number of species of bats using forest habitats has not been accurately determined, but between fifteen and twenty may occur in the region (Recher *et al.,* 1975a, Land Conservation Council, 1975). Not all bats are abundant and several species would be transient or irregular in their occurence. In addition to the native fauna, nine species of introduced or exotic mammals are present in the Eden District; European Rabbit (*Oryctolagus cuniculus*), European Hare *(Lepus europaeus),* Black Rat *(Rattus rattus),* House Mouse *(Mus musculus)* Sambar Deer *(Cervus unicolor),* Feral Goat *(Capra hircus),* Feral Pig *(Sus scrofa),* Red Fox *(Vulpes vulpes)* and Feral Cat *(Felis cattus).* Deer, goat and pig are uncommon and restricted to the western portion of the Bondi State Forest.

We have studied small ground mammals and arboreal mammals in detail (Recher *et al.,* 1975a; Recher, 1976). These groups were selected for ease of study and because several species of arboreal mammals depend upon mature forest (Tyndale-Biscoe and Calaby, 1975; McIlroy, 1978).

SMALL GROUND MAMMALS

Distribution and Abundance

Seven species of small ground mammals (less than 200 gms in weight) occur in the Eden District (Table 3; Appendix C). One of these, *Sminthopsis leucopus* the white-footed Dunnart, is rarely trapped (Morton *et al.,* 1980). It has been taken in the Nadgee Nature Reserve and in the Timbillica State Forest (Newsome *et al.,* 1975; Recher *et al.,* 1975a; Recher unpublished). In both locations the animal is uncommon and associated with dry, open forest having a sparse ground and shrub vegetation. Two introduced species, the House Mouse and the Black Rat, are widely distributed throughout the Eden District. The Black Rat has a limited habitat distribution and rarely occurs in either mature or regenerating native forest. We have taken it in the Nadgee Nature Reserve and Nadgee State Forest near water and elsewhere close to human habitation. In contrast the House Mouse occurs in a wide range of habitats (Table 3) and is abundant in forest 18 to 36 months following wildfire (Recher *et al.,* 1975b; Newsome *et al.,* 1975).

Two native rodents, the Bush Rat, *Rattus fuscipes* and the Swamp Rat *R. lutreolus,* and two dasyurid marsupials, the Brown Antechinus *Antechinus stuartii* and Swainson's Antechinus *A. swainsonii,* occur throughout the Eden District. The Bush Rat and Brown Antechinus are the most abundant native species and occur in most mature forest habitats (Table 3). Swainson's Antechinus occurs in wet forest and along gullies and streams and is absent from dry forest. The Swamp Rat is restricted to habitats with a dense ground vegetation dominated by grasses and sedges (Braithwaite & Gullan, 1978). It rarely occurs in forest and is then associated with openings or a sparse canopy layer.

Small ground mammals were trapped along some transects established for the census of birds. Trapping was by breakback and live traps alternated along the transect and spaced at 4 to 5 m intervals. The traps were baited with a peanut butter/oatmeal paste. A total of 50 traps were used on each line and the transect sampled for four consecutive nights. We removed all animals as they were caught.

Small ground mammals are most abundant in tall moist forest and low open forest (Table 3(A)). Each of these habitats is characterized by dense cover with well developed shrub or ground layers of vegetation. In some tall moist forest along creeks, additional cover is provided by flood debris. Few individuals occur in dry open-forest (Table 3 (A)) and, in our experience, forest along ridges is particularly poor for small ground mammals. These habitats are characterized by sparse cover with few shrubs.

TABLE 3

A. DISTRIBUTION IN MATURE FOREST OF SMALL GROUND MAMMALS ($\bar{x}$/TRANSECT)

Forest Type	A.st.	A.sw.	R.f.	R.l.	R.r.	Sm.l.	Mus
Dry open-forest (11)[1]	1.6	0	1.6	0	0	0.1	0.1
Tall moist forest (9)	3.7	2.0	16.6	0.2	0.1	0	0.9
Low open-forest (2)	8	4	16	10	0	0	3

1. Number of Transects

B. RESPONSE OF SMALL GROUND MAMMALS TO INTEGRATED LOGGING ($\bar{x}$/TRANSECT)

Forest Type[1] (logged)[2]	A.st.	A.sw.	R.f.	R.l.	R.r.	Sm.l.	Mus
Dry open-forest (6)[3]	4.8	0.7	17.2	0.5	0	0	5.3
Low open-forest (2)	17.0	2.5	23.5	0.5	0	0	6.5

1. No areas of clearfelled tall moist forest were available for comparison.
2. Transects were sampled two to three years after logging when regeneration was well established.
3. Number of transects.

A.st. = Antechinus stuartii
A.sw. = Antechinus swainsonii
R.f. = Rattus fuscipes
R.l. = Rattus lutreolus
R.r. = Rattus rattus
Sm.l. = Sminthopsis leucopus
Mus = Mus musculus

Effects of Logging

Several studies have now demonstrated the importance of vegetation structure to the abundance and distribution of small ground mammals in Australia (e.g. Cockburn, 1978; Braithwaite & Gullan, 1978; Fox, 1978). The change in forest structure with integrated logging followed by regeneration of dense ground and shrub vegetation also appears to determine the response of small ground mammals.

Recher *et al.*, (1975a) noted that Bush Rats and Brown Antechinus are able to reproduce even during logging and suggested that small ground mammals were not affected adversely by clearfelling. These points require modification. It is correct that small ground mammals may remain and reproduce during a logging operation, but they do this only where undisturbed vegetation provides cover. On highly disturbed sites, the numbers of small ground mammals is greatly reduced following clearfelling (this study; Friend, 1979). Nonetheless, as regeneration proceeds, logged areas are re-colonized and support dense populations of small mammals. The numbers of Brown antechinus and Bush Rat in regenerating dry open-forest and low open-forest is substantially greater (Table 3 (B)) than in mature forest of the same types. Numbers of House Mice may also increase.[1] Swamp Rat and Swainson's Antechinus may decrease in their original habitats, but they may be able to invade new areas (e.g. dry open-forest) in response to the greater density of cover (ground vegetation and logs). These changes are not different from those recorded after fire (Recher & Christensen, 1980) and we expect that, as the forest canopy develops on clearfelled sites, the numbers of small ground mammals will return to pre-logging levels (Recher, 1976).

Long term trends in small mammal distribution and abundance remain to be measured. For example, dense logging regeneration is probably not suitable habitat for the Dunnart. Whether it will colonize older regeneration depends on how rapidly the forest opens up and the density of ground and shrub vegetation is subsequently reduced. Similarly we cannot easily predict the long term response of exotic species (House Mouse and Black Rat) to extensive integrated logging. Both species are known to respond to disturbance (Fox and Fox, 1978; Milledge, 1980; Rohan-Jones, unpublished) and the intensive disturbance of large areas of forest through clearfelling could result in the development of permanent large populations of either species in the Eden District. The intrusion of these animals from logged forest could then have an adverse effect on native small mammals which survive in unlogged reserves.

ARBOREAL MAMMALS

Nine species of arboreal mammals occur in the Eden District. Seven species are dependent upon mature forest; Sugar Glider *(Petaurus breviceps),* Yellow-bellied Glider, *(P. australis),* Greater Glider, *(Schoinobates volans),* Feathertail Glider *(Acrobates pygmaeus),* Koala *(Phascolarctos cinereus),* Pygmy Possum *(Cercatetus nanus),* and Short-eared or Mountain Possum *(Trichosurus caninus)* (Tyndale-Biscoe & Calaby, 1975; McIlroy, 1978). This should not be taken to mean that they require 'virgin' forest, but only that they need continuous forest cover containing trees with hollows suitable as dens. Brush-tailed Possum *(T. vulpecula)* and Ring-tailed Possum *(Pseudocheirus peregrinus)* are not dependent upon mature forest although both will use tree hollows for refuge.

Because of the large number of species which depend on mature forest, there has been considerable concern about the effects of intensive forestry operations on arboreal mammals (McIlroy, 1978; Bell, 1978). For this reason, a large part of our research effort at Eden has been directed towards these animals. We have sought to determine their abundance and distribution, habitat requirements and capacity to survive in patches or strips of mature forest remaining after clearfelling.

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1. We have recorded this response only in the Nadgee State Forest east of the Pacific Highway where some of our transects may have been affected by the 1972 wildfire.

Using spotlights, censuses were taken along regular transects in the Tanja, Nadgee, Timbillica, East Boyd, Yambulla and Bondi State Forests including the Coast Range Road in Victoria (Figure 1). The transects are along forest roads and were conducted by vehicle or on foot between dusk and 0230 hours. The roads traversed predominantly pass through dry forest types and follow ridges. Except along the Imlay Road where arboreal mammals were observed incidental to a census of macropods and Wombats *Vombatus ursinus,* the procedure followed was to move slowly (5km/h) along the transect identifying each animal located, marking its position, and returning the following day to identify the tree in which it was located. The height and diameter (d.b.h.o.b.) of each tree was also measured. The length of each transect and the total kilometers surveyed are presented in Table 4.

TABLE 4

ARBOREAL MAMMAL TRANSECTS

(a)

Eden Sub-District

East Boyd, Nadgee, Yambulla and Timbillica State Forests

No.	Location (1) of each Transect	Year(s) Surveyed	Length km	Total (2) km
1.	Swamp Road	75, 76, 77	7	35
2.	Ireland Timms – Range Roads	75, 76	17	34
3.	Naghi Road	75, 76	15	30
4.	Bruces Creek Road	75, 76	10	20
5.	Royds Creek Road	76	16	32
6.	Broadaxe Road	75	12	24
7.	Mines Road	75, 76	13	39
8.	Mountain Road	75, 76	20	20
9.	Merrica River – Loop Roads	75, 76	12	24
10.	Dinner Creek Trail	75, 76, 77	3	12
11.	Wombat Road	77	9	27
12.	Goanna – Burrawong Roads	76, 77	16	64
13.	Anteater Road	76, 77	7	28
14.	Edrom Road	76	10	10
15.	Imlay Road	76, 77, 78	50	250
–	Miscellaneous Connecting Roads	75, 76	51	51
	Total Distance Transected (1)	–	–	450

TABLE 4

(b)

Bombala and Bega Sub-Districts

Sub-District	No.	Location of each Transect	Year(s) Surveyed	Length km	Total km
	16.	Coast Range Road	75, 78, 79	4.5	36
	17.	Jacksons Bog Island	78	5.5	22
Bombala	18.	Bondi Forest Way	77, 78	3	6
	19.	Canabull Road-Buffer Strip 5 Circuit	78	10	20
	20.	Goldfields Road	75	10	20
Bega	21.	Nielsen Road – Quarry Road	78	5	10
		Total Distance	–	–	114

(1) Does not include Imlay Road Transect

(2) Total distance of transects used are not exact multiples of each unit length due to occasional partial completion of transects because of rain.

Arboreal mammal populations in remnant mature forest were studied in the Nadgee State Forest (Connection Road Reserve) and in the western part of the Bondi State Forest (Jacksons Bog Island and various buffer strips through the pine plantation). The colony of Yellow-bellied Gliders at Connection Road (Recher, 1976) and the Greater Glider population along Coast Range Road (Recher *et al.*, 1975a) were selected for detailed study of food preference, movements and behaviour.

Distribution and Abundance

As illustrated by the few animals observed during road transects (Table 5), arboreal mammals are uncommon throughout most of the dry forest types in the Eden sub-district (Table 6) (see also Recher **et al.**, 1975a; Recher, 1976; A. Fox, 1978). Arboreal mammals are abundant in moist forest along gullies, creeks and swamp edges where they tend to be associated with a variety of smooth-barked eucalypts. In the Eden sub-district, these include *Eucalyptus cypellocarpa, E. viminalis,* and *E. maidenii.* In the Bega and the Bombala sub-districts, arboreal mammals are generally more abundant than at Eden (Table 5) (See also Recher *et al.*, 1975a). This reflects the greater amount of moist forest in these districts.

Despite difficulties in observing these animals, our observations and reports from logging contractors suggest that Feathertail and Sugar gliders are widely distributed in the Eden and Bombala sub-districts. In contrast the Yellow-bellied Glider has a discontinuous distribution with known colonies in the Nadgee Nature Reserve (personal observation; A. Fox, 1978), the Nadgee State Forest, the East Boyd State Forest, and the Yurramie State Forest in the north of the Eden sub-district. It also occurs in the Bombala sub-district. The Greater Glider is uncommon in the Eden sub-district in tall moist forest along creeks, but is more common at

TABLE 5 TOTAL NUMBERS OF ARBOREAL MAMMALS RECORDED DURING VEHICLE TRANSECTS IN EDEN SUB-DISTRICT

Transect number	Total Kms	Predominant forest type	Greater Glider	Yellow-bellied Glider	Feathertail Glider	Sugar Glider	Pygmy Possum	Koala	Brush-tailed Possum	Ring-tailed Possum	Mountain Possum
1	35	Banksia, tall moist	9	1	?	3	?	+	1	3	0
2	34	Dry open, some tall moist	2	+	?	+	?	0	1	1	0
6	24	Dry open	0	0	?	+	?	0	0	1	0
7	39	Dry open	1	0	?	+	?	0	0	0	0
12	64	Dry open	1	0	?	+	?	0	0	0	0
Imlay Road	250	Dry open	1	0	?	+	?	0	0	0	+
All others	254	Dry open	1	0	?	+	?	0	+	+	0
Total			15	1	?	+	?	+	2	5	+

+ known to be present

? difficult to observe but known to be present in the district from other records

higher elevations. This distribution follows closely that of tall moist forest which is in greater abundance above 600 metres altitude. Neither the Brush-tailed nor Short-eared Possum is common in the Eden and Bombala sub-districts. The Brush-tailed Possum is seen most often in the coastal forests (i.e. Nadgee State Forest and Nadgee Nature Reserve). The Short-eared Possum does not extend below an elevation of about 100 metres. It is present in moist gully forest in the East Boyd State Forest along the Imlay Road and again in the Bondi State Forest and along the Coast Range Road. (These comments on Trichosurus modify previous statements on their altitudinal distribution in Recher *et al.* (1975 a)). Ring-tailed Possums are also widely distributed throughout these forests, but other than in the Nadgee Nature Reserve (A. Fox, 1978), are uncommon. The status and distribution of the Pygmy Possum is less certain, but we have records of it for the Nadgee Nature Reserve and the Timbillica State Forest where it occurs in forest and heath in association with Banksia. A. Fox (1978) considers it is common in mixed dry sclerophyll forest on the Nadgee Nature Reserve. The Koala is rare in the Eden District. Individuals have been reported from the Nadgee State Forest and near the Coast Range Road in the Bondi State Forest. Small colonies are present in the Yurramie State Forest and in the Bega sub-district.

In the Tanja, Tanja West, Mumbulla, Murrah and Bermagui State Forests in the Bega sub-district, arboreal mammals are most abundant in tall moist forest types. Ring-tailed Possum, Brush-tailed Possum, Sugar Glider and Feathertailed Glider are common throughout. The Short-eared Possum has not been recorded from these coastal forests, whilst the Yellow-bellied Glider occurs in spotted gum forest. The status of the Pygmy Possum is unknown, but should be similar to the Eden sub-district.

Glider Research

Arboreal mammals are especially vulnerable to forestry operations (Tyndale-Biscoe & Calaby, 1975; McIlroy, 1978). There are several reasons for their vulnerability. Gliders and possums mostly require tree hollows for dens and all species forage in trees where they variously feed on leaves, buds, nectar, sap and insects. In addition, the moist forest types where arboreal mammals are most abundant are of limited extent. Two species, the Greater Glider and the Yellow-bellied Glider, have been therefore selected for intensive study.

Populations of Greater and Yellow-bellied Gliders have been studied throughout New South Wales (Rohan-Jones, in preparation), but two sites in the Eden District have been used for intensive study. Greater Gliders were studied along the Coast Range Road (Figure 1) adjacent to the Bondi State Forest and a colony of Yellow-bellied Gliders was studied in the Nadgee State Forest. In both instances, the objective was to obtain data on population densities (as opposed to relative abundances), reproductive cycles, movements, den trees and foraging preferences.

Yellow-bellied Glider

Research on the Yellow-bellied Glider commenced in 1978. The colony is in a reserve between two logged compartments (Recher, 1976); one side was logged in 1970, the other in 1973. The reserve is tall, moist forest dominated by *Eucalyptus cypellocarpa* and *E. obliqua*. Both eucalypts are food sources for the gliders: the animals feeding on sap, buds and nectar. The Yellow-bellied Glider has not been seen to take insects. Individuals often forage in low (3 to 10 m high) vegetation including eucalypt regeneration, but most foraging is done in tall (15 m), mature canopy trees.

In addition to regular spotlight procedures, the animals in the Nadgee State Forest have been tracked by recording calls and glide directions. One den hollow was monitored during 1978 with low light video equipment using an infra-red light source.

Video records showed that up to three gliders shared the hollow. They emerged regularly about 30 minutes after sunset, calling vigorously soon after climbing into the outer branches (Figure 3). Animals using a second den hollow in the Nadgee Nature Reserve had a similar pattern of activity (Recher personal observation). The frequency of calls varies from night to night and is greatest during the autumn and

PLATE 5

Two of the richest study transects are along Swampcock Road, Nadgee State Forest and in tableland forest near the Bondi State Forest work camp. The Swampcock Road Plot (Plate 5) is dominated by *Eucalyptus consideniana* with an understorey of *Banksia serrata* and *Casuarina litoralis.* The tableland plot (Plate 6) shown here is an association of *E. dalyrmpleana* and *E. dives.*

FIGURE 3

Evening call frequency of Yellow-bellied Glider — number of calls recorded from the centre of the study area.

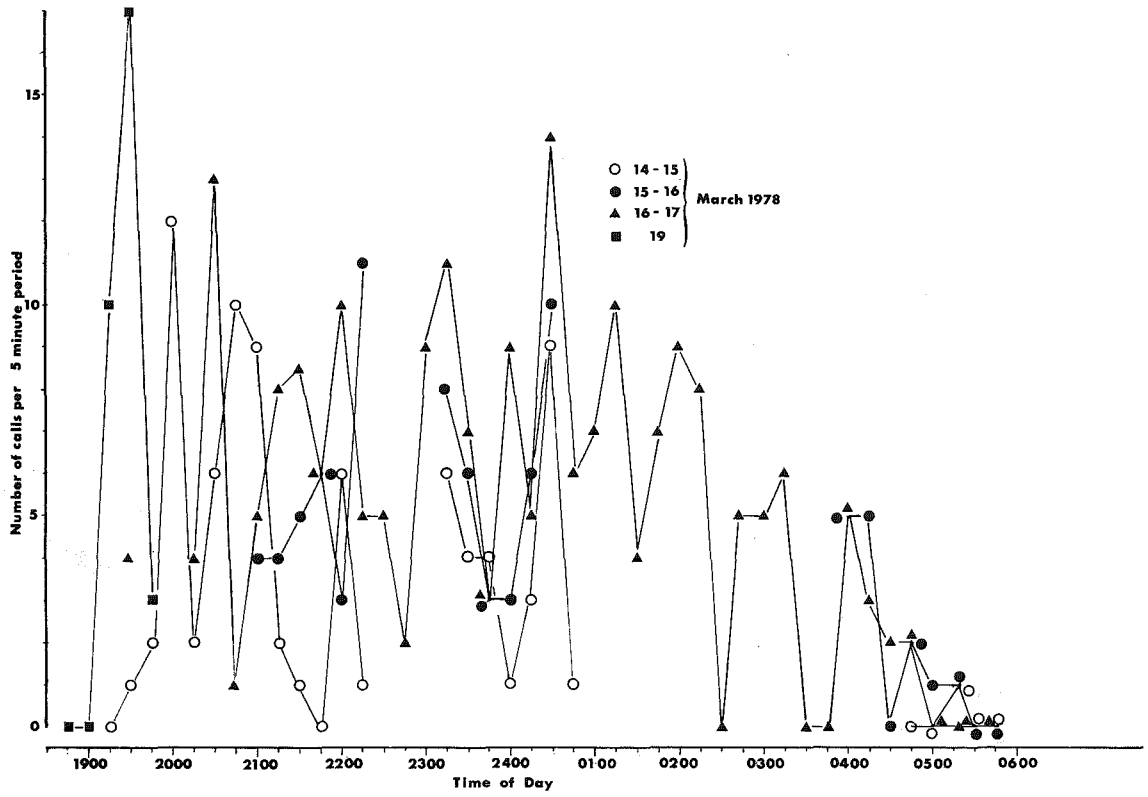
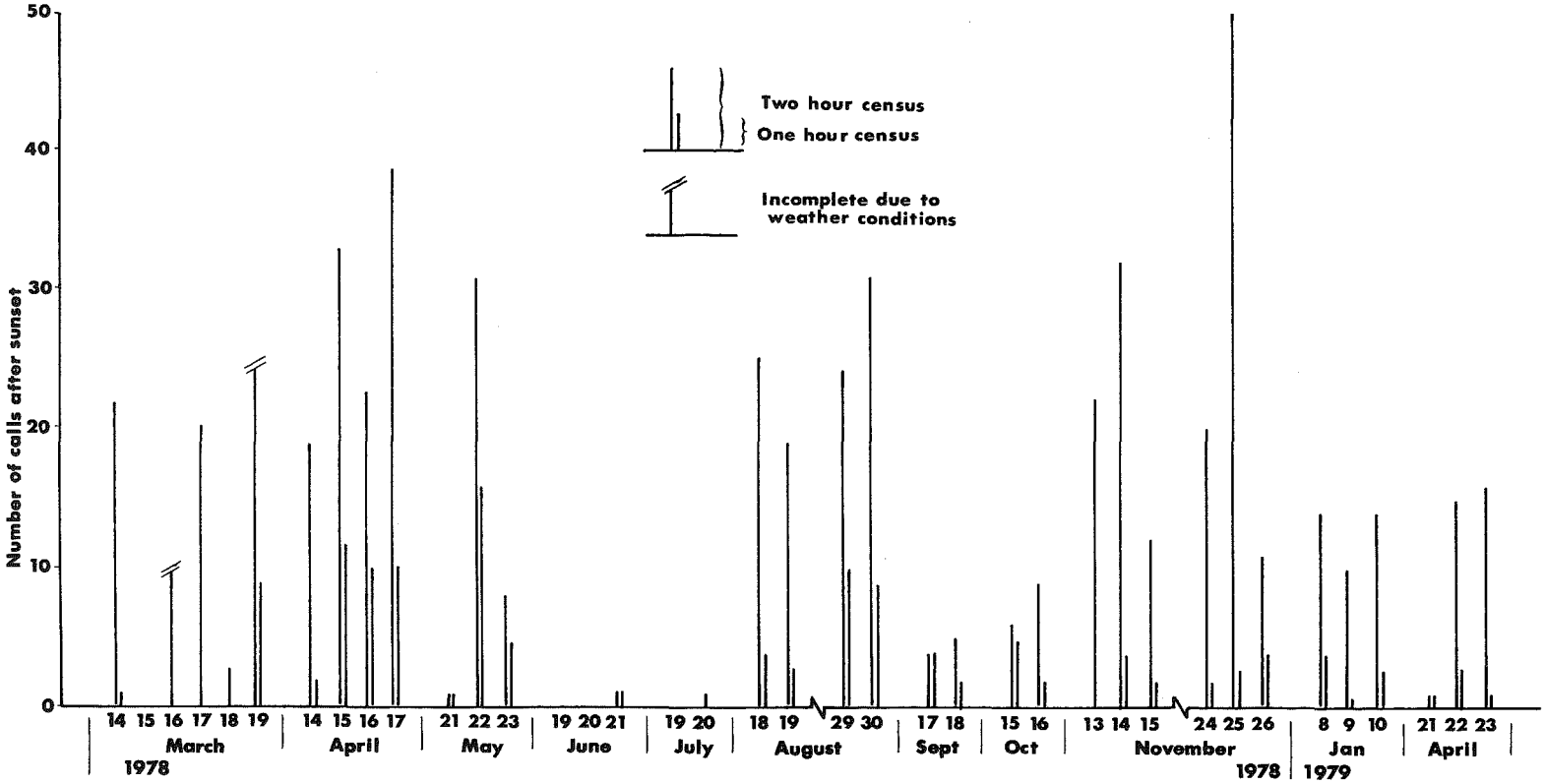


FIGURE 4

Seasonal call frequency of Yellow-bellied Glider — number of calls recorded from centre of study area during the first two hours after sunset.



spring (Figure 4). There are three distinct calls; one is given while the animal is stationary and the others in flight. One flight call is protracted and much like a loud gurgle. The direction of glide is easily plotted from this call. The second flight call is a low moan and seems to be uttered just as the animal launches into flight or just before landing.

Den hollows of yellow-bellied gliders are located in large, live trees. We have found hollows in use in *Eucalyptus gummifera, E. cypellocarpa* and *E. obliqua*. Hollows are used regularly, although it is unsure whether the same animals use the same hollows every night. Return to the hollows occurs just before sunrise, but the timing is less regular than the times of evening emergence. Individuals do not necessarily return together, although they leave together in the evening, and some animals may return during the night.

Yellow-bellied gliders are resident through the year on our study sites. The size of the colony studied varied between 5 and 11 animals in an area of about 60 hectares. The gliders moved distances in excess of 1.5 km along the reserve and into adjoining logged areas where taller trees had been left. Gliders of up to 150 m are common and the animals can move through logged areas with scattered tall trees.

Greater Glider

The tall (up to 60 m) mature forest along the Coast Range Road has been used for the study of Greater Glider population densities and habitat requirements. The forest on the study transect is dominated by *E. dives* and *E. obliqua*. In decreasing order of abundance, associated species are *E. fastigata, E. dalyrympleana, E. cypellocarpa* and *E. viminalis* (Table 6). The abundance of these trees and their size class distribution has been compared to their use by gliders (Table 6).

At points spaced 100 m along the 4.5 km long transect, the heights of the 10 nearest trees and the diameter (d.b.h.o.b.) of each were measured. For each tree the presence of hollows suitable for use by Greater Gliders was estimated. The same measurements were made for each tree in which gliders were observed.

On the Coast Range Road, Greater Gliders are recorded most often in large trees (Table 6). *E. obliqua* are the most abundant large trees along the transect. These trees also contain what appear to be the largest hollows, consequently the first observations of gliders in the evening are usually in *E. obliqua* trees. This bias in the data is reflected in Table 6 which shows Greater Gliders occuring in *E. obliqua* more often than if the animals selected trees at random. It is reasonable to conclude that large *E. obliqua* provide dens and after awakening in the evening the gliders remain for a while in their den trees. As evening progresses, the animals move into other trees to feed and show no obvious preference for species. Sightings of Greater Gliders along the transect are clumped (unpublished data) with the greatest numbers associated with the large *E. obliqua*, high tree species diversity, and better quality soils. Data from 1979/80 confirming these conclusions are being prepared for publication (Rohan-Jones, in preparation).

Effects of Logging

Clearfelling eliminates arboreal mammals from the logged area. Early studies on Greater Gliders by Tyndale-Biscoe & Smith (1969) showed the only individuals which survived clearing were those animals with retained unlogged forest in their original home ranges. This is consistent with our observations in the Nadgee, East Boyd and Bondi State Forests where small numbers of arboreal mammals (e.g. Greater Glider, Mountain Possum) persist in patches of mature forest (e.g. Jackson's Bog Island at Bondi State Forest) or in the strips of forest retained along water courses. There is no indication of an increase in the number of animals on remnant unlogged areas following logging (Table 7). As illustrated by Jackson's Bog Island at Bondi State Forest which has been isolated by pine plantations for 10 years, at least in the short term, arboreal mammals can persist in remnants of mature forest.

At elevations below 600 m (in the Eden sub-district), the forest types which are most productive of arboreal mammals occur in gullies and along creeks. In this instance normal forestry procedures for the protection of water quality (i.e. filtration or buffer strips) retain valuable habitat for wildlife dependent upon mature trees.

TABLE 6

TREES USED BY GREATER GLIDER AND OCCURRENCE OF SUITABLE HOLLOWS IN TRANSECT 16, COAST RANGE ROAD

(a)

TREES USED BY GREATER GLIDER

YEARS: 1978, 1979

NUMBER OF TREES IN WHICH GLIDERS WERE SEEN					
Tree Species		Diameter (DBH) Class (m)[1]			
		0–0.6	0.6–1.2	1.2–1.8	1.8–2.4
	% Occurrence	25	65	8	2
E. dives	53	5	18	1	
E. obliqua	27	2	8	8	8
E. fastigata	10		9		
E. dalrympleana	2		2		
E. cypellocarpa	2		2	1	1
E. viminalis	2		1		1
Dead	4	2			1
% in class		13	57	15	15

(b)

OCCURRENCE OF SUITABLE HOLLOWS ALONG TRANSECT

NUMBER OF TREES WITH OBVIOUS LARGE HOLLOWS					
Tree Species		DBH Class (m)			
		0–0.6	0.6–1.2	1.2–1.8	1.8–2.4
	Number Examined	108	288	36	8
E. robertsonii	232		10	2	
E. obliqua	118		6	14	5
E. fastigata	44		1	2	1
E. dalrympleana	11		8		
E. cypellocarpa	10		1	3	1
E. viminalis	7		3		
Dead	18	1	3	8	1
% in class		1	46	42	11

(1) DBH values have been divided into 4 equal classes based on the maximum recorded value of 2.4 metres.

TABLE 7

NUMBERS OF ARBOREAL MAMMALS IN BONDI STATE FOREST SPOTLIGHT TRANSECTS

SITE DETAILS				TOTAL NUMBER OF SIGHTINGS PER SPECIES				
Transect Number	Year of Census	Distance Total Km	Number of Sights	Greater Glider	Yellow bellied Glider	Sugar Glider	Brushtail Possum	Ringtail Possum
Coast Range Road (No. 16)	1978	9	2	24	1	–	–	2
	1979	54	6	59	2	–	2	4
Jackson's Bog Island (No. 17)	1978	10.4	3	17	–	–		–
Buffer Strips	1978	7	2	9	–	–	2	3
	1979	10.5	2	8	–	2	2	–

These important wildlife habitats are characterized by large trees and a high tree species diversity. Mountain Grey Gum (vernacular 'monkey gum') *Eucalyptus cypellocarpa* is an indicator species and one which provides abundant hollows for dependent mammals (and birds). Thus slight modifications of logging procedures in the Eden sub-district which extend protection to forest dominated by *E. cypellocarpa* would therefore be highly beneficial to wildlife and in particular to arboreal mammals. For the Bega and Bombala sub-districts where forest types and topography differ from Eden, it will be necessary to identify appropriate indicator species before recommending changes to management to benefit wildlife.

TERRESTRIAL BIRDS

One hundred and fortythree species of terrestrial birds have been recorded from our study areas in the Eden District; 116 species in the Bega sub-district, 114 species in the Eden sub-district and 113 species in the Bombala sub-district (Table 8). Of the 143 species, eleven were vagrants which do not normally occur in southeastern New South Wales. Ninety-four species are typical forest birds while the remaining 38 species are birds of heaths, fields and other habitats more open than forest. The majority of the forest birds are widespread: 89 species occur in the Eden sub-district (58 commonly, 31 uncommonly), 80 occur in the Bega sub-district (63 commonly, 17 uncommonly), and 80 occur in the Bombala sub-district (52 commonly, 28 uncommonly). A complete list of species and their status (common or uncommon) is given in Appendix D. A common bird is one which is seen regularly even though it may not be abundant (e.g. Wedge-tailed Eagle). An uncommon bird is one which is seldom seen even though it may occur in large flocks (e.g. Yellow-tufted Honeyeater). The Appendix should also be referred to for scientific names. Scientific and vernacular names follow *An Index of Australian Bird Names* (CSIRO[1], 1969) for passerines and the *Checklist of the Birds of Australia I.* (RAOU[2] 1975) for non-passerines.

TABLE 8

NUMBERS AND STATUS OF TERRESTRIAL BIRDS

	SUB-DISTRICT			
	Eden	Bombala	Bega	TOTAL
Total Number of Terrestrial Birds	114	115	118	143
Exotics	4	4	7	7
Vagrants	1	6	4	10
Forest Species	89	81	82	94
Common*	58	52	63	
Uncommon*	31	29	19	
Non-forest Species	20	24	25	32

* A common bird is one which is seen regularly even though it may not be abundant (e.g. Wedge-tailed Eagle). An uncommon bird is one which is seldom seen even though it may occur in large flocks (e.g. Yellow-tufted Honeyeater).

Our emphasis has been on the birds of mature forest, but we have also established plots to study the effects of integrated logging on the forest avifauna. We have emphasised mature forest to obtain a baseline on the distribution and abundance of birds which can be used to monitor changes in the avifauna which may occur as a result of forestry operations.
Primarily our work has been during the spring and summer (October-January) to obtain data on the distribution and abundance of breeding birds, their nesting habitats, and yearly variation in numbers.

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1. Commonwealth Scientific and Industrial Research Organisation.
2. Royal Australasian Ornithologists Union.

Study Plots and Methods

Forty-five census plots have been located in mature forest throughout the Eden District. The plots were selected to sample the full range of forest types in the District; 24 are in the Eden sub-district, 12 in the Bega sub-district and 9 in the Bombala sub-district (Figure 1). An additional twenty-four plots are located in buffer strips and forest regenerating after clearfelling; 18 in the Eden sub-district and 6 in the Bombala sub-district. The basic plot is a transect 420m long by 120m wide located in areas of uniform habitat (Recher, 1976; Recher *at al.*, in preparation). Where the area of uniform habitat is limited, a circular plot 60 m in radius is used. Each census consists of four separate two hour counts. The counts are done on different days in close succession and sample early morning, late morning and late afternoon periods when birds are most active. Counts are done only when the weather is calm and dry. For one hour of each count a sub-tally is kept of birds inside a circle 60 m in radius. This 'point census' is normally located at the centre of the transect and is identical to the circular census plots. The latter are also counted for one hour on each of four days.

With the exception of hawks hunting for food and aerial feeders such as swallows, birds flying through or over the plot are not counted. For each plot a list of species recorded during the four counts and the average number of individuals of each species are used for all analyses.

On each plot we have also collected data on the vegetation at 10 points spaced at 30 m intervals along the transect. At each point horizontal foliage density was estimated in four directions (using the method of MacArthur and MacArthur 1961) at a series of heights above the ground: 15 cm, 60 cm, 1.5 m, 3 m, 4.5 m, 6 m, 9 m, 12 m, 18 m, 24 m, 30 m, and so on. A profile of foliage density was then constructed and from this estimates of the total foliage, the effective canopy height and foliage height diversity were derived. Previous studies, including the report of Recher (1976), have divided the foliage profile into ground, shrub, understorey and canopy layers (see Recher, 1972). The less subjective division of the vegetation profile into 1.5 m layers has yielded interesting data on the relationship between birds and their forest environment and is used here. Reference is made to Recher's (1976) analysis for comparison.

For each plot, plant species diversities were calculated for the canopy and taller understorey vegetation where these were present. At each of the 10 points used for foliage measurements, the 10 nearest canopy plants and the 10 nearest understorey plants over 3 metres were identified. From these data a species number and a species diversity index ($\bar{H}$) were obtained for both layers.[1]

In addition to studies of the distribution and abundance of birds, we have investigated their breeding (nesting) and foraging ecology. This work has been done intensively on two 10 ha study plots in a peppermint/gum association (*Eucalyptus dives* with *E. dalrympleana* and *E. pauciflora)* at Bondi State Forest (Figure 1) but, nesting data is available from all census plots. The plots are gridded at 30 m intervals and were selected because they have a particularly abundant (about 40 birds/ha) and rich (about 45 breeding species) avifauna. Up to 1980, approximately one thousand birds on each plot have been netted and individually marked with colour bands. The mist net data are used as a second measure of population densities and the colour banding enables us to investigate social relationships among individuals, longevity, use of habitat and reproductive success. Birds are also netted and colour banded on two buffer strips within the pine plantation at Bondi. These are used to supplement the work on the Bondi study plots, but have the principal objective of determining survival and reproductive success of the birds using buffer strips along water courses. Although data were obtained between 1975 and 1979 on breeding and foraging ecology of forest birds, this work was taken up intensively with the 1979/80 breeding season and will not be considered in detail in this report.

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1. Plant and bird species diversity (and foliage height diversity) were calculated using Shannon-Weaver (1963) equation

$$\bar{H} = -\sum_{i} P_i \log_e P_i$$

where P_i is the proportion of the i^{th} species (or foliage layer).

FIGURE 5

Similarity analysis (MULTBET normal) has been used to associate census transects on the basis of the presence or absence of bird species. The first two divisions separate high elevation sites (Bondi and Yambulla State Forests, N.S.W., and Coast Range Road, Victoria) from low elevation sites (Nadgee and East Boyd State Forests, N.S.W.). Both high and low elevation sites are separated into 'dry' and 'moist' forest types with divisions approximating the forest type classification based on tree species (Table 1). The data used in this analysis are from 1976.

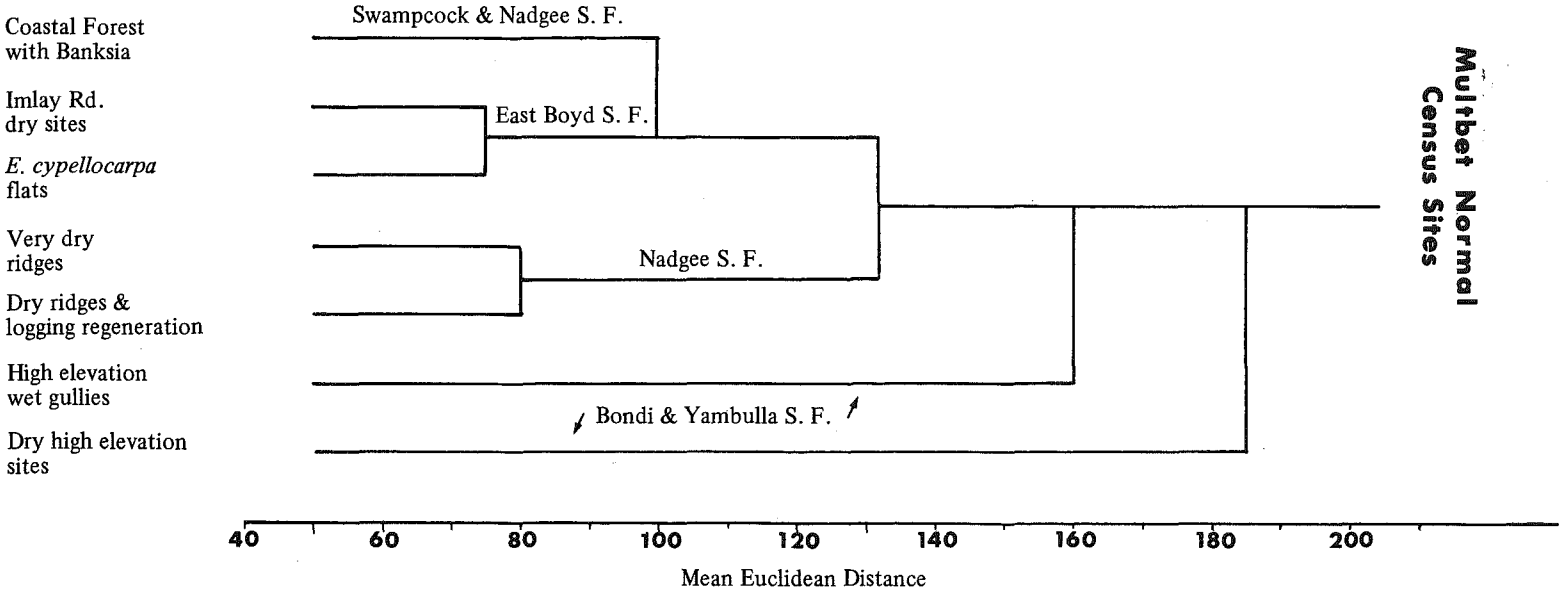
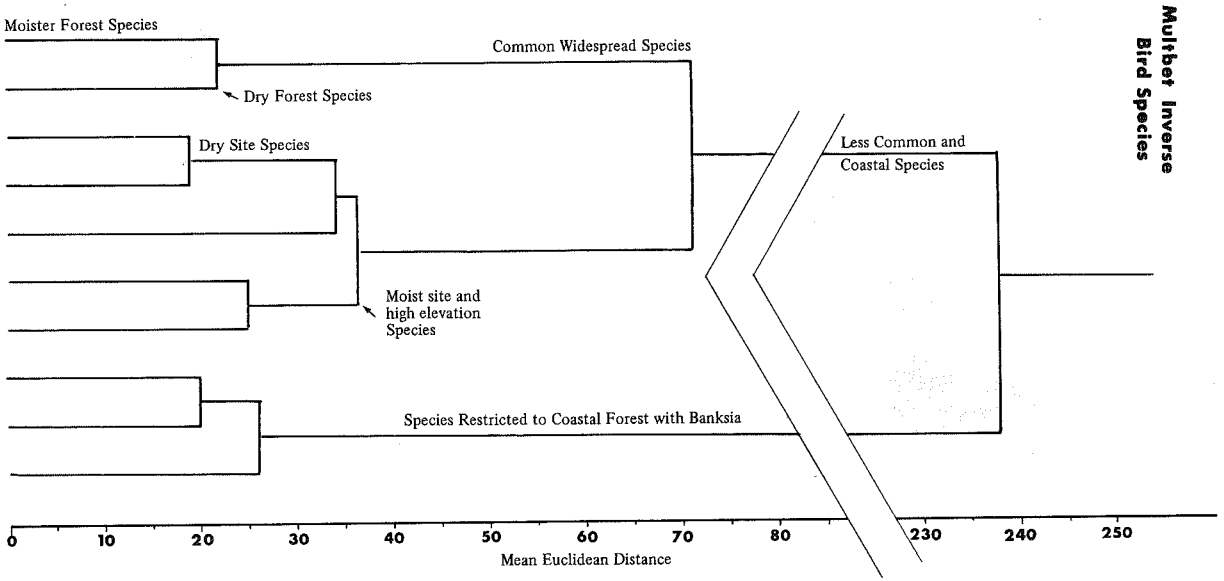


FIGURE 6

In this Figure, the inverse of the analysis presented in Figure 6 is shown. Groupings are of bird species as determined from their association with each other. The first division splits common and widespread species from those that are less common, rare or which are restricted to limited habitats (e.g. coastal forest with banksia). Each of these divisions is further separated into 'dry' and 'moist' forest associations with an additional division on altitudinal range.



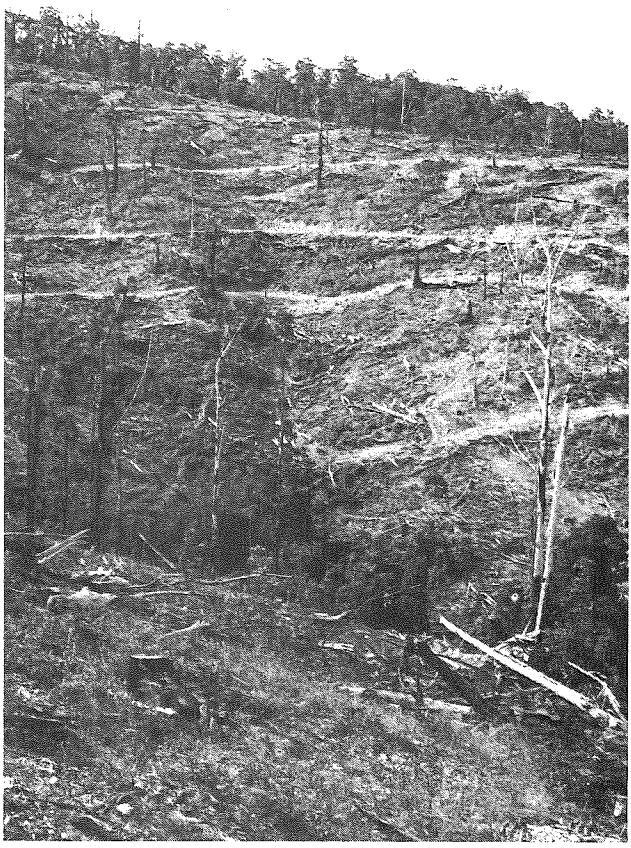
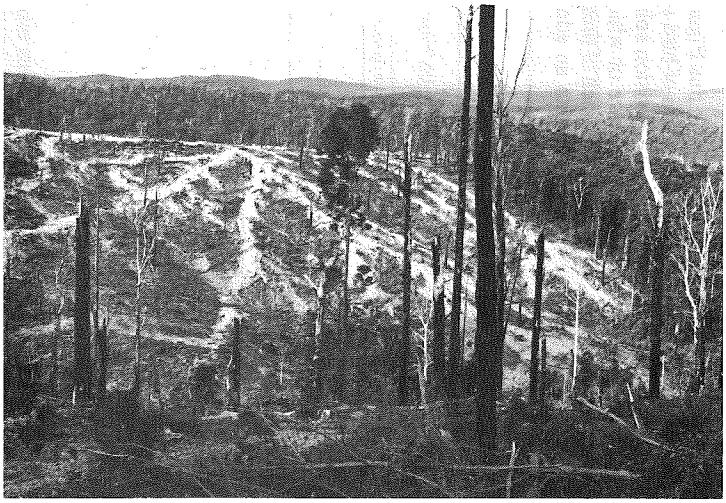


PLATE 7—PLATE 8

The large coupe on Anteater Road is a major study area. The two photographs were taken in February 1977 soon after logging and illustrate two procedures for the removal of trees. In Plate 7 the hillside has been roaded along contours and in Plate 8 the normal snigging procedure of skidding trees up hill to a dump has been followed. Anteater Road coupe was clear-felled with all trees above 8 cm d.b.h.o.b. removed. Below the point shown in Plate 7, an 80 m wide buffer strip was retained along the water course.



Data from our studies of terrestrial birds forms the largest and most comprehensive part of our work. Several parts of this research are complete and are being prepared for publication. In this report, we present an outline of our findings. In cooperation with the National Parks and Wildlife Service of N.S.W., an annotated list of the birds of southeastern New South Wales is in preparation.

Distribution and Abundance

Similarity analysis (MULTBET normal) has been used to associate census plots on the presence or absence of bird species. This program groups plots on the basis of species that they have in common and on common absences. It is a measure of similarity of the avifaunas in different localities in species composition, but does not consider differences in abundance. The 'inverse' program (MULTBET inverse) groups bird species on the basis of which other birds they occur with and on those species with which they do not associate. Again abundance is not considered, but the program identifies groups of species which associate together by habitat. Only the data from 1976 are used in the analysis presented here and the results must be considered preliminary.

The MULTBET normal analysis tends to group sites on the basis of altitudes and moisture relations (Figure 5). That is, there is a division between sites below about 600 m, (Nadgee, East Boyd and Yambulla State Forests) and those above 600 m (Bondi State Forest and adjacent Victoria). Within each of these altitudinal divisions there is a further separation into dry (e.g. ridge) and moist (e.g. gully) sites. The results of this analysis are consistent with the forest types we have characterized by vegetation structure and tree species composition.

The inverse analysis groups birds into species which are generally common and widespread and those which are uncommon or retricted to limited habitats (e.g. coastal forest with Banksia). In this case, a habitat may be extensive in the district, but poorly sampled by our census plots. Consistent with the grouping of sites, each of these major groupings is further separated into groups of species associated with dry and moist forest and high and low elevations (Figure 6). Similar results were obtained in the RAOU Bird Atlas project for Eurobodalla Shire (*Corella* 2, Supplement, 1979) which is immediately north of the Eden District and has the same avifauna (Recher *et al.*, 1975a). Divisions of forest bird communities on the basis of altitude and moisture relations have also been reported for northern New South Wales by Kikkawa (1968) and Recher (1975).

Of the 94 forest bird species, forty-eight have broad preferences in forest-type, twenty-five species are characteristic of moist forests (low rainforest, moist gully forest and Spotted Gum forest), thirteen species are characteristic of dry forests (dry ridge forest, low forest with Banksia and tableland forest), three species (Brush Bronzewing Pigeon, Southern Emu-wren and Little Wattlebird) are most abundant in low forest with Banksia, two species (Sacred Kingfisher and Noisy Friarbird) are most common in Spotted Gum forest, and three species (Buff-tailed Thornbill, White-eared Honeyeater and Striated Pardalote) are most common in tableland forest (Table 9). The habitat preferences of each bird species are given in Appendix D.). The numbers of forest bird species which have been recorded from each type of forest are as follows: 28 in low rainforest, 57 in tableland forest, 59 in Spotted Gum forest, 61 in low forest with Banksia, 71 in dry ridge forest and 79 in moist gully forest.

The low number of species in low rainforest is due to the absence of the eucalypt layer and its associated avifauna. Additional factors include the small area of rainforest in southeastern N.S.W., the limited extent of each patch of rainforest, and the fact that low rainforest has fewer plant species and a simpler foliage structure than warm temperate or tropical rainforest. With the exception of the Yellow-throated Scrub-wren, which was found only in one locality, all species found in low rainforest were also found in moist gully forest, the understorey of which closely resembles the low rainforest community in structure and plant species. In terms of the mean number of species and individuals recorded per census, plots in dry ridge forest had poorer avifaunas than plots in the other four categories of eucalypt forest, all of which had similar densities of species and individuals (Table 9).

TABLE 9

MATURE FOREST AVIFAUNA: BREEDING SEASON COUNTS

	Dry Ridge Forest	Low Forest with Banksia	Tableland Forest	Moist Gully Forest	Spotted Gum Forest
No. of censuses 1975-79	22	11	12	31	3
Mean No. of species (range)	28 (14-37)	33 (25-44)	35 (24-44)	34 (25-43)	35 (28-40)
Difference from dry ridge forest (t – test)	–	$p < .05$	$p < .05$	$p < .01$	–
Total species	71	61	57	79	59
No. of species prefering forest type	0	3	3	0	2
		13		25	
Range of No. of individuals per census	100-350	125-400	300-450	220-480	260-420

Superimposed on the variation of bird species with forest-type there is a change with altitude. The four most characteristic birds of higher altitude forest are Flame Robin, Olive Whistler, Satin Flycatcher and Grey Currawong. Lower altitude forests are characterised by Wonga Pigeon, Rainbow, Musk and Little Lorikeets, King Parrot, Brush Cuckoo, Cicadabird, Leaden Flycatcher, Little Wattlebird, Lewin's Honeyeater, New Holland Honeyeater and Olive-backed Oriole. Most species, however, occur throughout the southeast wherever suitable forest occurs and have a wide distribution in eastern Australia. For example, 90 per cent of the bird species of the Eden District occur in southern Queensland and 40 per cent of the bird species occur along the coast from Cape York to Victoria (Recher *et al.*, 1975a).

Changes in Abundance

For 60 per cent of the avifauna, breeding and non-breeding habitats or distributions are virtually the same. The other 40 per cent (or nearly 60 species), use different habitats during the breeding and non-breeding season and many range widely throughout the southeast and along the coast. The forest used when not breeding must be considered as important to the bird as those in which it nests; for most birds the breeding season spans 3 months, the non-breeding season 9 months.

Fifteen of the 94 forest bird species in the Eden District are latitudinal migrants which are absent from southeastern N.S.W. during the winter (Appendix D), although small populations of four species, Fan-tailed Cuckoo, Golden Bronze-cuckoo, Black-faced Cuckoo-shrike and Olive-backed Oriole, remain over winter. Migrants are most common among the cuckoos *(Cuculidae)*, cuckoo-shrikes *(Campephagidae)*, flycatchers *(Musicicapidae)* and honeyeaters *(Meliphagidae)*.

There is a large-scale migration of Yellow-faced Honeyeaters, White-naped Honeyeaters, and Red Wattlebirds through southeastern N.S.W. northwards and into coastal areas in autumn, returning in spring (Keast, 1968; personal observation). In the study area the populations of these three species decline during winter at higher altitudes but increase at lower altitudes. Also present in the area during winter are birds belonging to the Tasmanian races of the Silvereye and Striated Pardalote.

Several species are altitudinal migrants, moving out of the Bondi State Forest during winter into lower altitudes on the coast or to other parts of the tablelands and western slopes. These species are Rose Robin, Flame Robin, Eastern Spinebill, Mistletoe-bird, Spotted Pardalote, Red-browed Finch and Grey Fantail. The last is probably a partial latitudinal migrant. It is abundant in coastal areas during winter, but its numbers are lower than in summer.

Outside of the breeding season many birds range widely and occur in habitats where they do not breed. For instance, Rose Robin and Golden Whistler nest only in moist forest, but during the winter range throughout the forests of the southeast. Of particular significance are the movements of nectar-feeding honeyeaters and lorikeets. Nectivorous birds of various species dominate many of our census plots and consideration must be given to their changing needs during the year. Although species of honeyeater differ in their dependence on nectar, evidence is accumulating that all honeyeaters require a carbohydrate source for successful reproduction (*Paton,* in press). Alternatives to nectar are honeydew, manna, and tree sap. Honeydew is the sugary excretion of sap-sucking insects and manna is a secretion put out by several eucalypts (e.g. *Eucalyptus viminalis*) in response to injury and which is rich in sugars. Honeyeaters and lorikeets rely on nectar, however, and their movements are related to the availability of nectar-rich flowers. As the pattern of flowering varies from year to year, nectivorous birds show considerable yearly and seasonal variation in distribution. This is most noticeable for the three species of lorikeets, and honeyeaters of the genera *Melithreptus* and *Phylidonyris,* but may be reflected in year to year changes in the structure of the avian community as a whole.

Of the 69 bird census plots in mature and regenerating forest, seven have been censused each year from 1975 through 1978 and eight have been censused each year from 1976. In all, two or more years data are available for 25 plots. Abundance, species number and the composition of the avian community differs between years for all plots on which we have two or more years data. The differences are often substantial with species number varying by as much as thirty per cent (Figure 7) and the number of individuals by fifty per cent. Changes are equally great in mature and regeneration plots, but plots do not necessarily change in unison. As shown in Figure 7, on four mature forest plots species number decreased between 1977 and 1978, but increased on three others. Generally changes in the number of species recorded during a census were paralleled by changes in abundance (Figure 8).

Since the numbers of birds vary independently on different plots, changes in the avian community are not the result of regional weather patterns. Instead we consider the changes reflect yearly variations in food resources with local and regional conditions affecting the numbers and kinds of birds occuring on any plot at any particular time of the year. The largest changes are almost certainly due to variations in the blossoming of eucalypts and other nectar producing plants. If there is an abundance of blossom, as on the Goanna Creek A and B plots in 1977 (Figure 7), then it is likely that there will be an influx of nectar feeders with an increase in abundance and species number. However, we have often observed patches of blossom which failed to attract nectar feeders. In these instances, it may be that the regional pattern of flowering was such that the birds congregated elsewhere.

Bird Species Diversity and Habitat

Logging alters the structure of the forest and to understand the effects of integrated logging on animal communities, we must understand the relation between animal communities and the structure of mature forest. When different habitats are compared, the number of bird species is correlated with the physical structure or diversity of the habitat as measured by a vertical profile of the foliage (MacArthur & MacArthur, 1961). Thus a heath has fewer species of birds than a forest because it has fewer layers of vegetation and, in a physical sense, is less complex. Presumably the greater number of vegetation layers in the forest provide more and, perhaps, different foraging opportunities for birds. Hence more species can co-exist.

FIGURE 7

Variation between years in the number of bird species on census plots during the breeding season (October-January). Plot A is a coastal forest with banksia in the Nadgee State Forest. Plot B is in moist gully forest, a 'monkey gum' *E. cypellocarpa* flat, along Goanna Creek in the East Boyd State Forest. Plots C and F are dry ridge forest along the Imlay Road in the East Boyd State Forest. Plots E and G are 1939 fire regeneration plots on a dry ridge along Dinner Creek Road in the Nadgee State Forest. Plot K is a dry ridge transect parallel to and up slope from Plot A. It was logged in 1978. Plots H, I and J, shown as dotted lines, are logging regeneration in the Nadgee State Forest. Plot H was logged in 1974/75. Plot I was logged in 1969/70. Plot J was also logged in 1969/70, but burnt in the 1972 fire. These three plots were originally mature dry ridge forest.

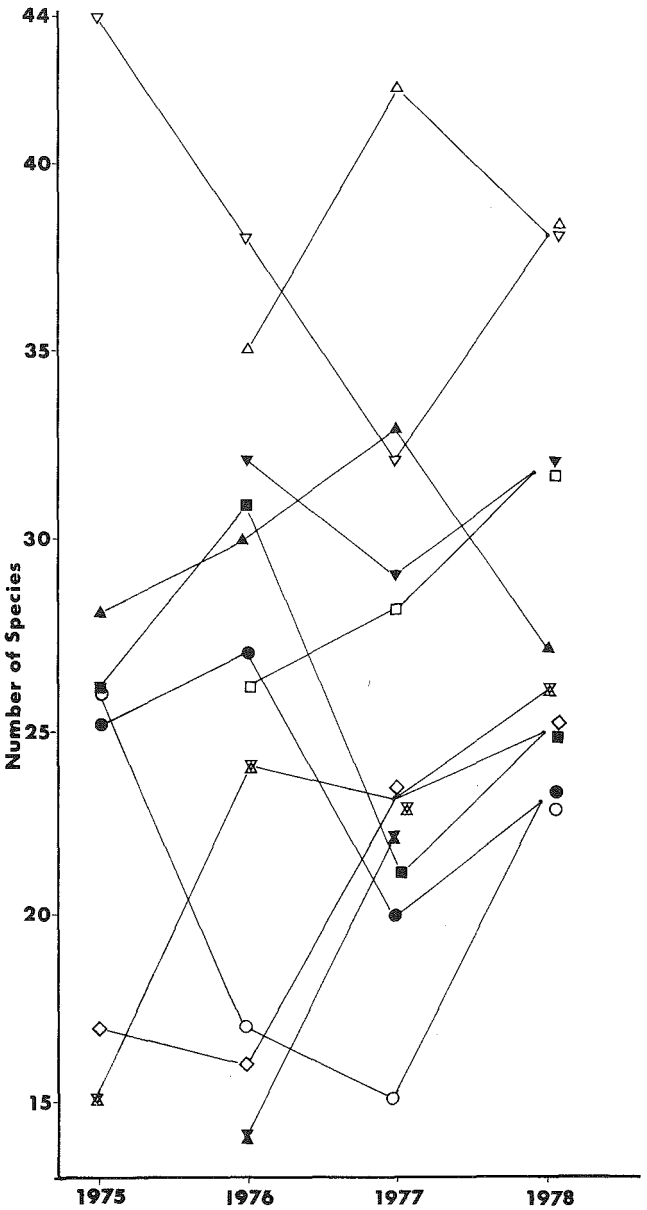
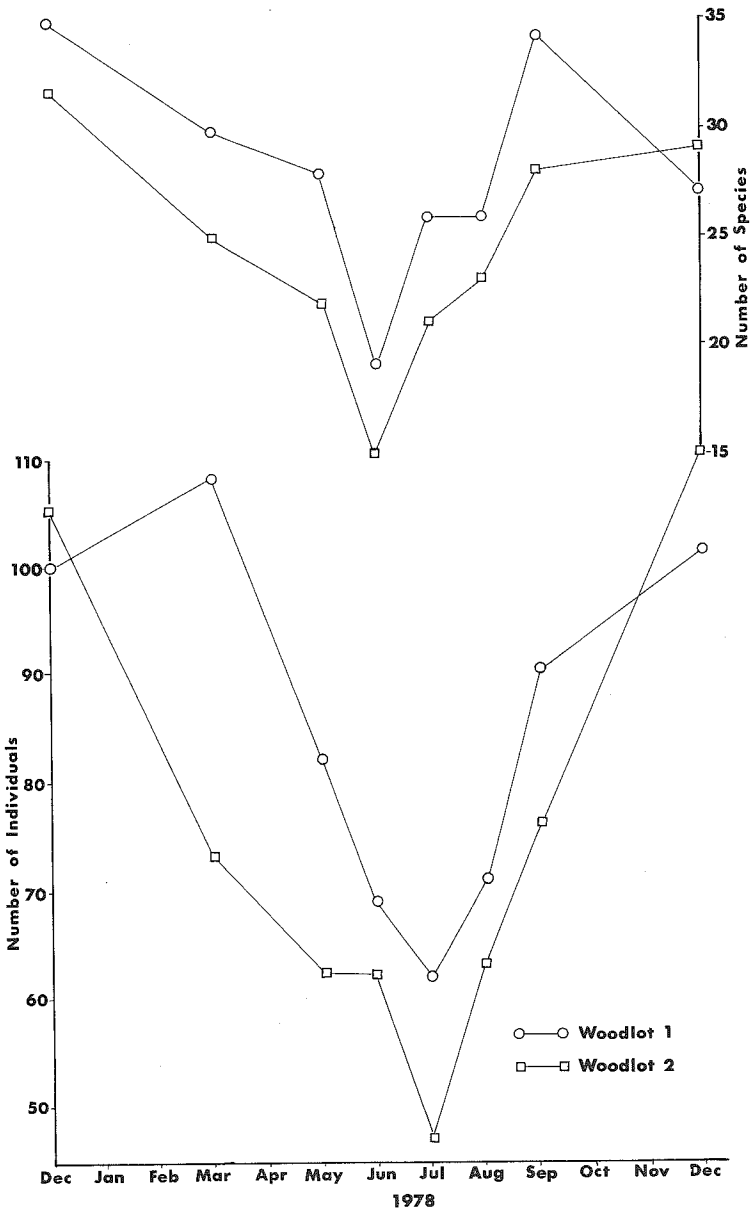


FIGURE 8

The numbers of species and individual birds on the 10 ha study plots at Bondi. Censuses were done most months during 1978. These tableland forests are highly seasonal and a large section of the bird community leaves during the winter.



Although this broad correlation is useful, other environmental parameters affect species diversity. As noted by Willson (1974), there is no clear pattern between vegetation structure and bird species diversity when different mature forests are compared. In comparing forests which have a fundamentally similar structure (i.e. ground, understorey and canopy layers of vegetation), variation in bird species number may be better explained by plant species composition or diversity, horizontal patchiness, total vegetation or even historical events. These factors may also be important in explaining variation in the numbers of small ground mammals (Braithwaite and Gullan, 1978). There are several results which bear on the relation between habitat and bird species diversity and which are useful in predicting long term effects of integrated logging on avian populations.

Australian forest bird communities differ in a number of ways from bird communities in North America (Table 10). An important difference is that Australian forests have a larger number of flocking and social species and as a result species are less equitable in their abundance than in North America. Although the number of bird species in Australian and North American Forests is similar, the lower equitability values results in reduced diversity indices ($\bar{H}$) for Australian forests. As discussed above, many Australian birds congregate at nectar-rich flowers and in consequence diversity values may be affected more by plant species composition than they are in North America (Recher, in preparation).

TABLE 10

A COMPARISON OF SPECIES EVENNESS (J^2) OF AUSTRALIAN AND NORTH AMERICAN FOREST BIRD COMMUNITIES

		Eden District Forest	
		120 Min. Census Plots (N=35)	60 Min. Census Plots (N=42)
North American Forest[1]		.836 ± .039[4]	.862 ± .055
Coniferous (N=51)	.880 ± .050[4]	S[3]	NS[3]
Upland Deciduous (N=62)	.879 ± .047	S	NS
Mixed Coniferous/Deciduous (N=31)	.893 ± .044	S	S
Floodplain Deciduous (N=18)	.898 ± .042	S	S
Tropical Woodlands (N=21)	.921 ± .027	S	S

1. Data from Tramer (1969).
2. $J = \frac{\bar{H}}{\bar{H}_{max}}$ where $\bar{H} = -\sum_i P_i \log_e P_i$ (J is a measure of the evenness of species abundances).
3. Significance of differences tested by Student's t; S($p < .05$) NS ($p > .05$).
4. Mean ± Standard Deviation.

Foliage height diversity explains a significant part of the variation in species number between mature forest plots and plots regenerating after clearfelling (Recher, 1976). When mature forests with similar foliage profiles are compared there is a significant correlation between canopy height and bird species diversity (Table 11). Higher canopies may indicate better site conditions and hence higher levels of primary productivity, resulting in higher levels of plant and animal food for birds. The major exceptions are the plots in low forest with Banksia; these plots are rich in birds in spite of the low canopy. The richness of these plots is probably explained by the abundance of nectar-rich flowers and the variety of foraging opportunities provided by the different kinds of foliage in the understorey (i.e. eucalypts plus *Banksia, Acacia* and *Casuarina*). There is a significant correlation between the number of understorey plant species and bird species diversity in mature forest (Table 11).

TABLE 11

COEFFICIENTS OF CORRELATION BETWEEN BIRD AND VEGETATION DATA

		Bird Data		
Vegetation Data		Species Diversity	Number of Species	Number of Individuals
Mature Eucalypt Forest and Regeneration Stages (69 plots)	Foilage height diversity*	0.48S	0.59S	0.48S
	Canopy height	0.50S	0.64S	0.55S
	Total foliage	0.41S	0.43S	0.31S
Mature Eucalypt Forest only (45 plots)	Foliage height diversity*	0.15N	0.28N	0.23N
	Canopy height	0.31N	0.43S	0.38S
	Total foliage	0.21N	0.20N	0.10N
	Canopy species diversity	0.12N	0.17N	0.08N
	Canopy species number	0.26N	0.29S	0.26N
	Understorey > 3 m species diversity	0.26N	0.29S	0.15N
	Understorey > 3 m species number	0.42S	0.46S	0.29S

* calculated from proportions of vegetation in 1.5 m layers
S significant at 5% level
N not significant at 5% level

Buffer Strips

Forests in gullies and along streams are particularly rich in wildlife and have diverse avifaunas (Table 9). Most birds which occur on the dry ridges also breed in moist forest and the retention of strips of mature forest along water courses is therefore likely to be useful for wildlife management.

During the time we were engaged in the research presented in this report, several different criteria were used in deciding on the location and width of buffer strips along creeks. The one with the most extensive application called for strips 40 m wide to either side of a watercourse beginning at the point where the catchment area was 100 ha. The strips we have studied in the large coupe on Anteater Road are of this type. Logging was prohibited within the first 20 m from the watercourse, but trees could be taken from the second 20 m so long as machinery remained outside the buffer strip and the trees were felled away from the watercourse.

It is necessary to understand that the buffer strips along watercourses were reserved to protect water quality and that any benefits they might have had for wildlife or recreation were incidental considerations. This is distinct from the much wider reserves retained along major waterways, such as Imlay Creek and the Wallagaraugh River, where wildlife, aesthetics and recreation are primary considerations. It has now been decided that the 40 m prescription is not necessary to maintain water quality and the width of strips has been reduced to 20 m (bringing them in line with procedures elsewhere in New South Wales and in Victoria) with logging permitted so long as trees are not felled across the watercourses. Machinery is excluded.

In order to evaluate the role of buffer strips in wildlife management, nine census plots have been located in vegetation retained along gullies and streams. Six plots are in areas cleared for pine plantations and provide strips of native vegetation without the complication arising from birds which may inhabit adjoining unlogged native forest. These strips in the Bondi State Forest are of three different widths; two are less than 40 m along each side of the creek (varying between 20 m and 40 m), two are about 40 m wide and two exceed 50 m. Three other strips are in a large coupe on Anteater Road in the East Boyd State Forest. One of these consists of the rainforest understorey at the top of the gully, the eucalypt canopy having been logged. The others are 40 m in width to either side of the gully and continue into unlogged forest which permits a check on the fauna the buffer strips support relative to that in unlogged forest.

The four narrower buffer strips at Bondi have been censused since 1976 and, on average, have fewer species of forest birds than comparable plots in mature forest with a similar tree species composition (Student's t – test, $p<0.02$) (Table 12). The unlogged buffer strips on Anteater Road do not differ significantly in species number from transects in comparable unlogged forest.

Several points emerge from the data available. Although each individual buffer strip contains fewer birds, overall, no one species is excluded. Birds are abundant within the buffer strips; a fact which may reflect a tendency of several species of forest and open-country birds to nest and shelter in the buffer strip forest, but forage extensively in the adjoining pine or eucalypt regeneration. The buffer strips have a rich forest avifauna which includes the hole and cavity nesting species absent as breeding pairs from regeneration. We conclude that buffer strips are important refuges for wildlife and should be an integral part of any wildlife management program developed for the Eden District. Our data (Table 12) and observation of very narrow strips of mature forest in the Bondi State Forest suggest that a total width of 80 m is a minimum requirement for the management of forest avifauna. At narrower widths fewer forest birds are present and the avifauna is dominated by open-country and edge species (e.g. Australia Magpie, Superb Blue Wren).

Small Coupe Logging

Generally it might be expected that logging smaller patches of forest and creating a complex mosaic of forest age classes will have a net positive benefit for wildlife (Recher *et al.*, 1975a). Nevertheless there is the possibility that coupes can be too small thereby excluding species where the requirements of an individual or a pair for space exceed the area of the coupe. Small coupe logging is a relatively new innovation at Eden and our data are limited. It does appear that coupes (logged and unlogged) which are about 10 ha in area support fewer birds and have a less diverse avifauna than larger coupes of the same forest type (Table 13). The richer avifauna recorded in the larger logged areas includes some breeding open country and heath birds (e.g. Nankeen Kestrel, Brush Bronzewing) absent from the small coupes.

Effects of Logging

Clearfelling replaces the complex vegetation of the mature forest with a single layer of regrowth. As expected from the correlation between bird species diversity and foliage (Table 11), the number of bird species in early logging regeneration is less than in mature forest (Table 14) although individual species may be more abundant in regeneration.

TABLE 12

DIVERSITY AND ABUNDANCE OF BIRDS IN BUFFER STRIPS

	BONDI S.F. BUFFER STRIPS			EAST BOYD S.F. BUFFER STRIPS		MATURE FOREST	
Forest Type	**Tableland**	**Tableland**	**Moist Gully**	**Moist Gully**	**Moist Gully**	**Tableland**	**Moist Gully**
Total Width of Buffer Strip	<80m	80m	>80m	logged but under-story left	80m	–	–
No. of Censuses	6	6	2	1	4	12	31
Mean No. of Species	26	26	39	26	32	35	35
(Range)	(20-36)	(22-33)	(36-41)	–	(29-34)	(24-44)	(25-43)
Range of No. of Individuals	140-330	225-315	360-420	210	215-340	300-450	220-480

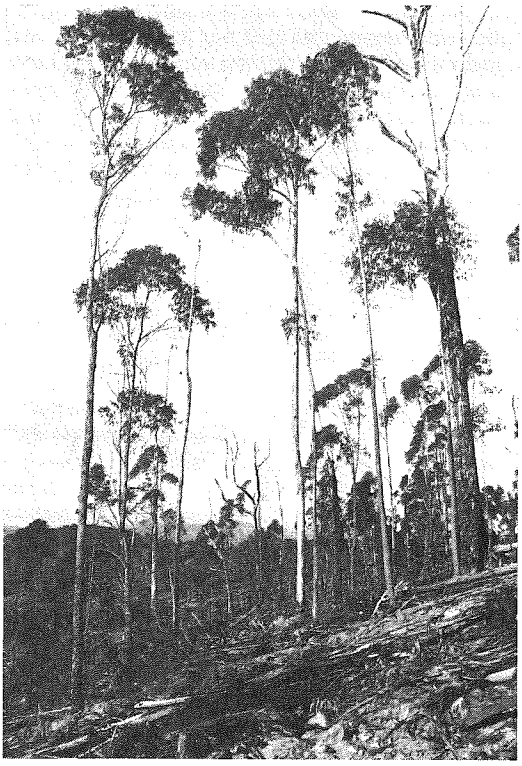


PLATE 9—PLATE 10

Often trees remain after logging. Plate 9 is typical of many recently logged areas in East Boyd State Forest. Plate 10 is in Compartment 63 on Swamp Road in Nadgee State Forest. This plot has been studied since being logged in 1975/76 and is shown here in 1979. Originally a dry forest dominated by *Eucalyptus sieberi* and *E. globoidea*. Regrowth, especially on badly drained areas in the foreground, has been poor.

(Photos — Australian Museum — H.F. Recher)

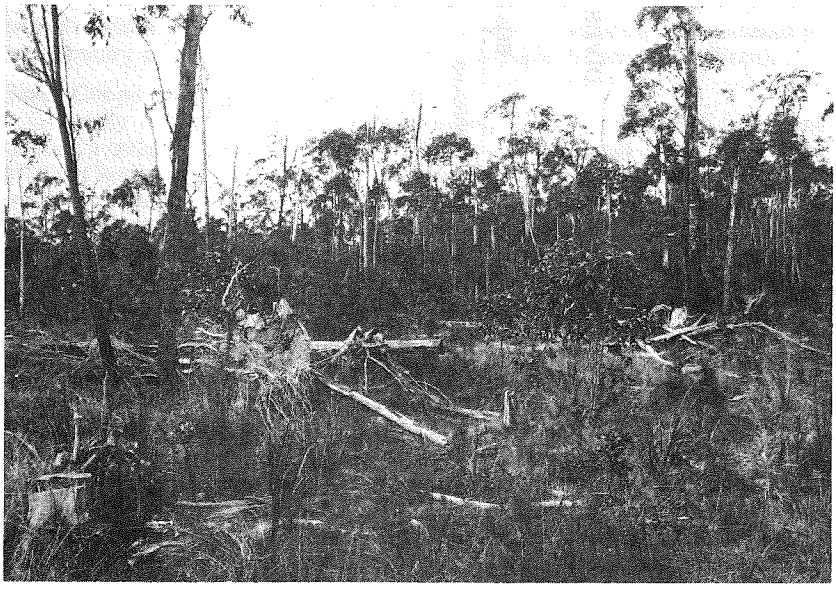


TABLE 13

BIRD CENSUS [1] RESULTS FOR SMALL AND LARGE COUPES IN DRY RIDGE FOREST (IMLAY ROAD, EAST BOYD STATE FOREST) 1976–1979

	Small Coupes (10 ha)		Large Coupes	
	logged [2]	unlogged	logged [2]	unlogged
No. of censuses	6	6	7	8
Mean No. of species (range)[3]	7 (2-13)	14 (10-17)	13 (10-17)	19 (10-24)
No. of individuals (range)	10-60	40-70	40-80	45-125

(1) Census plots are 120 m in diameter and a census consists of 4 x 60 minute counts on separate days. (Census data in Tables 9 and 12 are from 4 x 120 minute counts on plots 420 m x 120 m).

(2) Logged 1 to 3 years before census.

(3) The differences in mean species number between logged small coupes and logged large coupes, and between unlogged small coupes and unlogged large coupes are significant (t–test, $p < .05$)

The early stages of regeneration in the Eden District support bird species found also in the ground and shrub layers of mature forest. Examples of these species are Brown Thornbill, Superb Blue Wren and White-browed Scrubwren. In addition regeneration supports bird species typical of heath, scrub and open-country habitats and which are not normally found in mature forest. A number of open country and shrub birds appear to be increasing in abundance as a result of integrated logging: Brown Falcon, Nankeen Kestrel, Brush Bronzewing, Jacky Winter and Chestnut-rumped Heath-wren. Birds which feed in the canopy of mature forest (e.g. Spotted Pardalote) or on the trunks and branches of trees (e.g. White-throated Treecreeper) are absent or scarce in young regeneration. As the regeneration matures, these species colonize the young forest and the others disappear or decline in abundance. A primary question remains, 'At what age does a regenerating forest provide conditions suitable for birds requiring mature forest?'.

Studies in the Boola Boola State Forest in Victoria suggest that 40 years after clearfelling forest of the types common on dry sites in the Eden district, the regeneration is too young for some species (R. Loyn, 1980). The oldest regeneration from clearfelling at Eden dates from 1969/70. Except where it contains older trees not removed during logging, birds requiring mature forest are absent, or present only as non-breeding individuals. To approximate what forests at Eden will look like 25 and 40 years after logging, we have located census plots in known age fire regeneration (Recher, 1976). Caution must be used in interpreting these data, but fire regeneration does provide some information on the longer term re-colonization of forest which has been clearfelled.

Considering only dry forest on ridges, the differences in species number, species diversity and species abundance between mature forest and forest regeneration seem minor (Table 14). Dry forest has been selected for comparison because it is the most extensive area of forest affected by integrated logging. As suggested by Recher (1976), there is a trend for species number to increase as the forest matures, but there is considerable variation between plots in the same age

TABLE 14

AVIFAUNA OF FIRE AND INTEGRATED LOGGING REGENERATION: DRY RIDGE FOREST BREEDING SEASON COUNTS

	AGE OF REGENERATION					
	Logging			Fire		Mature dry ridge forest
Years	1–2	3–6	7–8	25	36–39	
No. of Censuses 1975-79	5	6	4	2	8	22
Mean No. of Species (range)	20 (15-26)	18 (15-24)	24 (23-26)	23 (20-26)	25 (20-31)	28 (14-37)
Range of No. of Individuals per Census	85-200	100-200	100-200	135-165	85-200	100-350
Mean Bird Species Diversity ($\bar{H}$) (range)	2.5 (2.2-2.8)	2.3 (2.2-2.4)	2.7 (2.6-2.8)	2.7 (2.6-2.8)	2.6 (2.3-2.8)	2.7 (2.0-3.1)
Number of Breeding Forest Bird Species	4-8	8-10	8-10	15-20	15-25	10-30

class. The poorest mature forest plots appear to have only half the species and individuals of some newly cleared sites. In this instance, numbers are deceptive. Many of the species occuring in regeneration are birds of open or shrub habitats and are replaced by forest birds as the forest matures. Moreover about half the species on the regeneration plots were non-breeding or transient individuals.

In effect, logging regeneration up to ten years of age supports fewer than half the breeding bird species expected in mature forest on a comparable site (Table 14). In particular, species which nest in hollows or in the canopy and those which forage on tree trunks or in the canopy are absent from young logging regeneration. Most of these are present in 40 year old fire regeneration, but as indicated by the data from Boola Boola in Victoria, a 40 year old forest is not quite as rich as a mature forest with trees of mixed ages and sizes. We can not, at this time, answer the question as to how old a forest must be to support all the bird species of the mature forest. In all probability, it lies somewhere between 40 and 100 years and depends as much on the age of individual trees as on the age of the forest. A young forest with some older trees which provide nest and foraging sites will have more birds than a forest of the same age where older trees are absent. The presence of some older trees on our plots of 40 year old fire regeneration probably explain why these sites have a richer avifauna than the 40 year old regeneration following clearfelling studied by Loyn in Victoria.

DISCUSSION

The immediate impact of clearfelling on wildlife is clear. The fauna of a mature forest is replaced by the animals of a young forest. The two communities overlap — indeed they grade imperceptibly one into the other as with time one set of species replaces another. What is not clear is the time scale on which this process operates nor the impact of the industry in a regional or continental context. On plots with up to four years of data on bird populations, changes in abundance and species number between years are as great as differences between plots (Figure 7). Trends in species number and the pattern of colonization of regenerating forest must therefore be interpreted cautiously. Nonetheless the following effects can be expected and, if they are unacceptable, consideration needs to be given to the ways in which they can be avoided or minimized.

1. There will be a decline in the abundance of animals which require mature forest. The impact will probably be greatest on species which require large trees or tree hollows. A number of birds and mammals may be threatened with extinction on a regional level.
2. Open-country, shrub and heath species of birds will increase in abundance. Some ground mammals may also become more abundant.
3. Changes in the pattern of flowering and the abundance of nectar will affect the movements and numbers of nectivorous birds. There will be fewer opportunities for reproduction of these species and there may be a decrease in the abundance of nectar feeders north and south of Eden.
4. There may also be other changes in abundance, patterns of movement or nesting cycles which will not become apparent until a significant part of the existing mature forest is logged and replaced by regeneration.

Dependent Wildlife

It is possible to identify some species of birds and mammals which require mature forest, but insufficient data are available to identify other dependent animals or plants. Dependent species are 'sensitive' to the effects of integrated logging and may require special consideration in management.

We use the term 'sensitive' in the following way. A species is sensitive if it appears that integrated logging significantly reduces one or more of the resources (e.g. food and living space) needed by the animal and for which considerable reduction in population has been recorded. In the case of the Koala, which is already rare in the Eden District, it implies that any increase in population is prevented or seriously hindered. In each of these cases, regional extinction is the ultimate risk. None of the birds and mammals found at Eden are confined to the district and in a continental context may not be threatened. However, any contraction of a species range increases its vulnerability to other disturbances (e.g. fire, disease) and risks the extinction of the species. With the rapid changes in forest management throughout Australia, it is best to be cautious and ensure that populations of all species are retained in each forestry district.

At this stage of our research, we consider that all gliders *(Schoinobates, Petaurus,* and *Acrobates)*, the Koala *(Phascolarctos)*, and several forest bats (e.g. *Myotis, Miniopterus, Nyctophilus,* and *Tadarida)* (Tyndale-Biscoe & Calaby, 1975) among the native mammals are probably sensitive to the effects of integrated logging (Table 15). Populations of Pygmy Possum *(Cercartetus)*, Short-eared Possum *(Trichosurus)* and Dunnart *(Sminthopsis)* may also be reduced. Among the birds, 10 to 15 per cent or more of the terrestrial avifauna is sensitive to the effects of clearfelling (Table 15). The most sensitive birds in our estimation, are the cockatoos *(Calyptorphynchus* and *Callocephalon)*, lorikeets *(Trichoglossus* and *Glossopsitta)*, owls *(Ninox* and *Tyto)*, parrots *(Aprosmictus* and *Platycercus)*, Owlet-nightjar *(Aegotheles)*, Scared Kingfisher *(Halycon)*, and tree-creepers *(Climacteris)*. These constitute 10 per cent of the terrestrial avifauna. Each of these birds and mammals requires tree hollows as nest or den sites. Species which need tree hollows are the species *most likely* to be affected by integrated logging.

TABLE 15 A PARTIAL LIST OF BIRDS AND MAMMALS SENSITIVE TO THE EFFECTS OF INTEGRATED LOGGING

A. BIRDS

Species	Size (mm)	Forest Habitat	Nest Requirements	Main Food Sources	Status	Comments
Glossy Black Cockatoo	400–500	Dry ridge forest with Casuarina	Large tree hollow high up	Casuarina seed	Uncommon	
Yellow-tailed Black Cockatoo	600–690	Throughout	Large tree hollow high up	Wood boring insects larvae	Common	Food supply may increase in logging regeneration and pine plantations
Gang Gang Cockatoo	350	Throughout	Large tree hollow high up	Eucalypt and Wattle seed	Common	
Rainbow Lorikeet	230	Lower altitude forests	Trunk or limb hollow high up	Eucalypt nectar	Uncommon	May be affected by changes in distribution and abundance of eucalypt blossom
Musk Lorikeet	220	Lower altitude forests	Limb hollow fairly high up	Eucalypt nectar	Common	
Little Lorikeet	155	Lower altitude forests	Trunk or limb hollow	Eucalypt nectar	Uncommon	
King Parrot	430	Lower altitude forests	Deep hollow in trees	Fruit, seeds and nectar of various plants	Common	
Crimson Rosella	320–360	Throughout	Tree hollow	Seeds, fruit and nectar of various plants	Common	
Powerful Owl	600–650	Moist gully forest	Large tree hollow at least 15m up	Arboreal mammals, especially Greater Glider & Ring-tail possum	Uncommon	
Sooty Owl	350–450	Low rainforest, moist gully forest	Tree hollow	Large insects and mammals such as rats and possums	Uncommon	
Owlet Nightjar	220	Throughout	Tree hollow	Insects	Common	
Sacred Kingfisher	220	Throughout, but most common in Spotted Gum forest	Tree hollow or cavity dug in termite nest	Lizards and insects	Uncommon	
White-throated Treecreeper	150–170	Throughout	Trunk or limb hollow	Insects, especially ants	Common	
Red-browed Treecreeper	145–150	Throughout, but more common in moister forests	Tree hollow, esp. hollow in upright branch	Insects, especially ants	Common	

B. MAMMALS

Greater Glider		Tall, moist forest	Large tree hollow	Eucalypt leaves, buds and flowers	Common	Significant losses in areas being planted to pine in Bondi State Forest
Yellow-bellied Glider		Tall, moist forest	Large tree hollow high up	Eucalypt nectar, flowers and sap	Uncommon	A colonial species
Feather-tailed Glider		Tall forest	Tree hollow	Nectar, sap and insects	Probably Common	A colonial species
Sugar Glider		Throughout	Tree hollow	Nectar, sap and insects	Common	Often associated with second growth wattle. A colonial species.
Koala		Various	None	Eucalypt leaves	Uncommon	

Habitat Trees

Managing dependent fauna means managing the forest so that there are adequate numbers of tree hollows of different sizes. This means allowing overmature or, as they are often called, habitat trees to develop. Hollows begin to appear in eucalypts from about 50 to 100 years of age depending upon the species (e.g. Disney & Stokes, 1976) and are more common in some eucalypts than others. Dead trees appear to be unsuitable to many (although not all) species of birds and mammals which require tree hollows (personal observation). *Eucalyptus dalrympleana, E. cypellocarpa, E. obliqua, E. fastigata* and *E. consideniana* are important habitat trees in the Nadgee, East Boyd, Timbillica and Bondi State Forests. In the forest near Bega, *E. maculata* and *E. longifolia* are also commonly used by hole nesting birds and mammals. It must be stressed that these trees are not the only sources of hollows — only that on our study areas they are important.

With present logging procedures, habitat trees in gully and creek reserves or buffer strips are the principal source of hollows for wildlife retained in the State Forests. Unfortunately this creates a number of problems. Some are purely physical. The sudden exposure of large trees to new wind stresses after clearing the adjacent forest commonly leads to these trees dying or being thrown by the wind. Others are biological. Management of habitat trees requires the retention of existing trees *and* the provision of other trees which will mature into habitat trees. There are several ways to achieve this goal. Habitat trees may be retained in buffer strips along creeks and gullies, in reserves, in patches of unlogged forest or single trees distributed throughout the logged forest. Which of these or which combination is most effective remains to be determined and will vary according to forest type, topography and logging practices.

Problems of Scale

Impacts 3 and 4 above are problems of scale. We know that nectivorous birds (e.g. honeyeaters, silvereyes, and lorikeets) travel long distances in search of blossom and that thousands of these birds will congregate on patches of eucalypt, mistletoe or Banksia blossom in the Eden District. Extrapolating from spot observations over the whole of the district, the numbers of birds involved must be numbered in the hundreds of thousands. During autumn and spring their numbers are increased by the movements through the region of birds from Tasmania, Victoria and the high country. What we do not know is the extent to which these birds are dependent on nectar sources within the forests affected by integrated logging. Nor do we know how these birds, other than the migrants, relate to or interact with populations outside the Eden district. If we are dealing with a single avian community and not a series of discrete populations along the coast, then changes in resource abundance (i.e. nectar) in the Eden District will affect the numbers of nectivorous birds outside the region.

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1. On the Eden Project Map (Forestry Commission of N.S.W.) 405 000 ha of timbered crown land are shown along with a smaller area of private forest land (about 80 000 ha). Twenty-two per cent of the crown land is reserved as National Park or Nature Reserve. The remainder is mostly State Forest. About 1500 ha is reserved within the State Forests as forest preserves and flora reserves. R. Dobbyns *(in litt.)* estimates that "25 per cent of the State Forest land will not be logged for various reasons such as reservations, steepness or rock. This means a total of 47 per cent of the timbered crown land on the Eden Project Map will not be logged". These differ from those presented by Scott & Co. (1975) and Heyligers (1977) for the Eden District. The differences arise from the inclusion of the Bega sub-district within the Eden Woodchip Concession in Dobbyns' calculations. This larger area includes the southern portion of the newly reserved Wadbilliga National Park. In the area of the Eden Woodchip Concession as defined by Scott & Co. (1975), the area reserved as National Park, Nature Reserve or Flora Reserve is 33 500 ha or 12 per cent of a timbered crown land area of 293 000 ha. Allowing that 25 per cent of the State Forest will not be logged, thirty-four per cent of the crown timber land in the Eden and Bombala sub-districts or about 30 per cent of the total forested lands (sources of data are; R. Dobbyns *(in litt.)*; Scott & Co., 1975; Heyligers, 1977) will remain unlogged.

We are in a similar dilemma when it comes to predicting the escalating impact on fauna as the area of mature forest is progressively reduced in area.[1] It is possible that some populations of dependent fauna which we presently record in buffer strips, on reserves and in regenerating forest are derived from animals bred in the large area of mature forest which remains (i.e. in 1979) in the Eden District. There may come a time in the logging cycle when the area of mature forest is reduced to a level where the numbers of animals produced are insufficient to maintain these populations. If this critical point is reached, there would be a precipitous decline in species number and abundance, leaving little scope for remedial action.

Other Considerations

The impact of the Eden Woodchip Industry cannot be considered in isolation. The forests in the Eden District are part of a forest which stretches more or less unbroken from Cape York to Wilsons Promontory and which should be managed as a unit (Recher & Rohan-Jones, 1978). The effects of integrated logging must therefore be evaluated with reference to trends in forest management throughout eastern Australia and in detail to the establishment of pine plantations in the Bondi State Forest. The reservation of mature forest in National Parks and Nature Reserves within the Eden District and any extension of the woodchip industry to East Gippsland are other events which must be considered. However, in this report we are not prepared to speculate on how the Victorians will or will not manage their forests nor can we discuss fully the impact of replacing native forest with plantations of *Pinus radiata*. We will only point out that some of the eucalypt forests removed for pine were probably the richest and most productive of native plants and animals in the Eden District and the replacement of these forests by pines places an onus on the Forestry Commission to manage the remaining State Forests with special consideration for wildlife. We do not consider the National Parks and Nature Reserves in the Eden District adequate by themselves for the long term conservation of the region's wildlife.

Adequacy of National Parks

This report is not the appropriate place to go into detail on the inadequacies of the national parks system (see Recher & Rohan-Jones, 1978; Lunney & Recher, 1979 for a discussion of this issue), but the following criticisms must be considered when planning the management of wildlife in the State Forests of the Eden District.

1. With the exception of the Ben Boyd National Park/Nadgee Nature Reserve complex, and the Wadbilliga National Park, the parks in the District are small (<4 000 ha) and well separated (Figure 1). Alone each is probably inadequate in area for the long term survival of the region's full complement of wildlife and their isolation means the prospect of recolonization between parks is remote for all except the most mobile animals.

2. The parks west of the Pacific Highway have been located mainly on rough terrain and therefore sample higher elevation and ridge vegetation in greater proportion than the moist gully forest types known to be richest in wildlife.

3. With the exception of Nadgee Nature Reserve, none of the parks was established following a survey of their flora and fauna nor was the scientific community (e.g. the Scientific Committee on Parks and Reserves advising the Minister for Lands) consulted. In other words, decisions on the long term management of the forests in the Eden District were made without reference to the full body of knowledge available to the people of New South Wales.

Despite the oversights of the past, it is our opinion that wildlife can be managed concurrently with integrated logging.

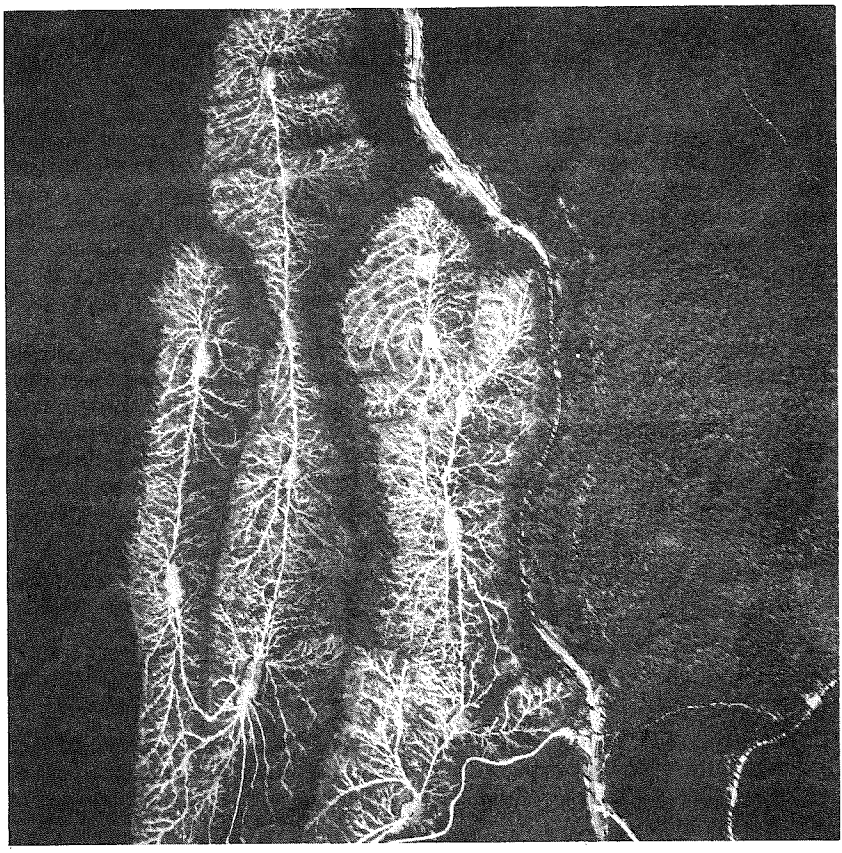

PLATE 11

Anteater Road coupe on Imlay Road in the East Boyd State Forest is a major study site. Census plots are located in the buffer strips and in the logged areas including the gully, slopes and ridge. The buffer strips are 80 m wide and begin where the catchment area is 100 ha. Note the length of the gully along which there is no buffer strip retained and the separation of the two buffer strips in the gullies by a clearfelled ridge.

RECOMMENDATIONS FOR WILDLIFE MANAGEMENT

There are a number of options available for wildlife management within the present structure of the Eden operation. For example the differences we have recorded in the abundance and diversity of wildlife throughout the Eden District immediately suggests that the intensity of logging, length of logging cycles, size of logging coupes and retention of reserves of mature forest can be significantly different between forest types. With respect to birds and mammals, for example, dry ridge forests could be managed intensively on a 40 to 50 year logging cycle with less impact on populations than if the same procedures were applied to moist gully forests.

Management of wildlife will have to be finely tuned to the patterns of species distribution and abundance and their habitat requirements. As our knowledge improves, management procedures will need to change; like the forest, management is an evolving system. Nonetheless wildlife management requires the forester and the industry to accept a reduced yield of wood products from the forest (Recher & Rohan-Jones, 1978). Within the framework of present management procedures, the following changes would be of immediate benefit to the conservation of terrestrial birds and mammals in the Eden District.

Buffer Strips

We recommend that:

1. The importance of buffer strips along watercourses and in gullies for wildlife and as corridors for wildlife movements should be formally recognized and incorporated within the plan of management for the State Forests within the area affected by integrated logging.

2. Forty metres to either side of a watercourse should be the minimum width for buffer strips.

3. On watercourses where there is a flood plain (e.g. 'monkey gum' *Eucalyptus cypellocarpa* flats in the Eden sub-district), the boundary of the buffer strip should follow the boundary between the flood plain, riparian forest and adjacent forest on the slope. That is the riparian environment should be retained intact. The strips retained should include side creeks as well as the main watercourse.

4. On major catchments, where flood plains are retained, the minimum width of buffer strips to either side of a watercourse should be 50 m. Elsewhere, buffer strips should be extended to the top of some drainage lines within each compartment. The width of these extensions may be less than 40 m, but should retain the continuity of the canopy. This is to ensure the movement of wildlife and prevent the isolation of populations. Corridors should therefore extend across the catchment boundaries to link up with corridors in adjoining catchments.

5. Logging should be excluded from any part of the buffer strip. In forest adjacent to flood plain reserves (e.g. 'monkey gum' flats), identifiable habitat trees should be retained.

6. The above prescriptions cater for wildlife in moist gully forest and low rainforest, and to some extent, tableland forest. They make no provision for plants and animals which might be restricted to dry ridge, Spotted Gum, Banksia and some tableland forest types (see Appendix A). These also require a corridor pattern to ensure viable populations. The existing small coupe pattern should be reviewed to ensure that there are continuous corridors of unlogged forest.

7. An immediate objective of the pattern in which coupes are logged should be to ensure continuity of mature forest between the various national parks and nature reserves.

8. Because of the adverse impact of the pine planting program in the Bondi State Forest on wildlife and the implications this has for the woodchip industry, the same prescriptions for buffer strips as recommended for areas affected by integrated logging should be applied within the areas planted to pine. In the older parts of the plantation, where buffer strips have not been reserved along watercourses, buffer strips to prescription should be established at the commencement of the second rotation. If necessary, these should be planted to eucalypts, and other management procedures followed which allow the regeneration of native vegetation.

9. In the second rotation, consideration should be given to re-establishment of some areas to hardwood management to provide more viable areas of habitat and increase the effectiveness of buffer strips.

Habitat trees

At present there is no policy on the retention or provision of habitat trees for wildlife. The following procedures are recommended:

1. Logging should be excluded from buffer strips and reserves. This will preserve a significant number of habitat trees and make provision for the maturation of new habitat trees.

2. Known habitat trees should be reserved from logging. Where these trees are separated from buffer strips or other reserves, the patch of forest surrounding the tree should be protected. Sufficient trees should be kept around a habitat tree to protect it from winds and exposure and to provide cover for birds and mammals entering and leaving hollows in the habitat tree.

3. Individual trees of species known to develop into habitat trees should be selected and protected from logging so as to ensure the continuous maturation of such trees throughout the forest. Ideally such trees should be located near a known habitat tree (and can be part of the patch shielding that tree) and should be selected for their youth and vigour. Intuitively the healthiest and most vigorous individuals will develop into the largest and longest-lived trees with an abundance of hollows.

4. As a matter of urgency, guidelines for the number of habitat trees within a given area of forest should be developed for eucalypt forests in Australia.

5. Trees selected for retention on these criteria should be monitored for wildlife value and development of hollows in the case of those chosen for future nest sites.

Logging Cycle

Existing management proposals suggest that a cutting cycle of 40 to 45 years will be followed in the Eden Woodchip Concession. This means that by AD 2015 all forest in the district except that reserved in buffer strips, unlogged reserves or National Parks and Nature Reserves will be regeneration between 0 and 45 years. Forest of this age is unsuited for birds and mammals which require older trees. To ensure the survival of these species in the Eden district, the length of the logging cycle should be staggered through space and time. The following are recommendations:

1. Patches of forest which are rich in wildlife should be cut on a longer cycle than forest with poorer plant and animal communities.

2. Logging coupes which have particular importance for wildlife — for example forest with a high proportion of habitat trees or which is rich in a more specialized food resource such as nectar — should be reserved from clearfelling and managed on a selective logging basis.

3. Preferential protection from clearfelling should be given to coupes which fit into a network of buffer strips or corridors for the movement of wildlife between regeneration of different ages and mature forest in National Parks and Nature Reserves.

Additional Timber Resources

In order to maintain yields of wood from the forests while implementing the above recommendations for the management of wildlife, the following are recommended:

1. An increasing amount of pulpwood should be taken as thinnings from logging and fire regeneration. A major research program should be initiated as a matter of urgency into methods of thinning, silvicultural effects of different levels of thinning, and the use of smaller diameter logs for pulp.

2. A greater proportion of wood should be used from each tree, and the range of wood products extended. Whole tree logging and on-site chipping should be thoroughly investigated with the economics of the operation evaluated in consideration of the likely benefits to wildlife from the diversification of the logging rotation system.

National Parks

By themselves we consider the National Parks and Nature Reserves in the Eden District inadequate for the long term conservation of forest wildlife. At this time we have no specific recommendations for an increase in the number or area of parks and reserves. These will depend on events such as the development of forest management procedures in East Gippsland and the extent to which wildlife management procedures are implemented within the concession. In the event that integrated logging on the scale currently practiced in the Eden District is initiated in East Gippsland or that wildlife management procedures are not adopted we simply foreshadow the need to enlarge the existing parks west of the Pacific Highway in the Eden and Bombala sub-districts and to dedicate new parks incorporating the types of forest which are poorly represented in the existing system of reserves, and protecting sufficient habitat to maintain viable populations of dependent species.

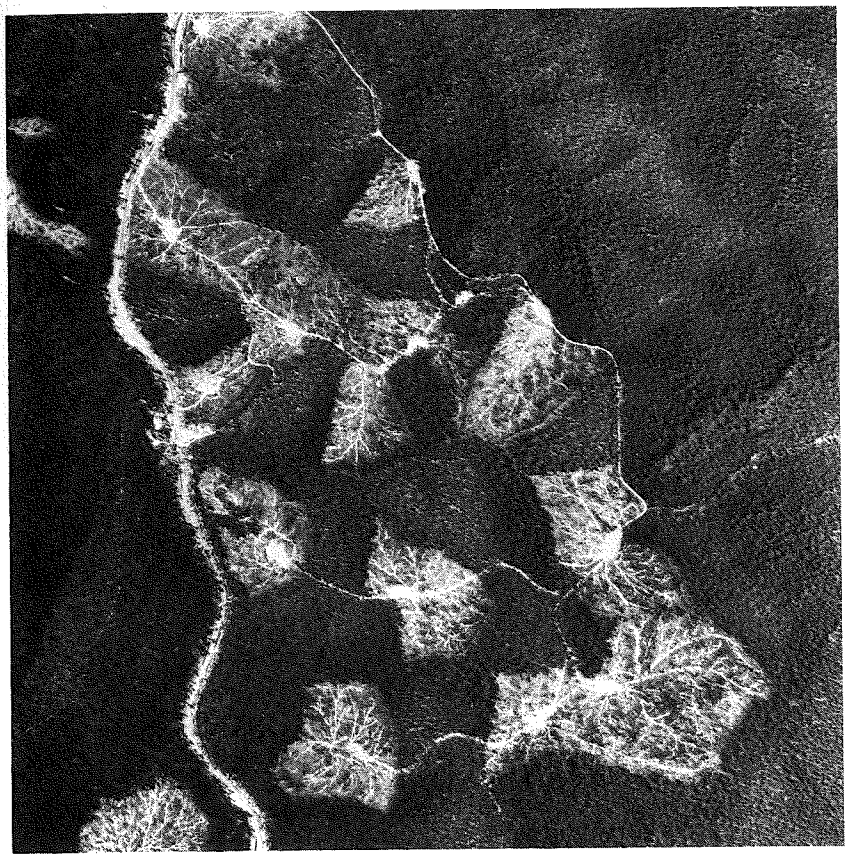

PLATE 12

Near Anteater Road coupe are a number of small logging coupes on which we census bird and mammal populations. The limited data available suggest that some of these areas may be too small for the full complement of species.
(Dept. of Lands Photograph)

ACKNOWLEDGEMENTS

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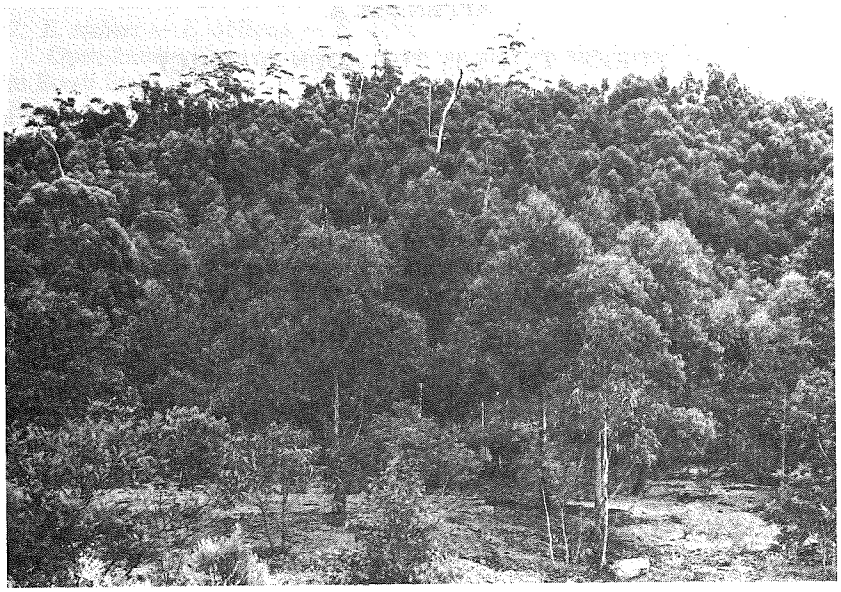

PLATE 13—PLATE 14

Regeneration after logging has generally been good in the sense that a tree and shrub cover is rapidly established. These photographs illustrate regeneration on a dry ridge in the Nadgee State Forest about 10 years after clearfelling. The site supports an abundant avifauna (see Figure 7), but lacks mature forest species. Small ground dwelling mammals are also common. The top photograph shows eucalypts planted on a logging dump in the foreground, and some reject or cull trees amongst the regeneration in the background.

APPENDIX A

FOREST TYPES IN THE EDEN DISTRICT

The following describes the major forest types occurring on our study sites; in describing the vegetation structure we have followed Specht *et. al.* (1974). The names of the forest types indicate the most common tree species. Baur's (1965) names for N.S.W. forest-types have been used wherever possible but in most instances his divisions were found to be too fine for a general description of the forests in our study areas.

LOW RAINFOREST

1. Acmena smithii

Rainforest 10 m to 15 m in height. Mainly found in the Bega sub-district in sheltered sites below about 100 m. Similar vegetation also occurs in small patches or as an understorey in the tall eucalypt open-forest of gullies elsewhere in the Bega and Eden sub-districts. (Baur's Type 23, Myrtle. Other rainforest types also occur, but less commonly).

MOIST GULLY FOREST

2. Eucalyptus cypellocarpa — E. muellerana — E. obliqua

Tall open-forest with an understorey of mesomorphic shrubs and ferns. Found in sheltered sites in all three regions: on granite above about 200 m in the Bega sub-district, throughout the Eden sub-district, and below about 600 m in Bondi State Forest. Other major species are *E. globoidea* and in broader gullies, *E. elata.* (Baur's Types 152, Messmate-Gum and 157, Yellow Stringybark-Gum).

3. E. longifolia — E. muellerana — E. smithii

Tall open-forest with an understorey of mesomorphic shrubs and ferns. Found in sheltered sites on sedimentary rocks between about 100 m and 200 m in the Bega sub-district. Other major species are *E. bosistoana, E. cypellocarpa* and in broader gullies *E. elata.* (A wet form of Baur's Type 86, Coastal Grey Box-Woollybutt).

4. E. fastigata

Tall open-forest with an understorey of mesomorphic shrubs and ferns. Found in sheltered sites in all three regions above about 600 m. Associated species are *E. obliqua, E. cypellocarpa, E. nitens* and *E. viminalis*. (Baur's Types 151, Brown Barrel-Messmate, 154, Brown Barrel and 155, Brown Barrel-Gum).

DRY RIDGE FOREST

5. E. sieberi — E. globoidea — E. agglomerata

Open-forest with an understorey of xeromorphic shrubs. Found in exposed sites above about 100 m in the Eden sub-district and on granite above about 200 m in the Bega-Bermagui State Forests. *Angophora floribunda* is a common understorey species in the Bega sub-district but is rare in this forest-type in the Eden sub-district. (Baur's Types 112, Silvertop Ash and 114, Silvertop Ash-Stringybark).

6. E. sieberi — E. globoidea — E. gummifera

Open-forest with an understorey of xeromorphic shrubs. Found in the Bega sub-district in exposed sites on coarse-grained, infertile soils below about 100 m, and in the Eden sub-district in exposed sites below about 50 m. Associated species are *Angophora floribunda* and *E. botryoides*. (Baur's Type 126, Stringybark-Bloodwood).

7. E. sieberi — E. obliqua — E. dives

Open-forest with an understorey of xeromorphic shrubs. Found in exposed sites in Bondi State Forest. *E. globoidea* is an associated species. (Baur's Type 113. Silvertop Ash-Peppermint).

8. E. longifolia — E. muellerana — E. sideroxylon

Open-forest with an understorey of xeromorphic shrubs and grasses. Found in exposed sites on sedimentary rocks between about 100 m and 200 m in the Bega sub-district. Other major species are *E. bosistoana* and *E. sieberi*. A sub-form from which *E. sideroxylon* and *E. bosistoana* are largely absent occurs in the Eden sub-district in exposed sites between about 50 m and 100 m. (A dry form of Baur's Type 86, Coastal Grey Box-Woollybutt).

SPOTTED GUM FOREST

9. E. maculata

Tall open-forest with an understorey of moderately mesomorphic shrubs. Found in the Bega sub-district on ridges and slopes on fine-grained, moderately fertile soils below about 100 m. There are various associated species but one which appears to be unique to this type is *E. paniculata* (Baur's Types 70, Spotted Gum, 74, Spotted Gum-Grey Ironbark/Grey Gum, and 75, Spotted Gum-Yellow Stringybark).

TABLELAND FOREST

10. E. dives — E. dalrympleana

Open-forest with an understorey of xeromorphic shrubs and grasses. Found in moderately exposed sites above about 600 m in Bondi State Forest. Associated species are *E. ovata* and *E. viminalis*. (Baur's Type 159. Mountain/Manna Gum).

11. E. pauciflora — E. stellulata

Open-forest or woodland, sometimes low, with a grassy understorey. Found in frosty, poorly-drained sites above about 700 m in Bondi State Forest. Associated species are *E. ovata, E. viminalis* and *E. rubida*. (Baur's Type 136. Snow-Gum-Black Sallee).

LOW FOREST WITH BANKSIAS

12. E. consideniana — E. globoidea

Open-forest or woodland, sometimes low, with an understorey of *Banksia serrata* and *Casuarina littoralis* trees and a lower layer of xeromorphic shrubs, sedges and Bracken *Pteridium esculentum*. Found in poorly-drained sites, mainly in the Eden sub-district. (Baur's Type 102. Yertchuk).

13. E. botryoides — E. globoidea

Low open-forest or low woodland with an understorey of *Banksia serrata* and *B. integrifolia* trees and a lower layer of xeromorphic shrubs, sedges and Bracken. Found on coastal headlands and stabilised sand-dunes, mainly in the Bega sub-district. (Baur's Type 108. Bangalay-Banksia).

APPENDIX B
TREE SPECIES — ENGLISH NAMES

Acmena smithii	Lilly Pilly
Angophora floribunda	Rough-barked Apple
Eucalyptus agglomerata	Blue-leaved Stringybark
Eucalyptus bosistoana	Coastal Grey Box
Eucalyptus botryoides	Bangalay
Eucalyptus consideniana	Yertchuk
Eucalyptus cypellocarpa	Mountain Grey Gum ('monkey gum' vern.)
Eucalyptus dalrympleana	Mountain Gum
Eucalyptus dives	Broad-leaved Peppermint
Eucalyptus elata	River Peppermint
Eucalyptus fastigata	Brown Barrel
Eucalyptus globoidea	White Stringybark
Eucalyptus gummifera	Red Bloodwood
Eucalyptus longifolia	Woollybutt
Eucalyptus maculata	Spotted Gum
Eucalyptus maidenii	Maiden's Gum
Eucalyptus muellerana	Yellow Stringybark
Eucalyptus nitens	Shining Gum
Eucalyptus obliqua	Messmate
Eucalyptus ovata	Swamp Gum
Eucalyptus paniculata	Grey Ironbark
Eucalyptus pauciflora	Snow Gum
Eucalyptus radiata	Narrow-leaved Peppermint
Eucalyptus rubida	Candlebark
Eucalyptus sideroxylon	Red Ironbark
Eucalyptus sieberi	Silvertop Ash
Eucalyptus smithii	Gully Peppermint
Eucalyptus stellulata	Black Sallee
Eucalyptus viminalis	Manna Gum

APPENDIX C
TERRESTRIAL MAMMALS OF THE EDEN DISTRICT

		Status
Order **Monotremata**		
Family *Tachyglossidae*		
Tachyglossus aculeatus	Echidna	Common
Family *Ornithorhynchidae*		
Ornithorhynchus anatinus	Platypus	Uncommon
Order **Marsupialia**		
Family *Dasyuridae*		
Antechinus stuartii	Brown Antechinus	Common
Antechinus swaisonii	Swainson's Antechinus	Common
Phascogale tapoatafa	Tuan	Expected, not recorded
Sminthopsis leueopus	White-footed Dunnart	Uncommon
Dasyurus viverrinus	Eastern Quoll	Prob. extinct in area
Dasyurus maculatus	Tiger Cat	Reported from tableland forest near Bombala, expected elsewhere
Family *Perameliade*		
Perameles nasuta	Long-nosed Bandicoot	Common
Isoodon obesulus	Short-nosed Bandicoot	Common
Family *Phascolomidae*		
Vombatus ursinus	Common Wombat	Common
Family *Phalangeridae*		
Acrobates pygmaeus	Feather-tail Glider	Common
Petaurus australis	Yellow-bellied Glider	Uncommon
Petaurus norfolcensis	Squirrel Glider	Expected, not recorded
Petaurus breviceps	Sugar Glider	Common
Cercartetus nanus	Eastern Pygmy Possum	Common
Trichosurus vulpecula	Brush-tailed Possum	Uncommon
Trichosurus caninus	Short-eared Possum	Uncommon
Pseudocheirus peregrinus	Ring-tailed Possum	Common
Schoinobates volans	Greater Glider	Common
Phascolarctos cinereus	Koala	Uncommon Recorded in Tanja, Yurramie & Nadgee State Forests
Family *Macropodidae*		
Bettongia gaimardi	Eastern Bettong	Extinct in area
Potorous tridactylus	Potoroo	Uncommon
Wallabia bicolor	Swamp Wallaby	Common
Macropus rufogriseus	Red-necked Wallaby	Common
Macropus giganteus	Eastern Grey Kangaroo	Common

Order **Lagomorpha**		
Family *Leporidae*		
Oryctolagus cuniculus	Rabbit	Common, western parts Bondi State Forest, uncommon elsewhere
Lepus europaeus	European Hare	Uncommon, rarely associated with forest habitat
Order **Rodentia**		
Family *Muridae*		
Rattus rattus	Black Rat	Uncommon except near human habitation
Rattus norvegicus	Norway Rat	"
Rattus fuscipes	Bush Rat	Common
Rattus lutreolus	Swamp Rat	Common
Hydromys chrysogaster	Eastern Water Rat	Uncommon
Mus musculus	House Mouse	Common
Order **Chiroptera** (expected series)		Status of bats uncertain
Sub-Order **Megachiroptera**	Fructivorous Bats	
Family *Pteropodidae*		
Sub-Family *Pteropinae*		
Pteropus poliocephalus	Grey-headed Fruit Bat	
Pteropus scapulatus	Flying Fox	
Sub-Order **Microchiroptera**	Insectivorous Bats	
Family *Emballonuridae*		
Sub-Family *Emballonurinae*		
Taphozous flaviventris	Yellow-bellied Tomb Bat	
Family *Rhinolophidae*		
Rhinolophus megaphyllus	Eastern Horseshoe Bat	
Family *Vespertilionidae*		
Sub-Family *Vespertilioninae*		
Pipistrellus tasmaniensis	Pipistrelle	
Eptesicus pumilus	Little Brown Bat	
Nycticeius rueppellii	Evening Bat	
Nycticeius greyii	Evening Bat	
Chalinolobus gouldii	Gould's Lobe-lipped Bat	
Chalinolobus morio	Lobe-lipped Bat	
Sub-Family *Miniopterinae*		
Miniopterus australis	Lesser Bent-winged Bat	
Miniopterus schreibersii	Bent-winged Bat	
Sub-Family *Nyctophilinae*		
Nyctophilus geoffroyi	Lesser Long-eared Bat	
Nyctophilus gouldii	Gould's Long-eared Bat	
Family *Molossidae*	Free-tailed Bats	
Tadarida australis		
Tadarida planiceps		

Order **Carnivora**		
Family *Canidae*		
Vulpes vulpes	Fox	Common
Canis familiaris dingo	Dingo	Common
Family *Felidae*		
Felis catus	Feral Cat	Common
Order **Ungulata**		
Family *Cervidae*		
Cervus unicolor	Sambar Deer	Uncommon
Family *Bouidae*		
Capra hircus	Feral Goat	Uncommon
Family *Suidae*		
Sus scrofa	Feral Pig	Uncommon

1. This list replaces that in Recher *et al.*, 1975a and includes species known to occur or have occurred plus those expected to occur in southeastern N.S.W.

PLATE 15

This is a study transect in the Nadgee State Forest along Mountain Road which was logged immediately after the 1972 fire. The site was chosen originally (in 1975) to represent the worst possible post-logging conditions. Regeneration of vegetation was initially slow, but since 1977 has developed rapidly. The fauna in 1979 is typical of post-logging regeneration of about 3 years of age.
(Photo — Australian Museum — H.F. Recher)

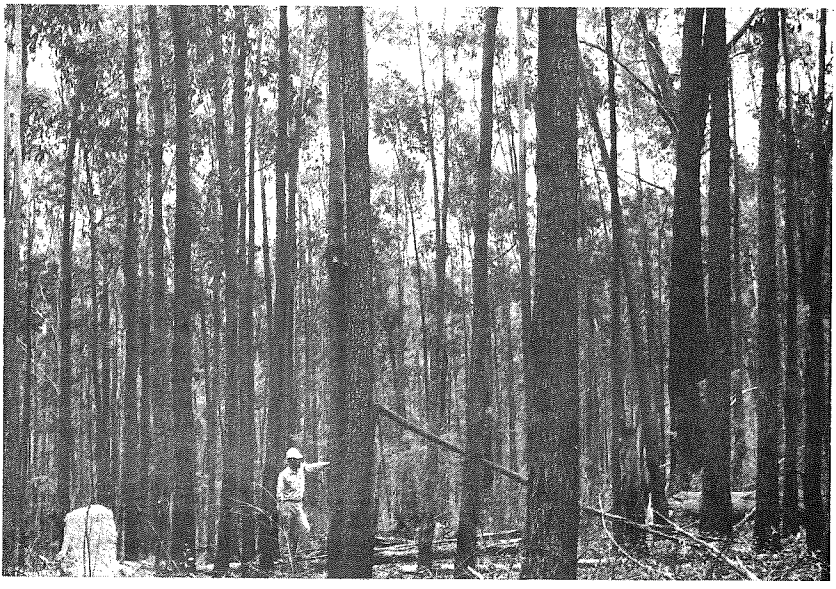

PLATE 16

In the absence of older logging regeneration, we have used even-aged stands of fire regeneration to obtain an 'idea' of how succession might proceed on clearfelled sites. Shown here is *Eucalyptus sieberi* regeneration on dry sites from the 1939 fire. This study site is on Dinner Creek Road in the Nadgee State Forest.
(Photo — Australian Museum — H.F. Recher)

APPENDIX D
TERRESTRIAL BIRD SPECIES RECORDED DURING THE STUDY

Explanation of the Symbols

C - Common. A species which is seen regularly even though it may not be abundant (e.g. Wedge-tailed Eagle).

U - Uncommon. A species which is present in the area or habitat-type for at least part of the year but which is only seen irregularly or in certain localities, even though it may occur in large flocks (e.g. Yellow-tufted Honeyeater).

V - Vagrant. A species which is only seen irregularly and is not normally present in the area.

* - Absent or in reduced numbers during winter.

SPECIES	AREAS			HABITAT PREFERENCES									
				EUCALYPT FORESTS					OTHER HABITATS				
	Bega-Bermagui State Forests	Eden-Nungatta State Forests	Western Bondi State Forest	Low Forest with Banksias	Dry Ridge Forest	Tableland Forest	Spotted Gum Forest	Moist Gully Forest	Low Rainforest	Shrub Communities	Aerial (above the Canopy)	Waterside Habitats	Open Habitats
1. Black-shouldered Kite *Elanus notatus*	U												U
2. Fork-tailed Kite *Milvus migrans*			V										V
3. Square-tailed Kite *Lophoictinia isura*	V		V				V	V					
4. Whistling Kite *Haliastur sphenurus*	C	U										C	C
5. Brown Goshawk *Accipiter fasciatus*	C	C	C	C	C	C	C	C					
6. Collared Sparrowhawk *Accipiter cirrhocephalus*	U	U	U		U			U					
7. Grey Gowhawk *Accipiter novaehollandiae*	U							U	U				
8. White-breasted Sea-eagle *Haliaetus leucogaster*	C	U										C	
9. Wedge-tailed Eagle *Aquila audax*	C	C	C	C	C	C	C	C					C
10. Little Eagle *Hieraaetus morphnoides*	C	U	U	U	U	U	U	U					U
11. Swamp Harrier *Circus aeruginosus*		U	U									U	
12. Peregrine Falcon *Falco peregrinus*		U	U		U			U					U
13. Little Falcon *Falco longipennis*	U	U	U	U	U	U	U	U					
14. Brown Falcon *Falco berigora*	U	U	C										C

SPECIES	AREAS			HABITAT PREFERENCES									
				EUCALYPT FORESTS						OTHER HABITATS			
	Bega-Bermagui State Forests	Eden-Nungatta State Forests	Western Bondi State Forest	Low Forest with Banksias	Dry Ridge Forest	Tableland Forest	Spotted Gum Forest	Moist Gully Forest	Low Rainforest	Shrub Communities	Aerial (above the Canopy)	Waterside Habitats	Open Habitats
15. Nankeen Kestrel *Falco cenchroides*	U	U	C										C
16. Brown Quail *Coturnix australis*		U	U							U		U	
17. Spotted Turtledove (introduced) *Streptopelia chinensis*	U												U
18. Brown Pigeon *Macropygia amboinensis*	V						V						
19. Peaceful Dove *Geopelia placida*	U	U											U
20. Common Bronzewing *Phaps chalcoptera*		U	U		U								
21. Brush Bronzewing *Phaps elegans*	C	C		C						C			
22. Wonga Pigeon *Leucosarcia melanoleuca*	C	U					C	C	C				
23. Glossy Black Cockatoo *Calyptorhynchus lathami*	U	U	U	U	U								
24. Yellow-tailed Black Cockatoo *Calyptorhynchus funereus*	U	C	C	C	C	C		C					
25. Gang-gang Cockatoo *Callocephalon fimbriatum*	C	C	C	U	C	C	C	C					
26. Galah *Cacatua roseicapilla*	C		C										C
27. Sulphur-crested Cockatoo *Cacatua galerita*	U		C*										C
28. Rainbow Lorikeet *Trichoglossus haematodus*	U	U		U	U		U	U					

SPECIES	AREAS: Bega-Bermagui State Forests	AREAS: Eden-Nungatta State Forests	AREAS: Western Bondi State Forest	HABITAT PREFERENCES — EUCALYPT FORESTS: Low Forest with Banksias	EUCALYPT FORESTS: Dry Ridge Forest	EUCALYPT FORESTS: Tableland Forest	EUCALYPT FORESTS: Spotted Gum Forest	EUCALYPT FORESTS: Moist Gully Forest	EUCALYPT FORESTS: Low Rainforest	OTHER HABITATS: Shrub Communities	OTHER HABITATS: Aerial (above the Canopy)	OTHER HABITATS: Waterside Habitats	OTHER HABITATS: Open Habitats
29. Musk Lorikeet *Glossopsitta concina*	C	C		C	C		C	C					
30. Little Lorikeet *Glossopsitta pusilla*	U	U		U	U		U	U					
31. King Parrot *Alisterus scapularis*	C	C	U	U	C		C	C	C				
32. Crimson Rosella *Platycercus elegans*	C	C	C	U	C	C	C	C	U				U
33. Eastern Rosella *Platycercus eximius*	C		U										C
34. Pallid Cuckoo *Cuculus pallidus*	U*	U*	U*										U
35. Brush Cuckoo *Cuculus variolosus*	C*	C*	U*	C	C		C	C	C				
36. Fan-tailed Cuckoo *Cuculus pyrrhophanus*	C*	C*	C*	C	C	C	C	C	C				
37. Horsfield's Bronze-cuckoo *Chrysococcyx basalis*		U*	U*										U
38. Golden Bronze-cuckoo *Chrysococcyx lucidus*	C*	C*	C*	C	C	C	C	C					
39. Powerful Owl *Ninox strenua*		U	U					U					
40. Boobook Owl *Ninox novaeseelandiae*	C	C	C	C	C	C	C	C					
41. Barking Owl *Ninox connivens*		U						U					
42. Sooty Owl *Tyto tenebricosa*	U		U					U	U				

SPECIES	AREAS			HABITAT PREFERENCES									
				EUCALYPT FORESTS						OTHER HABITATS			
	Bega-Bermagui State Forests	Eden-Nungatta State Forests	Western Bondi State Forest	Low Forest with Banksias	Dry Ridge Forest	Tableland Forest	Spotted Gum Forest	Moist Gully Forest	Low Rainforest	Shrub Communities	Aerial (above the Canopy)	Waterside Habitats	Open Habitats
43. Tawny Frogmouth *Podargus strigoides*	U	C	C	C	C	C		C					
44. Owlet-nightjar *Aegotheles cristatus*	U	C	C	C	C	C		C					
45. White-throated Nightjar *Caprimulgus mystacalis*	C*	C*			C		C				C		
46. Spine-tailed Swift *Hirundapus caudacutus*	C*	C*	C*								C		
47. Fork-tailed Swift *Apus pacificus*			U*								U		
48. Azure Kingfisher *Ceyx azureus*	U	U	U									U	
49. Laughing Kookaburra *Dacelo novaeguineae*	C	C	C	C	C	C	C	C					C
50. Sacred Kingfisher *Halcyon sancta*	C*	U*	U*	U	U	U	C	U					
51. Superb Lyrebird *Menura novaehollandiae*	C	C	C	U	U	U	C	C	C				
52. Skylark (introduced) *Alauda arvensis*	U		U										U
53. White-backed Swallow *Cheramoeca leucosternum*			V										V
54. Welcome Swallow *Hirundo neoxena*	C	C	C								C	C	C
55. Tree Martin *Cecropis nigricans*	U*	U*	C*	U	U	U	U	U			C		C
56. Australian Pipit *Anthus novaeseelandiae*	U	U	C										C

SPECIES	AREAS: Bega-Bermagui State Forests	AREAS: Eden-Nungatta State Forests	AREAS: Western Bondi State Forest	HABITAT PREFERENCES: EUCALYPT FORESTS: Low Forest with Banksias	EUCALYPT FORESTS: Dry Ridge Forest	EUCALYPT FORESTS: Tableland Forest	EUCALYPT FORESTS: Spotted Gum Forest	EUCALYPT FORESTS: Moist Gully Forest	EUCALYPT FORESTS: Low Rainforest	OTHER HABITATS: Shrub Communities	OTHER HABITATS: Aerial (above the Canopy)	OTHER HABITATS: Waterside Habitats	OTHER HABITATS: Open Habitats
57. Black-faced Cuckoo-shrike *Coracina novaehollandiae*	C*	C*	C*	C	C	C	C	C					C
58. Little Cuckoo-shrike *Coracina papuensis*	U	U	U	U	U								
59. Cicada-bird *Coracina tenuirostris*	C*	C*	U*	C	C		C	C					
60. White-winged Triller *Lalage sueurii*			V			V							
61. Ground Thrush *Zoothera dauma*	C	C	C			U	U	C	C				
62. Blackbird (introduced) *Turdus merula*	U	U	U					U					U
63. Rose Robin *Petroica rosea*	C	C	C*	U	U	U	U	C	C				
64. Pink Robin *Petroica rodinogaster*		U	U					U					
65. Flame Robin *Petroica phoenicea*	U	U	C*		C	C							C
66. Scarlet Robin *Petroica multicolor*	C	C	C	C	C	C							C
67. Hooded Robin *Melanodryas cucullata*			V										V
68. Eastern Yellow Robin *Eopsaltria australis*	C	C	C	C	C	C	C	C	C	C			U
69. Jacky Winter *Microeca leucophaea*	C	U	U										C
70. Crested Shrike-tit *Falcunculus frontatus*	C	C	C	U	U	C	C	C					

SPECIES	AREAS				HABITAT PREFERENCES								
					EUCALYPT FORESTS					OTHER HABITATS			
	Bega-Bermagui State Forests	Eden-Nungatta State Forests	Western Bondi State Forest	Low Forest with Banksias	Dry Ridge Forest	Tableland Forest	Spotted Gum Forest	Moist Gully Forest	Low Rainforest	Shrub Communities	Aerial (above the Canopy)	Waterside Habitats	Open Habitats
71. Olive Whistler *Pachycephala olivacea*			U					U					
72. Golden Whistler *Pachycephala pectoralis*	C	C	C	C	C	C	C	C	C	U			
73. Rufous Whistler *Pachycephala rufiventris*	C*	C*	C*	C	C	C	C	U					C
74. Grey Shrike-thrush *Colluricincla harmonica*	C	C	C	C	C	C	C	C		C			C
75. Black-faced Flycatcher *Monarcha melanopsis*	C*	C*	C*	U	U	U	U	C	C				
76. Leaden Flycatcher *Myiagra rubecula*	C*	C*	U*	C	C		C	U					
77. Satin Flycatcher *Myiagra cyanoleuca*		U*	C*		U	C		C					
78. Restless Flycatcher *Myiagra inquieta*	U	U	U										U
79. Rufous Fantail *Rhipidura rufifrons*	C*	C*	C*					C	C				
80. Grey Faintail *Rhipidura fuliginosa*	C	C	C*	C	C	C	C	C	C	C			
81. Willie Wagtail *Rhipidura leucophrys*	C	U	U										C
82. Eastern Whipbird *Psophodes olivaceus*	C	C	C	U	U	U	C	C	C	C			
83. Spotted Quail-thrush *Cinclosoma punctatum*	C	C	U		C	U	C						
84. Reed Warbler *Acrocephalus stentoreus*	U*											U	

SPECIES	AREAS: Bega-Bermagui State Forests	AREAS: Eden-Nungatta State Forests	AREAS: Western Bondi State Forest	HABITAT PREFERENCES: EUCALYPT FORESTS: Low Forest with Banksias	EUCALYPT FORESTS: Dry Ridge Forest	EUCALYPT FORESTS: Tableland Forest	EUCALYPT FORESTS: Spotted Gum Forest	EUCALYPT FORESTS: Moist Gully Forest	EUCALYPT FORESTS: Low Rainforest	OTHER HABITATS: Shrub Communities	OTHER HABITATS: Aerial (above the Canopy)	OTHER HABITATS: Waterside Habitats	OTHER HABITATS: Open Habitats
85. Little Grassbird *Megalurus gramineus*	U	U	U									U	
86. Tailor-bird *Cisticola exilis*			U									U	
87. Superb Blue Wren *Malurus cyaneus*	C	C	C	C	C	C	C	C		C			C
88. Southern Emu-wren *Stipiturus malachurus*		U	U	U						U			
89. Pilot-bird *Pycnoptilus floccosus*	C	C	C					C	C				
90. Large-billed Scrub-wren *Sericornis magnirostris*	C	U	U					C	C				
91. Yellow-throated Scrub-wren *Sericornis citreogularis*	U								U				
92. White-browed Scrub-wren *Sericornis frontalis*	C	C	C	C	C	C	C	C	C	C			
93. Chestnut-rumped Heath-wren *Hylacola pyrrhopygius*		U	U							U			
94. Brown Warbler *Gerygone mouki*	C	U	U				C	C	C				
95. White-throated Warbler *Gerygone olivacea*			V			V							
96. Brown Thornbill *Acanthiza pusilla*	C	C	C	C	C	C	C	C	C	C			
97. Buff-rumped Thornbill *Acanthiza reguloides*	U	U	C		U	C							
98. Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	C	U	C										C

SPECIES	AREAS: Bega-Bermagui State Forests	AREAS: Eden-Nungatta State Forests	AREAS: Western Bondi State Forest	HABITAT PREFERENCES: EUCALYPT FORESTS: Low Forest with Banksias	EUCALYPT FORESTS: Dry Ridge Forest	EUCALYPT FORESTS: Tableland Forest	EUCALYPT FORESTS: Spotted Gum Forest	EUCALYPT FORESTS: Moist Gully Forest	EUCALYPT FORESTS: Low Rainforest	OTHER HABITATS: Shrub Communities	OTHER HABITATS: Aerial (above the Canopy)	OTHER HABITATS: Waterside Habitats	OTHER HABITATS: Open Habitats
99. Little Thornbill *Acanthiza nana*	U												U
100. Striated Thornbill *Acanthiza lineata*	C	C	C	C	C	C	C	C		C			
101. Orange-winged Sittella *Daphoenositta chrysoptera*	C	C	C	C	C	C	C	U					
102. White-throated Treecreeper *Climacteris leucophaea*	C	C	C	C	C	C	C	C					
103. Red-browed Treecreeper *Climacteris erythrops*	C	C	C	U	U	C	C	C					
104. Red Wattlebird *Anthochaera carunculata*	C	C	C*	C	U	C	U	U					
105. Little Wattlebird *Anthochaera chrysoptera*	C	U		C						C			
106. Noisy Friarbird *Philemon corniculatus*	C*						C						
107. Bell-bird *Manorina melanophyrs*	C	U	U				C	C	C				
108. Noisy Miner *Manorina melanocephala*	U												U
109. Lewin's Honeyeater *Meliphaga lewinii*	C	U					C	C	C				
110. Yellow-faced Honeyeater *Meliphaga chrysops*	C	C	C*	C	C	C	C	C		C			
111. White-eared Honeyeater *Meliphaga leucotis*	U	U	C		U	C		U					
112. Yellow-tufted Honeyeater *Meliphaga melanops*		U						U					

SPECIES	AREAS: Bega-Bermagui State Forests	AREAS: Eden-Nungatta State Forests	AREAS: Western Bondi State Forest	AREAS: Low Forest with Banksias	HABITAT PREFERENCES: EUCALYPT FORESTS: Dry Ridge Forest	EUCALYPT FORESTS: Tableland Forest	EUCALYPT FORESTS: Spotted Gum Forest	EUCALYPT FORESTS: Moist Gully Forest	EUCALYPT FORESTS: Low Rainforest	OTHER HABITATS: Shrub Communities	OTHER HABITATS: Aerial (above the Canopy)	OTHER HABITATS: Waterside Habitats	OTHER HABITATS: Open Habitats
113. Fuscous Honeyeater *Meliphaga fuscus*	V							V		V			
114. Brown-headed Honeyeater *Melithreptus brevirostris*	C	C	C		C	C		C					
115. White-naped Honeyeater *Melithreptus lunatus*	C	C	C*	C	C	C	C	C					
116. Crescent Honeyeater *Phylidonyris pyrrhoptera*	C	C	C	C	U	U		C					
117. New Holland Honeyeater *Phylidonyris novaehollandiae*	C	C	U	C	C		C	C		C			
118. Eastern Spinebill *Acanthorhynchus tenuirostris*	C	C	C*	C	C	U	C	C	U	C			
119. Scarlet Honeyeater *Myzomela sanguinolenta*	V			V									
120. White-fronted Chat *Ephthianura albifrons*	U											U	
121. Mistletoe-bird *Dicaeum hirundinaceum*	C	C	U*	C	C		U	U					
122. Spotted Pardalote *Pardalotus punctatus*	C	C	C*	C	C	C	C	C					
123. Striated Pardalote *Pardalotus striatus*	U	C	C*		U	C		U					
124. Silvereye *Zosterops lateralis*	C	C	C*	U	U	C	C	C	C	U			
125. European Goldfinch (introduced) *Carduelis carduelis*	C	U	C										C
126. House Sparrow (introduced) *Passer domesticus*	C	U											C

SPECIES	AREAS			HABITAT PREFERENCES									
				EUCALYPT FORESTS						OTHER HABITATS			
	Bega-Bermagui State Forests	Eden-Nungatta State Forests	Western Bondi State Forest	Low Forest with Banksias	Dry Ridge Forest	Tableland Forest	Spotted Gum Forest	Moist Gully Forest	Low Rainforest	Shrub Communities	Aerial (above the Canopy)	Waterside Habitats	Open Habitats
127. Red-browed Finch *Emblema temporalis*	C	C	C*	C	C	C	C	C		C			C
128. Beautiful Firetail *Emblema bella*		U	U					U		U			
129. Diamond Firetail *Emblema guttata*			U										U
130. Common Starling (introduced) *Sturnus vulgaris*	C	U	C										C
131. Common Myna (introduced) *Acridotheres tristis*	U												U
132. Olive-backed Oriole *Oriolus sagittatus*	C*	C*	U*	C	C	U	C	C					
133. Satin Bower-bird *Ptilonorhynchus violaceus*	C	C	U				C	C	C				
134. White-winged Chough *Corcorax melanorhamphos*	U	U	U		U	U							U
135. Magpie-lark *Grallina cyanoleuca*	C	U	C										C
136. White-breasted Wood-swallow *Artamus leucorhynchus*		V			V								
137. Dusky Wood-swallow *Artamus cyanopterus*	C*	C*	C*	C	C	C					C		C
138. Grey Butcher-bird *Cracticus torquatus*	U	U	U	U	U	U	U	U					U
139. White-backed Magpie *Gymnorhina tibicen*	C	U	C										C
140. Pied Currawong *Strepera graculina*	C	C	C	C	C	C	C	C	C				C

SPECIES	AREAS				HABITAT PREFERENCES					
					EUCALYPT FORESTS				OTHER HABITATS	
141. Grey Currawong *Strepera versicolor*		U	C		C	C		C		U
142. Australian Raven *Corvus coronoides*	C	C	C	U	U	U	U	U		C
143. Little Raven *Corvus mellori*			U							U

PLATE 17

Large trees with hollows are an important resource for hole nesting birds and arboreal mammals. The provision of such habitat trees is an essential part of wildlife management in the Eden District. The *Eucalyptus cypellocarpa* shown in this illustration is on our Goanna Creek transect in the East Boyd State Forest and has been used for nesting by Striated Pardalote and Musk Lorikeet. It is one of many such habitat trees on an extensive creek flat and together they represent a major nesting area for lorikeets and cockatoos. Originally, large trees such as this were left untouched but modern technology now permits their use as woodchips.
(Photo — Australian Museum — H.F. Recher)

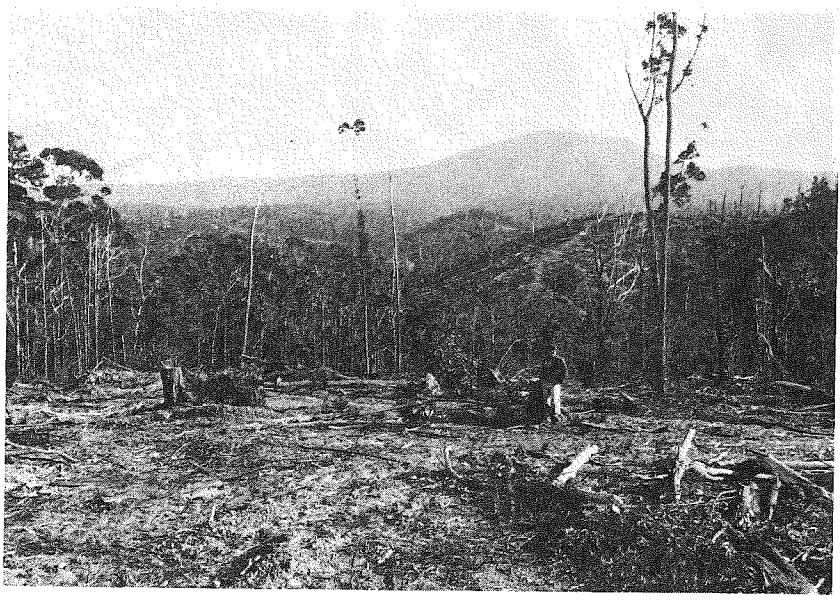

PLATE 18

East Boyd State Forest with Mt. Imlay National Park in the background. West of the Pacific Highway, the National Parks in the Eden District are small and like Mt. Imlay (3764 ha) are predominantly rugged with only limited samples of lower altitude and moist gully forest.

(Photo — Australian Museum — H.F. Recher)

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Plate 1 SC 6872; 2 — SC 6885; 3 — SC 6881; 4 — L 1054/9
Plate 5 L 1505/20; 6 — L 1504/12; 7 — SC 2966; 8 — SC 2968;
Plate 11 AT 265/7; 13 — L 1505/4; 14 — L 1505/10; 16 — SB 9004;

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Plate 12 — $\frac{29813}{2435|125}$