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***Wildlife Conservation
in the South-east Forests
of New South Wales***

G.H. Pyke & P.J. O'Connor



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Cover illustration: Long-footed Potoroo (*Potorous longipes*). The future of this rare mammal depends upon the existence of undisturbed old growth forest.

Artist: Jeff Davies

PREFACE

An earlier draft of this report was originally released for public comment in May 1990. This Technical Report incorporates changes suggested by Referees and other sources.

Wildlife Conservation in the South-east Forests of New South Wales

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SUMMARY. The aim of this paper is to review existing information on wildlife conservation within the South-east Forests Region of NSW and on the effects of logging and associated practices on conservation values of these forests, and to then make recommendations based on this review. We consider land systems, forest types, plant communities, plant associations and individual animal species. We do not, however, consider individual plant species.

Our conclusions and recommendations are as follows:

1. Logging of forests brings about essentially permanent changes in the distributions and abundances of their plants and animals and destroys any wilderness value of the forests. There should therefore be reservation of some areas essentially free from the effects of logging and associated practices.
2. Present National Parks and other Reserves are essentially unlogged or unaffected by other unnatural disturbance (i.e., are essentially undisturbed) and have generally low timber value because of their rugged topography. These existing reserves should therefore form the basis of a reserve system in the South-east Forests Region. Additions to the reserve system should come from the region's State Forests as they contain almost all remaining undisturbed forest.
3. Five of the region's ten land systems, as defined by Keith & Sanders (1988, 1990), are inadequately conserved (i.e., Rainshadow Valley, Western Flat Country, Tableland, Granitic Hinterland, Escarpment). We expect the same should be true for the forest types (*sensu* Forestry Commission of NSW, 1989a), plant communities (*sensu* Keith & Sanders, 1988, 1990) and plant associations (*sensu* NSW National Parks and Wildlife Service, 1986a) associated with these land systems.
4. A number of animal species are rare or endangered within the region and are therefore of concern. These include 15 mammal, two bird and one fish species. Also of concern are the region's 18 microchiropteran bat species as their distributions are very poorly known and they are likely to be adversely affected by logging. The region has been inadequately surveyed for all animal groups.
5. The reasonably large Coolangubra Wilderness area is not totally included in the present reserve system.
6. The conservation values of each of the region's State Forests were assessed in terms of extent of undisturbed forest, presence of areas of poorly conserved land systems, wilderness area,

- records of animal species of concern, potential to join with or link other reserve areas, and presence of areas of high predicted arboreal marsupial density. Based on these criteria, the Coolangubra Wilderness area and adjoining parts of Coolangubra State Forest have the highest conservation value.
7. We recommend that the Coolangubra Wilderness and State Forest be added to the reserve system. This would result in the reservation of the last remaining unreserved undisturbed area of poorly-conserved Western Flat Country, significant areas of Escarpment and Granitic Hinterland, which are also inadequately conserved, and an area containing many animal species of concern and high densities of arboreal mammals.
 8. We also recommend reservation of:
 - a) the last remaining unreserved undisturbed areas of the poorly conserved Tableland land system within Tantawangalo and Glenbog State Forest;
 - b) additional undisturbed areas of the Escarpment Land System from within Murrabrine, Glenbog, Bemboka, and Tantawangalo State Forests, and
 - c) all unreserved undisturbed areas of the Rainshadow Valley land system and any areas of this very poorly conserved and largely cleared land system that could be rehabilitated.Recommendations 8b and 8c will require further survey before appropriate areas can be identified.
 9. The existing forestry practices in the region will in many respects, help to conserve wildlife. We have, however, identified the following deficiencies:
 - a) the existing filter strips (20 m wide on either side of gullies with catchments exceeding 50 ha) and, to a lesser extent, the wildlife corridors (100 m or more wide along watercourses or gullies and connecting neighbouring catchments) will be inadequate for the long-term survival of species which require large home ranges such as the Yellow-bellied Glider and Powerful Owl. We recommend that these areas be expanded and/ or extended in areas where such species occur;
 - b) results of the logging research program in the Waratah Creek Flora Reserve are not yet available, even though the initial logging was carried out in 1984. We recommend that high priority be given to the presentation and publication of results to date; and
 - c) the present burning regime in the region's State Forests is overly simplistic in design and will result in fires that are too frequent, at too low an intensity and at the wrong season for some wildlife. We recommend that the burning regime be modified to ensure a reasonably high diversity of fire histories across forest areas, that many areas experience fire at ten to 25 year intervals rather than four to seven years, and that many areas experience hot, summer fires (or their equivalent, in terms of effects on the biota, if this can be established). We also recommend that controlled burning be used as a management tool to promote the long-term survival of rare or endangered species.
 10. Conservation of fauna on private property poses a problem as important habitat is continuing to be cleared for both pulpwood and sawlogs. We therefore recommend that:
 - a) communication be encouraged between private land-holders and the various individuals, groups and institutions interested in wildlife conservation;
 - b) private landholders be encouraged to conserve wildlife values;
 - c) with the agreement of land-holders, wildlife surveys of private forest be carried out, and
 - d) private forest of high conservation value be protected from unnatural disturbance.
 11. There is a great need for more wildlife-related research in the region and in general. We have identified the following subjects as being in particular need of study:
 - a) relationships between written forestry practices and what actually happens in terms of retention of trees and other vegetation in logged forest and in terms of timing, intensity and extent of fires;
 - b) effects of logging and burning on plants and animals, especially those that require tree hollows (e.g., arboreal marsupials, owls, microchiropteran bats) and those that are rare or endangered;
 - c) population biologies of rare and endangered species, and
 - d) distributions and abundances of species throughout the region.
 12. Current estimates of future timber yields from the region's State Forests are based on assumptions that are overly simplistic and not well substantiated. In order to ensure that approximately constant timber yields will be available in perpetuity, it is essential that a comprehensive and accurate computer model of forest growth and harvest be developed. Such a model would also assist in the consideration of alternative short and medium term strategies for timber harvest.

13. Most of the remaining undisturbed forest in the region's state forests is of high conservation value. Alternatives to logging these areas should therefore be fully explored and any increases in availability of timber should be used to enable additional undisturbed forest areas to be added to the reserve system. Any logging of the remaining undisturbed forest should be postponed as long as possible; if it occurs it should begin in areas of lowest conservation value.
14. Alternative strategies to logging the remaining undisturbed forest, such as those proposed by the South-east Forest Alliance, have not been adequately considered. We recommend a comprehensive and detailed evaluation of the range of alternatives along the lines of the current Resource Assessment Commission's Inquiry into Australia's Forest and Timber Resources.
15. Documentation of past land-use decisions (e.g., State Forest versus National Park) and their justifications is poor while that for land-management decisions (e.g., control burning regime) is reasonable. There is also little opportunity for interested parties to comment on land-use and land-management proposals. We therefore recommend the establishment of improved procedures for the preparation of supporting documentation in association with proposals for National parks, Flora Reserves and National Estate Listing, for soliciting and evaluating comments from interested parties on these proposals, and for comparison and combination of competing proposals. Advisory Councils, with appropriate expertise and representatives from a variety of interests, could make well-considered recommendations to the State and Federal Governments concerning the operations of the Forestry Commission and other Government Bodies.

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Introduction

Land management within the South-east Forest Region of New South Wales has been the subject of considerable discussion and dispute since the beginning of pulp logging in 1969 (e.g., Lunney & Moon, 1987). Plans have been made for the logging of the remaining unlogged State Forest of the region (Harris-Daishowa (Australia), 1986a; Forestry Commission of NSW, 1988a, appendix 2). Such logging is seen by the timber industry as necessary to maintain jobs (Harris-Daishowa (Australia), 1986a; Forestry Commission of NSW, 1988a, appendix 2). On the other hand, high intensity logging of an area affects wildlife and completely destroys its wilderness quality (Recher *et al.*, 1980; Wilderness Working Group, 1986; McIlroy, 1978; Harris-Daishowa (Australia), 1986a). It has been argued that the present system of protected areas such as National Parks leaves many species, plant communities, vegetation associations and land systems poorly conserved (Recher *et al.*, 1980; National Parks & Wildlife Service of NSW, 1986a, 1987; Keith & Sanders, 1988, 1990). Consequently a number of proposals have been made for preserving areas of present State Forest in new National Parks (Total Environment Centre, 1985a,b, 1986; National Parks & Wildlife Service of NSW, 1986a; Broadbent, 1987; South-East Forest Alliance, 1988). Much disagreement remains amongst interested parties (Pryor, 1989; South-East Forest Alliance, 1989; Forestry Commission of NSW, 1990).

The aim of this review is to summarise existing information on wildlife and wilderness conservation within the South-east Forest Region and on the effects of forestry practices on conservation values and to make recommendations to Government based on this review. Both State and Federal Governments, who, between them, will decide the future of these forests, recognise a need for such a review (Joint Scientific Committee, 1989, 1990). Australian Museum staff have been involved in research and wildlife management issues within this region since 1969 (e.g., Recher, Clark & Milledge, 1975; Recher, 1976; Recher *et al.*, 1980).

In this review we shall consider land systems, plant communities, forest types, vegetation associations, and individual animal species, but not individual plant species. For discussion regarding individual plant species see (Binns, 1988; Keith & Sanders, 1990; Joint Scientific Committee, 1989, 1990).

For scientific names of animal species see Tables 3 to 7 (Appendices 5 to 9).

Description of South-east Forest Region

The South-east Forest Region is roughly the same as the Eden Woodchip Agreement Area (National Parks & Wildlife Service of NSW, 1987). The region extends from near Bermagui in the north to the Victoria border in the south and from the coast to near Bombala in the west. The total area involved is approximately 630,000 ha and encompasses the Eden Native Forest Management Area (290,000ha) (Forestry Commission of NSW, 1988a, appendix 2). About 39% of the area is freehold and has been largely cleared for farming. The remaining area consists mostly of National Parks and Nature Reserves (63,123 ha), Flora Reserves and Forest Preserves (14,447 ha), State Forest excluding Flora Reserves and Forest Preserves (262,734 ha) (referred to from now on as simply "State Forest") and vacant Crown Land (about 19,200 ha).

Within the State Forest about 71,190 ha are reserved from logging under the Preferred Management Priority System in addition to Flora Reserves and Forest Preserves (e.g., wildlife corridors, areas that are too steep or rocky for logging). As of July 1986 about 174,295 ha were available for both pulpwood and sawlog production of which about 70,000 ha had already been logged. Most of the rest of the State Forest has either been subject to relatively light selective logging over a period of about 150 years or has never been logged (e.g., Lunney & Moon, 1989). Consequently, as of January 1990, there remain approximately 100,000 ha of forest that is essentially unlogged and is scheduled for integrated logging. It is this forest that has been

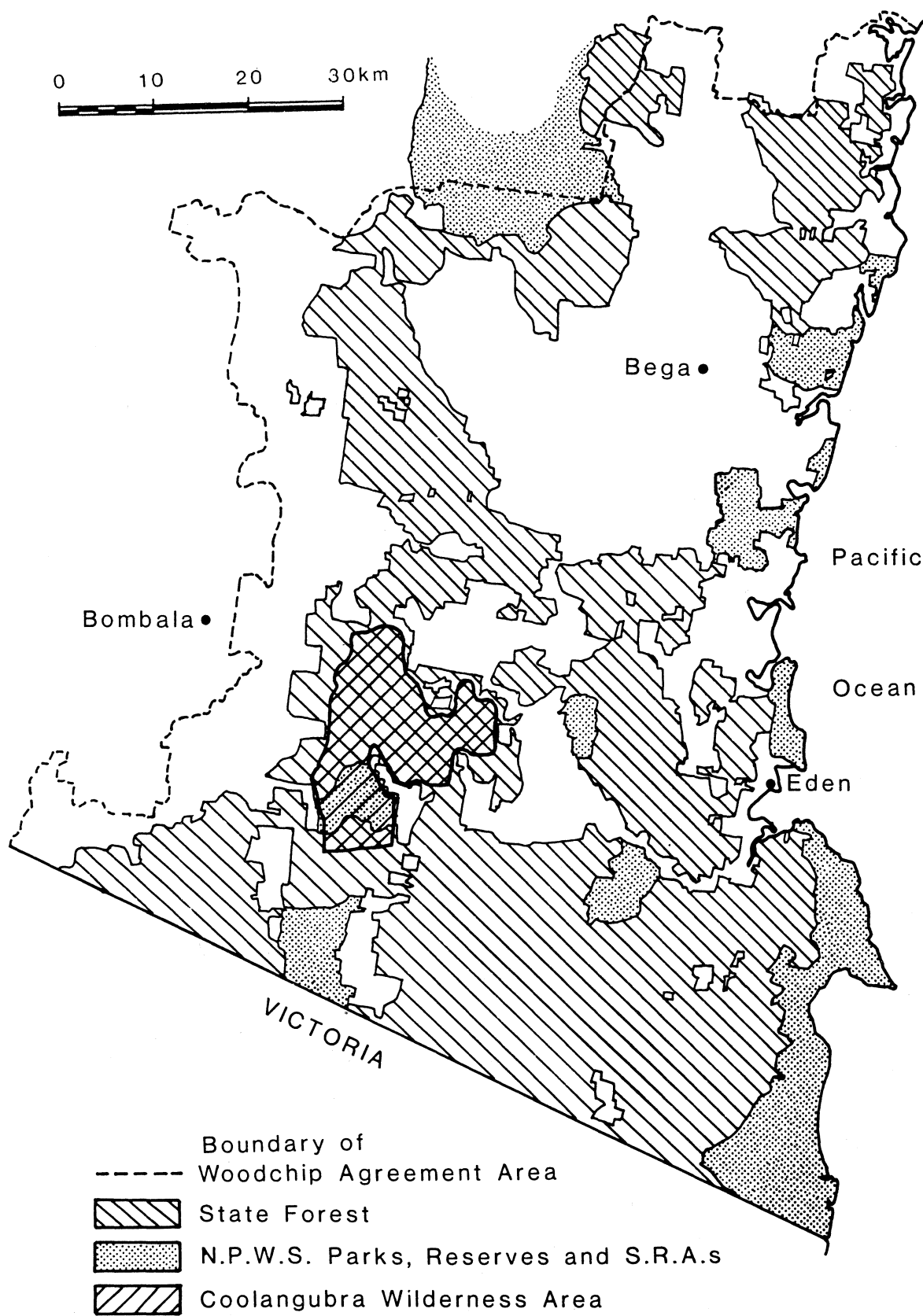


Fig.1. The South-east Forest Region of NSW.

the focus of debate and discussion concerning its future use. Logging for sawlogs and pulpwood is continuing within this forest at the rate of about 5000 ha p.a.

ESTABLISHING A BASIS FOR CONSIDERING LAND-USE AND LAND-MANAGEMENT IN THE SOUTH-EAST FOREST REGION

Principles of Wildlife Conservation

The Australian Museum adopts the following principles in terms of wildlife conservation in general and within the South-east Forests Region in particular:

1. Viable populations of all species should be preserved throughout the range of each species and especially near the limits of distribution. A region the size of the South-east Forest Region (i.e., of about 500,000 ha) should not lose any species;
2. Within any region of about 500,000 ha (such as the South-east Forest Region) large representative examples of all recognised vegetation types and land systems should be kept essentially free of unnatural disturbance (i.e., as "protected" areas);
3. Any existing Wilderness areas should be maintained as such;
4. Whole catchment headwater areas, rather than parts there of, should be preserved;
5. Areas of high conservation value and connecting areas should be combined as much as possible into large protected areas;
6. The network of protected areas should allow for natural movement and/or dispersal of plants and animals;
7. Forestry practices should be adjusted so that wildlife values within logged forest are well-maintained;
8. Logged forests should be managed so that they produce a roughly constant timber yield in perpetuity.

Application of Principles of Wildlife Conservation

Forestry practices: assessing the impacts on wildlife

POTENTIAL SOURCES OF INFORMATION. There are several ways in which one can estimate the likely effects of forestry practices on wildlife. One way is to make such estimates on the basis of experiments carried out in the South-east Forests or in similar forests using areas chosen before logging (e.g., Forestry Commission of NSW, 1989b; Margules, 1987). Such experiments can allow the effects of standard procedures to be compared

with a range of alternatives and with appropriate controls. They also permit comparisons to be made between data collected before and after treatment. Unfortunately, though such experiments are under way or have been carried out (Forestry Commission of NSW, 1989b; Margules, 1989), their results have not been published.

A second method is to study areas that have been subjected to logging and other forestry practices at different times in the past and to compare these areas with areas that have received no such treatment. In this case, areas are chosen after logging has already occurred. If the areas are otherwise very similar then such studies should indicate any effects of logging and the environmental time course following logging. Such studies have been undertaken in a number of different areas within the region by Recher *et al.* (1980) and more recently in Mumbulla and Tanja State Forests (Smith 1985a,b; Lunney & Barker, 1986a,b,c; Lunney, 1987; Lunney, Cullis & Eby, 1987; Lunney, Eby & O'Connell, 1990). However, a fire burnt most of the areas that were included in these Mumbulla and Tanja studies, and consequently it is difficult, for the post-fire period, to separate the effects of logging from the effects of fire.

A third method is to extrapolate from studies that provide information on the dietary, habitat and home-range requirements of the animal species that occur in the South-east Forests, their population biology, any known effects of logging on wildlife, and any known effects of fire on wildlife (e.g., Fleay, 1944; Seebeck, 1976; James, 1980; Braithwaite *et al.*, 1983; Braithwaite, Turner & Kelly, 1984; Davey, 1984; Henry & Craig, 1984; Kavanagh, 1984, 1987, 1988; Mackowski, 1984; Smith, 1984, 1989; Lunney, Barker & Priddell, 1985; Lunney, Ashby, Grigg & O'Connell, 1986; Lunney & Ashby, 1987; Lunney, Barker & Leary, 1987; Lunney, Ashby, Grigg & O'Connell, 1989; Lunney, O'Connell, Sanders & Forbes, 1989; Lunney, Barker, Priddell & O'Connell, 1989; Lunney & O'Connell, 1988; Lunney & Leary, 1989; Bennett & Baxter, 1989; Taylor & Savva, 1988; Scotts & Seebeck, 1989; Reed & Lunney, 1990). This is potentially the most useful approach since most existing information is of this form. It is, however, made difficult by the unclear relationship between the forestry practices as prescribed and what actually happens in the forest. Current forestry practices require, for example, that a minimum of five old trees containing hollows should remain per 15 ha after logging as "habitat trees" for use by animals that require such trees and that these trees should preferably occur in a clump along with younger trees that will eventually replace them (Forestry Commission of NSW, 1990). However, the actual number of old trees that are retained appears to depend on several factors such as whether each tree is of a commercially useful species, whether a tree can be felled without damaging other retained trees, whether an old tree is retained as a seed tree (D. Ridley, personal communication) and perhaps on the personal inclinations of the person who decides the fates of individual trees. As "future saw logs" are not felled and a minimum of two "seed trees" are retained near each log lump, the overall number of trees still standing after

logging operations have been completed, varies from site to site.

ACTUAL INFORMATION AVAILABLE. In order to consider management of the South-east Forests we sought information from a variety of sources, including papers published in scientific journals, unpublished scientific papers, published and unpublished reports, books, environmental impact statements and associated material, proceedings in the Land & Environment Court, and discussions with involved people. There is a large amount of such written material, especially in comparison with other forest areas in New South Wales. Our bibliography already contains over 420 references. However, the presently available information relating to the South-east Forests is inadequate in many respects for well considered decisions concerning their use and management. The results of wildlife surveys are not, for example, available for much of these forests. The effects of different fire regimes on wildlife in these forests are largely unknown. The effects of logging on many plant and animal species, especially understorey plants, invertebrates and uncommon vertebrates, are unknown. In the following discussion we highlight the areas of inadequate information.

This inadequacy warrants caution in making land management decisions. We do not want to discover after the fact that decisions have resulted in great and irreparable damage to environmental values. On the other hand, some decisions must be made now and cannot wait until further information is available. We must make maximum use of existing information and this is the approach taken in this report.

DO FORESTRY PRACTICES AFFECT WILDLIFE? If the effects of forestry practices on wildlife were zero or short-lived then there would be little conflict between forestry and conservation and the present analysis and discussion would be largely unnecessary. There is, however, ample evidence that forestry practices affect wildlife. Shortly after burning and/or logging some species are more abundant than before, while for other species the reverse occurs (Recher *et al.*, 1980; Kavanagh *et al.*, 1985; Smith, 1986, 1989; Lunney, 1987; Lunney & Ashby, 1987; Lunney, Cullis & Eby, 1987). With time these effects may disappear (Recher *et al.*, 1980; Kavanagh *et al.*, 1985; Loyn, 1989) but some effects such as those on animal species that require tree hollows will persist for 200 or more years (Mackowski, 1984). Since South-east Forest areas that are utilised for timber supply will be heavily logged after, at most, 150 years following the initial bout of integrated logging, (Forestry Commission of NSW, 1988, appendix 2) these forest areas will never return to a state approximating their unlogged condition.

It follows (see principle 2 above) that there must be reservation of areas free from the effects of forestry practices.

Wilderness

Remaining wilderness areas have high conservation value because development since European settlement of Australia has left so little area free from disturbance and these areas are the only places where wildlife remains free from the effects of roads and development. Long term survival of some species, such as the Spotted-tailed Quoll which is rare, is at the top of the food chain, requires a relatively large home range and is probably adversely affected by introduced predators, may depend on large areas remaining essentially free from unnatural disturbance. The presence of roads may lead to increased densities of introduced predators. For these reasons, the remaining large wilderness areas should be included in the reserve system (i.e., National Parks, Nature Reserves, Flora Reserves and Forest Preserves) and managed so that their wilderness values are retained.

To apply the above principles it is necessary to adopt a definition of wilderness and establish the relationship between the size and location of a wilderness area and its conservation value. We consider a wilderness area to be an area which:

- a) is essentially unaffected by unnatural disturbance or can be rehabilitated to approximately its natural state, and
- b) can be managed to retain its natural state.

This is basically the same definition as adopted by the National Parks and Wildlife Service of NSW (1989). We do not consider degree of isolation, human recreation or presence of a surrounding "buffer" area as part of the definition of wilderness, although these factors can affect the wildlife value of any area. Furthermore, we consider that any wilderness area that is approximately 25,000 ha in size should be included in the reserve system and that, for wilderness areas smaller than 25,000 ha, conservation value is proportional to area.

Within the South-east Forests the only wilderness areas that approximate 25,000 ha in size is the Coolangubra Wilderness Area as identified by the Total Environment Centre (1987) and National Parks and Wildlife Service of NSW (1989). It includes almost all of Coolangubra State Forest and Nalbaugh National Park and parts of Nalbaugh State Forest and Bondi State Forest (see Fig.1).

Also within the South-east Forest Region are parts of the Genoa (Total Environment Centre, 1987; National Parks and Wildlife Service of NSW, 1989), Brogo and Nadgee Wilderness Areas (Forestry Commission of NSW, 1988, appendix 1; Wilderness Working Group, 1986). The Genoa Wilderness Area includes almost all of Nungatta National Park and a small part of Bondi State Forest. The Brogo Wilderness is centred around Wadbilliga National Park while the Nadgee Wilderness includes Nadgee Nature Reserve and part of Nadgee State Forest.

For further State Forests within the region the area of old-growth forest provides an approximate estimate of wilderness area. For other discussions of wilderness in the South-east Forest Region see Helman *et al.* (1976) and Wilderness Working Group (1986).

Reserved areas: how large should they be and where should they be located?

A system of reserves in the South-east Forests must be based on the following existing information:

- a) areas of different land systems (*sensu* Keith & Sanders, 1988, see glossary for definition) that are present in the region. Each land system will contain associated distributions of plants and animals;
- b) knowledge relating to rare or endangered species, and
- c) knowledge of wilderness values.

To this information base, the following may be added when available:

- d) areas of different forest types (*sensu* Forestry Commission of NSW, 1989, see glossary for definition) that are present in the region;
- e) areas of different plant communities and vegetation types (*sensu* Keith & Sanders, 1988) or vegetation associations (*sensu* National Parks & Wildlife Service of NSW, 1986a) that are present in the region, and
- f) predicted distributions of plant and animal species and of their associations (e.g., Joint Scientific Committee, 1990; Margules, 1987b; Margules & Stein, 1989).

Based on existing information we consider that a reserve system in the South-east Forests should satisfy the following criteria:

- a) the percentage of the total area of each land system that is reserved should be sufficiently large so that the spatial heterogeneity within each land system is adequately sampled. It is not yet clear how large this percentage should be. Margules *et al.* (1988) found that 45% of the total wetland area in the MacLeay Valley flood plain would have to be reserved in order for each plant species to occur within at least one wetland reserve;
- b) the reserved area of each land system should be sufficiently large to allow for survival in perpetuity of rare species that require large areas of mature forest and for the mosaic of fire histories necessary for conservation of wildlife within each land system. It is not clear how large the area should be. However, single fire events often burn tens of thousands of hectares of forest;
- c) each land system should be represented by several distinct areas throughout the total land system area (this will enable sampling of the heterogeneity within each land system and facilitate a mosaic of fire histories across the

- reserved areas);
- d) reserves should, in general, be contiguous (this facilitates active management of the reserves and allows for natural movement of organisms between reserved areas)
- e) the reserve system in conjunction with areas of logged forest should permit survival of all plant and animal species in perpetuity;
- f) reserves should be predominantly forest that has not been affected by unnatural disturbance (i.e., is essentially undisturbed), and
- g) when there is insufficient undisturbed forest to meet conservation requirements, other appropriate land areas should be reserved and rehabilitated.

We utilise these criteria to evaluate the adequacy of existing reserves and considering additions to the system.

Present areas of undisturbed forest

In order to design a reserve system for the South-east Forests it is necessary to determine the location and extent of "undisturbed forest". We did this as follows.

We assumed that existing Reserves (i.e., National Parks, Nature Reserves, Flora Reserves and Forest Preserves) are undisturbed forest. We also considered that forest which has been subjected to alternate-coupe integrated logging is "logged forest", even though about half of the coupes have not yet been logged. We finally assumed that the remaining areas within State Forests are essentially undisturbed forest even though they may have been subject to light selective logging. Ideally the unlogged areas and areas that have been selectively logged should be considered separately, but this is not possible because the selective logging took place over a period of about 150 years and few records of its extent were kept (Lunney & Moon, 1989). On this basis we estimated, using the following method, the areas of essentially undisturbed forest within all State Forests within the region. A photocopy of Map 5 from the Forestry Commission of NSW, 1988 Environmental Impact Statement (EIS) (appendix 4) was made. Undisturbed areas as described above were then stencil cut, weighed and converted to areas by a weight/area conversion factor.

It seems reasonable to use the existing reserves as a starting point in designing a reserve system. The National Parks, which on the basis of area, comprise most of the present reserve system, are essentially undisturbed and, by virtue of their rugged topography, are of relatively low value as timber producing areas. The existing Nature Reserves and Flora Reserves have well-recognised high conservation value. The only reasonable immediate changes to the reserve system would therefore be additions from present State Forest. Wildlife conservation within the South-east Forest Region could also be enhanced, in the long-term, through habitat restoration in areas where native forest has been mostly or entirely cleared for farming or pine plantations.

Some State Forests are mostly undisturbed by logging (Appendix 3 Table 1). For Coolangubra, Tantawangalo, Murrabrine, Bemboka, Glenbog, Cathcart, Gnupa, Towamba, Nalbaugh and Nullica State Forests over 83% of the area is undisturbed (see Appendix 3 Table 1). The other State Forests are largely logged, although in some cases such as in Glenbog State Forest and the Rockton section of Bondi State Forest between Nalbaugh and Nungatta National Parks, there remain large areas of undisturbed forest. We shall consider these areas of undisturbed forest as candidates for inclusion in the reserve system for the region.

ASSESSING CONSERVATION IN THE SOUTH-EAST FOREST REGION

Present Adequacy of Conservation in the South-east Forest Region

Land systems

Keith & Sanders (1988, 1990) recognised ten land systems and provided a map of their occurrence within the South-east Forest Region. We used this map to estimate the area of each land system within each Reserve (including Flora Reserves and Forest Preserves) and State Forest (excluding any enclosed Flora Reserves and Forest Preserves, Appendix 4 Table 2). The area within the Woodchip Agreement Area was assumed to be 630,000 ha. Land Systems were stencil cut from an enlarged photocopy of the region (Keith & Sanders, 1988: fig.4) and weighed. The proportions of each land system (by weight) were then multiplied by 630,000 to give the regional total for each land system. Land system areas for the various land tenure classes (excepting Other Land) were similarly estimated using known (published) areas for each category. The land system areas for the category Other Land (which consists primarily of cleared land and some vacant Crown Land) was calculated by subtraction of the totals of all other categories from each land system regional total.

Three land systems, namely Rainshadow Valley, Western Flat Country, and Tableland) are poorly conserved in the South-east Forest Region. They are represented in reserves by both very small percentages of the total land system area and very small areas reserved (Appendix 4 Table 2).

Two other land systems, Escarpment and Granitic Hinterland are also inadequately conserved because the reserved areas of each (3,308 ha and 6,723 ha respectively) are too small to allow for the fire mosaics to ensure survival of all wildlife species.

The reserved areas of Western Sandstone Plateau and Dissected Mountainous Country are only 5,081 ha and 6,383 ha respectively, but we consider both of these land systems to be adequately conserved within the region. The reserved area of Western Sandstone

Plateau represents almost all (i.e., 89.6%; Appendix 4 Table 2) of the total area of this land system within the region. There are extensive areas of Dissected Mountainous Country in the part of Wadbilliga National Park to the north of the South-east Forest Region.

With the exception of Dissected Mountainous Country, the land systems of the South-east Forest Region are rare in reserves outside of the region. The nearest major Reserve to the west of the region is Kosciusko National Park which, by virtue of its different geology and climate, is very different to the South-east Forest Region. For similar reasons there is also a distinctive difference between East Gippsland and South-east New South Wales (Switzer *et al.*, 1989).

Reasonably large undisturbed forest areas of Western Flat Country, Tableland and Escarpment occur in several State Forests in the region, especially Coolangubra (Appendix 4 Table 2, Appendix 10 Table 8). The conservation of these land systems could therefore be significantly improved by further reservations of State Forest land (see below). Major improvement in the conservation of Rainshadow Valleys is not possible, however, as almost all the original area of this land system has been cleared (Appendix 4 Table 2) or logged (see Nullica State Forest and Yurammie State Forest in Appendix 10 Table 8). Coolangubra State Forest also contains the largest undisturbed area of Granitic Hinterland outside of the reserve system (3,727 ha; Appendix 4 Table 2, Appendix 10 Table 8).

Our findings are similar to those of Keith & Sanders (1988).

Forest types

Within the South-east Forest Region 33 forest types and four non-forest types (*sensu* Forestry Commission of NSW, 1989a) have been recognised (Forestry Commission of NSW, 1988, appendix 4). It is not possible to determine the extent to which these different forest types are represented in the reserve system because the areas of each Type within each Reserve and State Forest have not been calculated. However, it should not be difficult for the Forestry Commission to do this and publish the results as the Commission already has maps of forest types for the State Forests and could estimate forest types for the National Parks & Nature Reserves using Aerial Photograph Interpretation. We understand that this is already underway (D. Ridley, personal communication).

The type of forest occurring at a particular place depends on such features as soil, topography, moisture and altitude, which also define land systems (Forestry Commission of NSW, 1989a; Keith & Sanders, 1988, 1990). We therefore expect that most forest types will be concentrated within a single land system rather than spread across two or more and that the forest types associated with the poorly conserved land systems will themselves be poorly conserved.

Plant communities and vegetation associations

An analysis of the conservation status of plant communities (*sensu* Keith & Sanders, 1988, 1990) or vegetation associations (*sensu* National Parks and Wildlife Service of NSW, 1986a) potentially offers a more accurate assessment of conservation needs in the South-east Forest Region than analyses based on land systems or forest types. Keith & Sanders (1988) recognise 41 plant communities in the region as compared with 33 forest types, and their analysis is based on tree and understorey species whereas the forest types are based on tree species (Forestry Commission of NSW, 1989a). The National Parks and Wildlife Service of NSW (1986a) recognise 98 vegetation associations in the region.

Mapping of plant communities or vegetation associations is extremely time consuming and has not been carried out for any part of the South-east Forest Region. However, existing data do permit analyses of the relationship between geological and climatic variables and the distributions of plant species (e.g., Kelly & Turner, 1978), plant communities and vegetation associations. Based on these analyses and existing geological and climatic data it may be possible to accurately predict these distributions for the South-east Forest Region. It would then be possible to objectively evaluate the conservation status of plant communities and vegetation associations. Keith & Sanders (1988) have noted the importance of this further analysis for a complete assessment of regional conservation values. We expect that, as we argued above for forest types, the conservation status of vegetation types will, for the most part, reflect the conservation status of the land systems within which they occur.

We shall now consider the conservation status of the mammal, bird, reptile, amphibian and fish species known to occur in the South-east Forests Region.

Mammals

There are 48 native mammal species within the South-east Forest Region (Appendix 5 Table 3). An additional five mammal species are known or thought to have occurred within the region and are believed to now be regionally extinct (Lunney & Leary, 1988). We have done very poorly within the South-east Forest Region and throughout Australia in terms of conservation of mammal species (Lunney & Leary, 1988; Endangered Species Advisory Committee, 1989). Mammals appear to be particularly prone to extinction (Endangered Species Advisory Committee, 1989) and should therefore receive special attention in land management decisions.

The distributions and abundances of mammals within the South-east Forest Region are poorly known. For many of the Reserves and State Forests of the region there is no available information on which species are

present (Appendix 5 Table 3). For other Reserves and State Forests the presence of some mammal species may be known (Appendix 5 Table 3) but little is known about the abundances of these species. However, despite these limitations in the available data, some species appear to be more common and widespread than others. Seventeen mammal species can be considered common within the South-east Forest Region. These are the species which have so far been reported from ten or more of the Reserves and State Forests of the Region (Strahan, 1983; Appendix 5 Table 3). They include the Short-beaked Echidna, Brown and Dusky Antechinus, Long-nosed Bandicoot, Common Wombat, most of the possums and gliders, most of the large macropods, and the Bush Rat. The abundances of these species are affected by integrated logging (Tyndale-Biscoe & Smith, 1969; McIlroy, 1978; Recher *et al.*, 1980; MacKowski, 1984; Lunney, 1987; Lunney, Cullis & Eby, 1987; Recher, Shields, Kavanagh & Webb, 1987; Lunney & Leary, 1988; Lunney & O'Connell, 1988). However, with certain constraints on logging (see below), these species should remain in the logged forests.

Microchiropteran bats account for 18 of the mammal species known to occur in the region (Appendix 5 Table 3). However, because of limited surveys for bats, their distributions and abundances are very poorly known, both within the region and in general (Appendix 5 Table 3; Parnaby, 1984; Lunney & Barker, 1986a,c; Lunney, 1989). There is also very little information on the effects of logging on these species. Those species, which utilise tree hollows for roosting, will decline in abundance as a result of logging (Mackowski, 1984; Lunney, Barker & Priddell, 1985; Taylor & Savva, 1988; Lunney, Barker, Priddell & O'Connell, 1989).

The remaining 15 mammal species are relatively rare in the South-east Forest Region (Appendix 5 Table 3). Six of these species are listed as Endangered Fauna on Schedule 12 of the New South Wales National Parks and Wildlife Act, 1974 (Appendix 5 Table 3). Concern has also been expressed about the general conservation status of the Southern Brown Bandicoot (Ashby *et al.*, in press). This group of 15 species and the Microchiropteran bats warrant special consideration for conservation.

To ensure that this last combined group of species is adequately conserved within the South-east Forests Region, it will be necessary to:

- a) obtain much improved knowledge of their distribution and abundance in the region;
- b) ensure that the areas of highest density of these species are contained within reserves;
- c) better understand the effects of logging, burning and establishment of roads on the abundances of these species;
- d) manage logged and unlogged forest areas to the benefit of these species; and
- e) ensure that the effective population sizes of these species (allowing for movement between areas) are large enough to remain indefinitely viable.

Some State Forests are known to contain relatively high proportions of the 15 species of special concern (Appendix 5 Table 3). Most noteworthy in this regard is Coolangubra State Forest (6 of the 15 species).

The density of possums and gliders is estimated to be generally higher in tableland and escarpment forest than elsewhere (Braithwaite, Turner & Kelly, 1984; Margules, 1987). Consequently these areas are valuable in terms of the conservation of possums and gliders and their predators, such as the Powerful Owl (see below).

The mammal species of greatest concern for conservation are the Spotted-tailed Quoll and the Long-footed Potoroo. The Quoll may suffer from competition with foxes and cats and this competition may increase with the establishment of roads (Brunner *et al.*, 1981; Mansergh, 1983; Edgar, *in* Strahan, 1983; Saxon & Pascoe, 1989). It is apparently much less common in the South-east Forest Region than it used to be (Lunney & Barker, 1986a; D. Lunney, L. Dovey & B. Triggs, personal communication) and, during recent times, it is known within the region only from a few scats in Mumbulla, Coolangubra, Tantawangalo and Nullica State Forests and a sighting in Ben Boyd National Park (Lunney & Barker, 1986a; D. Lunney, L. Dovey & B. Triggs, personal communication; Appendix 5 Table 3). It is a carnivore at the top of the food chain and most likely requires a relatively large home range (Edgar, *in* Strahan, 1983). Its close relative, the Eastern Quoll is apparently extinct on the main-land (Caughley, 1979; Godsell, 1983). The Long-footed Potoroo is also of great concern because it is known from very few locations in Australia (one of these being in the South-east Forest Region). Its habitat requirements are poorly understood, it is affected by timber harvesting; it may suffer additional predation when roads are created nearby; its colonies are isolated and an improper fire regime may be detrimental to its numbers. (Drinnan & Hill, 1984; Hill & Triggs, 1985; Saxon & Pascoe, 1989; Scotts & Seebeck, 1989; J. Seebeck, personal communication).

The most obvious conclusion to us is that there is an urgent need for more species surveys of the South-east Forest Region and more research on the abundances and requirements of mammals in the region, especially the above group of 15 species plus the microchiropterans. The available information on mammal species does, however, contribute to conclusions and recommendations in terms of land management in the region (see below).

Birds

Birds are generally easy to observe and identifiable by many people. It is therefore surprising that there is so little available information on their distribution across Reserves and State Forests in the South-east Forest Region (Appendix 6 Table 4). General bird survey information is available only for 8 Areas (Nadgee Nature

Reserve, Tennyson Creek Flora Reserve, Watergums Creek Flora Reserve, Waratah Creek Flora Reserve, Bondi State Forest, East Boyd State Forest, Mumbulla State Forest, Yambulla State Forest). Consequently few birds are known to occur in more than 8 Areas within the region (Appendix 6 Table 4). More distributional data will be available when the results of the study by Recher *et al.* (1980) are presented separately for each Reserve and State Forest considered in the study. Additional information may also become available from the original data of the RAOU Australian Bird Count (S. Ambrose, personal communication). Special surveys have been carried out for the Powerful and Sooty Owls and, as a result of this, these species are known to occur in 10 and 16 Areas respectively (Kavanagh & Peake, 1989; Appendix 6 Table 4).

It is not possible to draw any conclusions in terms of bird species conservation from the presently available distributional data for the South-east Forest Region. Only three species are known to occur in eight or more of the Reserves and State Forests of the region (Australian Raven, Powerful Owl, Sooty Owl, see Appendix 6 Table 4). However, many species such as the Grey Fantail, are abundant and almost ubiquitous and would probably occur in all the Reserves and State Forests of the region. Based on the difficulty of finding the Powerful and Sooty Owls, these two species, though known from more areas than almost all other bird species, are exceptionally rare (Kavanagh & Peake, 1989; D. Milledge, personal communication).

Logging and burning affect the abundances of bird species (Recher *et al.*, 1980; Recher, Allen & Gowing, 1985; Kavanagh *et al.*, 1985; Smith, 1985, 1986; Recher, Shields, Kavanagh & Webb, 1987; Smith, 1989). For many species these effects disappear over a reasonable time scale (i.e., within 30 or 40 years) (Kavanagh *et al.*, 1985; Recher, Shields, Kavanagh & Webb, 1987). However, since tree hollows do not usually develop in trees that are less than about 200 years old (Mackowski, 1984), the proposed logging cycle with heavy logging every 80 to 120 years will produce a large and permanent reduction in the availability of tree hollows. Consequently, for species that require tree hollows for nesting and roosting (e.g., parrots, cockatoos, owls), logging will result in reductions in abundance that persist indefinitely. Other species that require mature forest will also be adversely affected by logging. Conservation of bird species within the South-east Forest Region therefore requires keeping some areas of mature forest free from unnatural disturbance and retaining a sufficient number of old trees within logged areas (see below).

Two bird species of particular concern are the Powerful and Sooty Owls. As mentioned above, they are very rare. Paul Peake found Powerful Owls at only 12 sites and Sooty Owls at only ten sites after 281 hours of searching for them in appropriate habitat within the South-east Forest Region (Kavanagh & Peake, 1989). After 38 survey nights covering 150 sites within Mountain Ash forests near Melbourne, Milledge (personal

communication) observed five and 26 owls respectively of these species. These species both appear to require large home ranges. Powerful Owls apparently require a minimum home range area of about 800 ha in good habitat (Fleay, 1968; Seebeck, 1976; Schodde & Mason, 1980; Kavanagh, 1988). Milledge estimates a population of 25 to 30 Sooty Owl pairs for his 1000 sq km study area with home range size thought to vary between 2 and 30 sq km depending on density of hollows for roosting and nesting and prey density.

Both species feed on prey which will be reduced in abundance by logging. Powerful Owls seem to prefer Greater Gliders and Common Ringtails (Fleay, 1944, 1968; Seebeck, 1976; James, 1980; Schodde & Mason, 1980; Van Dyck & Gibbons, 1980; Kavanagh, 1988). Adult Sooty Owls feed mostly on Common Ringtails while nestlings have been observed being mostly fed bush rats (D. Milledge, personal communication). Both owl species probably live for up to several decades and so any changes in their reproductive output could go unnoticed for a long time. Integrated logging has been occurring in the South-east Forest Region for about 20 years, which is considerably less time than the likely lifespan of these two species. Recent observations of Powerful and Sooty Owls within the Eden region were almost all made in unlogged forest (Kavanagh & Peake, 1989). Observations of Sooty Owls in Mountain Ash Forests indicate a strong association with mature stands (D. Milledge, personal communication). The prime areas for conservation of Powerful and Sooty Owls should therefore be mature forest areas where there are reasonable numbers of hollow-bearing trees. Powerful Owls appear to be most abundant in tableland and escarpment areas where arboreal marsupial densities are greatest (P. Peake, personal communication). Within the South-east Forest Region, Sooty Owls appear to be most abundant in coastal forest areas (Paul Peake, personal communication).

Reptiles

Within the South-east Forest Region 33 reptile species are known. As is the case for mammals and birds, distributional data for reptiles are not available for many of the Reserves and State Forests of the region (Appendix 7 Table 5). Nevertheless some species appear to be less widespread than others (Appendix 7 Table 5). There are, for example, relatively few Reserves and State Forests known to contain the following; Common Scalyfoot, Three-toed Skink, Grass Skink, Red-throat Skink, Southern Water Skink, Blotched Blue-tongued Lizard, Three-lined Skink, Oak Skink, Eastern Snake-necked Turtle, Striped Skink, and the Common Death Adder. The Grass Skink, though reported from few areas (Appendix 7 Table 5), is a ubiquitous species (D. Lunney, personal communication).

Integrated logging affects the abundances of reptiles with a few species becoming abundant while most species decrease greatly in numbers (H. Cogger,

personal communication; Lunney, Eby & O'Connell, 1990). Forestry practices therefore need to be modified so that these effects do not lead to drastic reductions or fluctuations in species abundances (see below; also Recher, Shields, Kavanagh & Webb, 1987; Lunney, Eby & O'Connell, 1990). Further research is necessary to determine the appropriate modifications.

The Diamond Python is the only reptile species from the region that is listed on Schedule 12 of Endangered Fauna of the New South Wales National Parks and Wildlife Act, 1974. It is primarily a species of dry and wet sclerophyll forest. Consequently, logging may adversely affect this species and forestry practices may need to be modified to ensure its long-term survival.

Frogs and fish

Fish are entirely aquatic while frogs depend on water for breeding. Consequently, logging, through its effects on stream levels (e.g., Campbell & Doeg, 1989), and sediment loads (e.g., Burgess, 1984; Campbell & Doeg, 1989), may adversely affect their populations. However, no research on these effects has apparently been carried out.

When not breeding, frogs disperse throughout the forest areas, some being terrestrial and others arboreal (H. Cogger, personal communication). Consequently, logging may also affect frogs at this time because of its effects on habitat parameters such as vegetation structure and humidity (H. Cogger, personal communication). This is another area requiring research.

Within the South-east Forest Region there are 20 known frog species (Appendix 8 Table 6). None of these is listed on Schedule 12 or 12a of Endangered Fauna of the New South Wales National Parks and Wildlife Act (1974), and none identified as warranting special concern.

There are 17 freshwater fish species known to occur within the region (Appendix 9 Table 7). One of these, the Australian Grayling, is identified by CONCOM (1988) as endangered and is known within the region only from the Tantawangalo State Forest (Appendix 9 Table 7) and the Brogo and Yowaka rivers. The New Zealand Grayling (*Prototroctes oxyrhynchus*) is a close relative and is now extinct with logging having been suggested as a contributing factor (J. Burchmore, personal communication). The Australian Grayling therefore warrants concern in terms of its conservation status within the South-east Forests Region.

As with the other vertebrate groups, many areas within the region have not yet been surveyed for frogs or fish (Appendix 8 Table 6, Appendix 9 Table 7).

Additions to the Reserve System

The present reserve system in the South-east Forest Region is inadequate because the areas of five land

systems are represented in Reserves by insufficient area (see section on land systems), forest types, plant communities and vegetation associations are predicted to be poorly represented in existing Reserves (see sections on forest types, plant communities and vegetation associations), and the Coolangubra Wilderness area is not totally included in the present reserve system (see section on Wilderness). In addition we are concerned about the long-term survival within the region of a number of species, especially the Spotted-tailed Quoll, Brush-tailed Phascogale, Long-nosed Potoroo, Long-footed Potoroo, Powerful Owl, Sooty Owl and Australian Grayling. Survival of these and other species will depend on the maintenance of large areas of prime habitat free from unnatural disturbance.

In evaluating areas for addition to the reserve system we have focussed attention on the remaining areas of old-growth forest. We assessed the conservation value of each using the following criteria (see Appendix 10 Table 8):

- a) presence of areas of above five poorly conserved land systems;
- b) presence of wilderness;
- c) records of species of concern;
- d) potential to create a link between other possible or existing Reserves or potential to expand an existing or potential Reserve, and
- e) known or predicted presence of areas of high density of arboreal marsupials and therefore likely to be prime habitat for the Powerful or Sooty Owls.

Based on this assessment the various areas of undisturbed forest differ in terms of conservation value (Appendix 10 Table 8). Of highest conservation value is the area including the unreserved parts of the nominated Coolangubra Wilderness Area (i.e., most of Coolangubra State Forest and parts of Nalbaugh and Bondi State Forests) plus the part of Coolangubra State Forest not contained within the nominated Wilderness Area. This combined area contains all of the remaining unreserved undisturbed areas of Western Flat Country and significant areas of Escarpment and Granitic Hinterland (Appendix 10 Table 8). It also contains many animal species of concern, has high densities of arboreal mammals and is contiguous with Nalbaugh National Park.

The other undisturbed areas of State Forests also have high conservation value. Glenbog, Tantawangalo and Cathcart State Forest's contain almost all of the remaining unreserved undisturbed areas of Tableland (Appendix 10 Table 8). These State Forests, along with Bemboka and Murrabrine State Forests contain significant undisturbed areas of Escarpment (Appendix 10 Table 8). Almost all of the remaining unreserved undisturbed areas of Rainshadow Valley occur in Nullica State Forest and parts of Yurammie State Forest (Appendix 10 Table 8). Yurammie State Forest is also known to contain Koala habitat (Appendix 10 Table 8).

Margules & Stein (1989) found that there is a suite of tree species not represented in the existing reserve

network. The area where these species are likely to occur includes the northern and western parts of Coolangubra State Forest, Nalbaugh State Forest, Cathcart State Forest, and parts of Tantawangalo State Forest for one group of species and the eastern part of Coolangubra State Forest, Yambulla State Forest, Towamba State Forest and Nungatta State Forest for the remaining species.

Inclusion within the reserve system of the Coolangubra Wilderness Area and the part of Coolangubra State Forest not included in this nominated area would increase the reserved area of Western Flat Country and Escarpment land systems to 3,572 ha and 5,727 ha or 14.9% and 15.4% of their total land system area respectively (Appendix 4 Table 2). There would then be little or no unreserved undisturbed areas of Western Flat Country (Appendix 10 Table 8) and so further reservation of undisturbed forest would have little effect on its conservation status. The reserved area of Granitic Hinterland would be increased to 10,405 ha representing 15.3% of total land system area. The reserved area of Rainshadow Valley and Tableland would remain unchanged. Reservation of the Coolangubra Wilderness Area and adjacent parts of Coolangubra State Forest not currently reserved would also contribute to wildlife conservation as an area known to include many species of concern (Appendix 10 Table 8) and high predicted density and diversity of arboreal marsupials (Appendix 5 Table 3, Appendix 10 Table 8). It is the only unreserved Wilderness Area in the South-east Forest Region.

For improved conservation of wildlife and wilderness in the South-east Forest Region it is therefore essential that the Coolangubra Wilderness Area and adjacent parts of Coolangubra State Forest not currently reserved be fully reserved.

Very little unreserved and undisturbed Rainshadow Valley exists (Appendix 4 Table 2, Appendix 10 Table 8). Consequently any such areas, along with appropriate buffer areas, should be reserved. In addition Rainshadow Valley areas that are not undisturbed forest should be surveyed to identify such areas that retain high conservation value and can be rehabilitated. These areas should also be reserved. This land system may never be adequately conserved.

Almost all of the unreserved and undisturbed areas of the poorly conserved Tableland land system occur in Tantawangalo and Glenbog State Forest's (Appendix 10 Table 8). We therefore recommend reservation of these areas, along with appropriate buffer areas.

With the reservation of the Coolangubra Wilderness and State Forest areas, the total reserved area of Escarpment (i.e., 5727 ha; Appendix 4 Table 2) would still be inadequate. It is not clear, however, which unreserved areas of Escarpment would best complement the existing and proposed above reserve system. We therefore recommend that the conservation values of these areas be assessed and that, based on this assessment, additional Escarpment areas be reserved.

In addition to the Coolangubra Wilderness and State

Forest areas, all of the other undisturbed forest in the South-east Forest Region has high conservation value (Appendix 10 Table 8). We therefore recommend that logging of these other undisturbed areas be postponed as long as possible while further information is obtained and alternatives are better evaluated (see below). We recommend that additional areas be added to the reserve system in accordance with their relative conservation value.

Forestry Practices within Logged Forest

Forestry practices within state forests

The Forestry Commission has already adopted the following practices that, although not all established with wildlife conservation in mind, should help to conserve wildlife values within logged forest (Forestry Commission of NSW, 1982, 1986, 1990; Harris-Daishowa (Australia), 1986a,b):

- a) logging is carried out on an alternate coupe basis with one half of the coupes to be logged during the first cutting cycle lasting about 20 years or so and the second half logged during the second cutting cycle of similar duration. This practice along with the timing of logging of each coupe (see below) could ensure that, at the end of the second cutting cycle, all ages of forest regeneration from 0 to about 40 years or so should be found within the logged forest;
- b) areas that are too steep and/or too rocky are not logged (about one third of the state forest area falls into this category);
- c) strips of vegetation are retained free from logging as Wildlife Corridors. These Corridors which are at least 100 m wide, occur mostly along watercourses or in gullies but also extend over ridges thus joining neighbouring catchments;
- d) logging is also restricted in filter strips which line any gully with a catchment of 50 ha or greater. These filter strips are 40 m wide (20 m on either side of the gully). Trees can be felled from the outer 10 m of each side of a filter strip but heavy equipment is excluded from the entire filter strip. Trees may not be felled into the gully;
- e) heavy equipment is not permitted within 5 m of any drainage line. Consequently some vegetation is retained along drainage lines;
- f) a minimum of five old hollow-bearing "habitat" trees are retained for every 15 ha of logged forest. Attempts are made to retain these trees in clumps rather than as isolated individuals. In addition some younger trees near the old trees are retained as future replacements for the old guard. These procedures may ensure that the regenerating forest contains some old trees which may provide suitable roosting, nesting or feeding habitat for animals that require such old trees;

- g) a minimum of four trees per hectare with a further three to five trees adjacent to each log dump are retained as "seed" trees. In addition the dump sites are ripped when logging is complete to reduce the effects of soil compaction. These procedures apparently encourage regeneration in the log dump areas;
- h) trees that are considered to be future sawlogs are also retained. In some areas a substantial number of trees may fall into this category. In other areas, especially those that have experienced an intense wildfire, there may be few or no future sawlogs; and
- i) also retained are trees of unacceptable (in terms of timber) species and trees which are less than 25 cm in diameter over bark at breast height or have a bole length of less than 4.9 m (Forestry Commission of NSW, 1986).

Other Forestry Commission practices which are designed to reduce fire hazard rather than in relation to wildlife conservation include the following (Harris-Daishowa (Australia), 1986a):

- a) areas to be logged are burnt between three years and one year before logging occurs;
- b) logged areas are burnt within 12 months after logging is completed;
- c) all forest areas, except regeneration that is less than 15 years old, are subject to "broad area burning" every four to seven years, and
- d) burning is mostly carried out during autumn and winter.

There has so far been almost no direct evaluation of how successful these procedures are in terms of wildlife conservation.

As indicated briefly above it is also difficult to estimate the effects of forestry practices on wildlife because there is considerable variability in the outcomes of the above procedures. The number of hollow-bearing trees may exceed five per 15 ha. The percentage of original trees that remain after logging varies from about 10% to 30% (D. Ridley, personal communication; Forestry Commission of NSW, 1990). When areas are burnt fire is generally excluded from wildlife corridors, filter strips and drainage lines (Forestry Commission of NSW, 1990; B. Brooker, personal communication) and, for the remaining areas, the goal is to remove 80% of elevated fuels, amounting to 35% of total fuels, over at least 40% of total area (D. Ridley, personal communication; Forestry Commission of NSW, 1982). Information on the average outcome and range of outcomes resulting from forestry practices is much needed in order to be able to accurately predict the effects on wildlife of these practices.

Research on the effects of logging on some animals indicates that logging has a large initial impact on species abundances (Smith, 1986, 1989; Lunney, 1987; Lunney, Cullis & Eby, 1987). To some extent these effects disappear as the forest regenerates but some species may remain rare or totally eliminated from logged forest for a long time (Loyn, 1980; Recher *et*

al., 1980; Mackowski, 1984; Kavanagh *et al.*, 1985).

The above forestry practices should help to conserve within logged forest, those species, such as possums and gliders, that require old trees and/or gullies (Recher *et al.*, 1980; Recher, Shields, Kavanagh & Webb, 1987). However, the future of other species is less certain. For example, a species that lives on dry ridges and requires forest that is a particular age, would be considerably reduced in numbers in a forest that contained ridge forest that was all either 0 or 20 years old. The Brush-tailed Phascogale may be such a species with its known habitat preferences being ridgeline dry sclerophyll forest with sparse ground cover (Cuttle, 1983). This problem would be minimised if logging of nearby coupes was staggered in time so that there was always forest of a variety of ages in any area. Maintaining some ridges free from logging would also help.

The value to wildlife of strips of natural vegetation of different width has been explored in two studies. Recher, Shields, Kavanagh & Webb (1987) found that 80 m wide or wider creek reserves of natural eucalypt forest within exotic pine plantation contained normal densities of small ground-dwelling mammals and reasonable densities of the gliders and possums except the Yellow bellied Glider. The widest creekside reserve contained more forest dependent bird species than narrower reserves (Recher, Shields, Kavanagh & Webb, 1987). For both birds and arboreal marsupials, reserve width, forest type, crown vigour, mean tree height and number of large trees were the most important factors affecting abundance (Shields & Johnson, 1983; Recher, Shields, Kavanagh & Webb, 1987).

Hence, the present wildlife corridors appear to be of adequate width for most wildlife while significant losses of wildlife will occur in the filter strips, at least in the short term. We therefore recommend that the system of filter strips be reviewed and consideration be given to modifications of it that will enhance its wildlife value.

For some species that require relatively large home ranges, both wildlife corridors and filter strips will be inadequate. Yellow-bellied Gliders, for example, change their diet seasonally (Kavanagh, 1987) and so, despite being of about the same size as other large arboreal marsupials, require much larger home ranges of about 40 to 70 ha (Henry & Craig, 1984). An area this size but only 100 m wide would be 4 to 7 km long and therefore too long and thin for efficient foraging (Recher, Shields, Kavanagh & Webb, 1987). Consequently wildlife corridors, even if they contain the range of plant species required by Yellow-bellied Gliders, are too narrow for this species (Recher, Shields, Kavanagh & Webb, 1987). We therefore recommend that wildlife corridors be expanded in areas where Yellow-bellied Gliders are known or predicted to occur. Species such as the Powerful Owl, that require even larger home ranges, may be unable to persist in logged forest and may depend, for their long-term survival, on large areas of essentially unlogged forest.

Relevant results should also be available from the

experimental logging research program carried out by the Forestry Commission of NSW in the Waratah Creek Flora Reserve. Logging was carried out in 1984, so the short-term effects of the different logging intensities should have been determined. We recommend that present results from this research be quickly made available by the Forestry Commission of NSW and included in scientific papers for subsequent publication.

Fire may have a greater impact on wildlife than logging. Large areas of forest may be subject to control burning and/or wildfires. Important ecological processes such as plant flowering, seed germination, plant survival, availability of food and shelter for animals, etc, are strongly influenced by fire season, intensity and frequency (e.g., Whelan & Muston, 1990). Fire also often exacerbates any effects of logging (Recher, Allan & Gowing, 1985; Lunney, 1987; Lunney *et al.*, 1987; Lunney, Eby & O'Connell, 1990). It is therefore essential that the Forestry Commission of NSW adopt a sophisticated fire management plan that takes these influences into account.

Taking the present Forestry Commission of NSW burning regime at face value, burning will occur too often, at too low an intensity and at the wrong season for some wildlife. Some plants are killed by fire and require up to about eight years to reach flowering age (e.g., *Banksia ericifolia*? Benson, 1985). Some plants require a hot fire to stimulate germination (e.g., *Acacia suaveolens*? Auld, 1986). Some animals are best served by conditions that occur five or more years after a fire (e.g., Ground Parrot, Jordan, 1987; Dusky Antechinus, H. Recher, personal communication). Plants and animals show strong seasonal patterns to their biology and have probably evolved in the context of predominantly summer fires. Consequently fires during other seasons will have quite different effects on their subsequent survival and reproduction than summer fires (Whelan & Muston, 1990).

The burning regime should therefore be modified to ensure the following:

- a) a reasonably high diversity of fire histories occurs across the forest areas;
- b) many areas experience fire at ten to 25 year intervals rather than four to seven years, and
- c) many areas experience hot, summer fires at long, irregular intervals.

To some extent existing conditions do contribute towards these goals. Burning in any particular area may be delayed because of wet conditions or lack of personnel. Despite control burning, hot summer fires will continue to occur. It is still necessary, however, to develop procedures and guidelines that will ensure the goals are met. It could also be necessary to use fire as a management tool in the Flora Reserves and Forest Preserves. The wrong fire regime may be extremely detrimental to the species for which these Reserves may have been established. For example, fire may affect the suitability of areas for the Long-footed Potoroo (Drinnan & Hill, 1984; Hill & Triggs, 1985; Scotts & Seebeck, 1989), so its long-term survival may depend

on establishing a proper fire regime. Further research on the effects of fire on this and other species is necessary in order for appropriate fire regimes to be developed. We recommend that such research be given high priority.

Forestry practices on private land

Because most unlogged forest occurs within State Forests, National Parks and other reserves, we have focussed, in the above analysis and discussion, on forests in these areas and on the Forestry practices carried out by the Forestry Commission of NSW. However, forest on private land within the South-east Forests Region is presently supplying 10.8% of the pulpwood logs processed by the Eden chipmill (P. Mitchell, personal communication) and much of this forest is subsequently being cleared for agriculture. The precise figure for sawlogs is not available. Furthermore, this source of timber is expected to be exhausted by the year 2021 (W. Braithwaite, personal communication). Consequently, the opportunity for identification and conservation of areas of private forest that are important in terms of wildlife values is rapidly vanishing. Since private forest generally occurs on soils that are relatively rich in nutrients, it is likely to support relatively high densities and diversities of plant and animal species, especially arboreal mammals (Braithwaite, Binns & Nowlan, 1988). This forest may therefore have high conservation value.

We therefore recommend that:

- a) communication be encouraged between private landholders and the various individuals, groups and institutions interested in wildlife conservation;
- b) private landholders be encouraged to conserve wildlife values;
- c) with the agreement of landholders, wildlife surveys of private forest be carried out; and
- d) private forest of high conservation value be protected from unnatural disturbance.

Long-term Sustainability of Timber Harvesting in the South-east Forest Region

It is widely accepted that logged forests should be managed so that an approximately constant timber yield will be available in perpetuity (Forestry Commission of NSW, 1976, 1982, 1988a). It is also recognised that such forest management may require some restructuring of the timber industry (South-east Forest Alliance, 1988, 1989; Cameron & Penna, 1989). It is therefore vital that future timber yield be predicted as accurately as possible.

Calculations concerning future timber yield can be found in Forestry Commission of NSW (1976, 1982, 1988) and Harris-Daishowa (Australia), 1986a). These calculations involve two assumptions that are not well supported. The first assumption is that, across the range of forest types within the South-east Forest

Region, the managed, logged forest will produce 3 m³ of commercially useful and harvestable timber per hectare per year. Based on this assumption and the present area of forest that has been or is planned to be logged (i.e., 200,000 ha, excluding areas within the logged forest that, for various reasons, are not logged), it is estimated that up until the year 2050 600,000 m³ of timber will be the region's annual forest increment. This annual forest increment is predicted to increase to 650,000 m³ of harvestable timber beyond the year 2050 (Harris-Daishowa (Australia), 1986b: fig.5.2).

The second assumption is that approximately 15% of future timber will be utilised for sawlogs with the remainder being used to supply pulpwood (Harris-Daishowa (Australia), 1986b: fig.5.2). Current harvesting levels (to be maintained until the year 2013) are 530,000 tonnes for pulpwood and 76,045 tonnes (i.e., 14%) for sawlogs (Forestry Commission of NSW, 1988). The estimated sawlog yield for the period 2013 till 2030 is unclear (Harris-Daishowa (Australia), 1986b: fig.5.2). Beyond the year 2030, 530,000 tonnes of pulpwood and 80,000 tonnes (i.e., 15%) of sawlogs are estimated to be harvested annually.

More accurate predictions of long-term timber yield are clearly required. These could be achieved if the following general steps are carried out:

1. Obtain growth rate data for trees as a function of species, size, nature of nearby trees, aspect, elevation and other variables.
2. Obtain data on factors which determine whether a tree grows to become suitable as a sawlog or as pulpwood.
3. Categorise logged forest area within the region on the basis of the variables shown to affect tree growth.
4. Make reasonable assumptions (these could be varied later) concerning the following:
 - a) what areas (ha) of each forest category will be heavily logged/thinned each year;
 - b) at what intervals will thinnings/heavy logging be carried out; and
 - c) what recipes will be used to determine which trees are felled and which are retained during thinning/heavy logging operations.
5. Develop a computer-simulation model in which each of the above growth categories and each age since heavy logging are considered as a separate component and which includes all the above data and assumptions.
6. Iterate the model over many years to determine whether a stable (non-oscillating) equilibrium is produced in terms of total timber yield and percentage sawlogs.
7. Adjust above assumptions until the model generates a stable equilibrium and determine the nature of the equilibrium in terms of total timber yield and percentage sawlogs.
8. Use model to further explore consequences of alternative assumptions and to locate other strategies that lead to a stable equilibrium.

Such a model could be continuously updated as better

information becomes available and would produce the best possible estimates of future timber supply. The model could predict not only the long-term yields but also the medium-term yields when all available undisturbed forest has been logged. Without such a model planning is largely guesswork and future forest management will be essentially a trial-and-error process.

We recommend that such a computer model of the logged forest of the South-east Forest Region be developed immediately and upgraded whenever possible.

Alternatives to Logging of Remaining Undisturbed Forest in the South-east Forest Region

Most of the remaining undisturbed forest in State Forests is of high conservation value. This forest is also of considerable value for human recreation and enjoyment and in one area (Tantawangalo) as a water catchment. Alternatives to logging these areas should therefore be fully explored and any increases in availability of timber should be used to enable additional undisturbed forest areas to be added to the reserve system. Logging of the remaining undisturbed forest should be postponed as long as possible and, if logging of these areas does occur, it should start in the areas of lowest conservation value.

There appears to be considerable scope for postponement of logging in the remaining undisturbed forest areas. Roughly half (i.e., 50,000 ha) of the forest that is presently planned to be logged occurs as unlogged coupes left after the first cutting cycle in areas already subject to integrated logging (Forestry Commission of NSW, 1988a; Harris-Daishowa (Australia), 1986a; South-east Forest Alliance, 1989). At the present rate of logging (about 5000 ha/year; Forestry Commission of NSW, 1988a) and, ignoring for a moment constraints on logging imposed by weather and narrow roads, this should last about ten years. After logging constraints are taken into account postponement of logging the remaining undisturbed areas might only be possible for a slightly shorter time. In any case there should be ample time for information to be gathered and alternatives to be evaluated. Commencing the second logging cycle now would require reducing the originally planned interval of about 20 years between the first and second logging cycles, but would not require abandonment of the basic idea of logging alternate coupes during each cycle.

The South-east Forest Alliance (SEFA) has made a number of suggestions for long and short-term alternatives to logging the remaining undisturbed forest areas which are included in the National Estate. In the latest proposal (South-east Forest Alliance, 1989) SEFA seeks exclusion of logging from a total of 60,000 ha of State Forest, made up of large sections of Coolangubra, Bondi, Nalbaugh, Tantawangalo/Glenbog and Nullica State Forests. These areas all have high conservation value (Appendix 10 Table 8).

The suggestions of SEFA include the following:

- a) establishment of eucalypt plantations on cleared farmland, and
- b) commence the harvesting of thinning and trees that were retained as future sawlogs in about the year 2000 rather than in about 2010 as presently planned.

These suggestions of SEFA have not been well considered. Pryor (1989), in reviewing the SEFA proposal, focuses largely on eucalypt plantations and does so inadequately. He asserts, without presenting supporting evidence, that the minimum annual rainfall for eucalypt plantations is 850 mm rather than 800 mm as assumed by SEFA (1989). He states, without describing his methods of calculation or presenting his data, that the total area within the South-east Forest Region that is suitable for eucalypt plantations is 12,000 ha as compared with the SEFA estimate of 14,000 ha (SEFA). He presents some data on growth rates in eucalypt plantations and deduces that timber yields from these plantations would average about 15 m³ per hectare per year using present plant stock and technology but could possibly be about 30% higher with improved stock and technology. The figure of 20 m³ per hectare per year assumed by SEFA may therefore be slightly optimistic but is within the realms of possibility. Pryor's (1989) basic conclusion is that the claims by SEFA are overly optimistic. He might be correct but he has not so demonstrated.

The Pryor Report (1989) is also inadequate in terms of assessing the consequences of pursuing the SEFA suggestions. Pryor (1989) asserts that timber mills will be closed and jobs will be lost. However, he presents no supporting evidence or calculations. The extent to which the SEFA suggestions would reduce or eliminate job losses is therefore unclear. Pryor (1989) does not evaluate the consequences of earlier than planned logging of the regrowth forest.

The high conservation values of much of the remaining undisturbed forest areas warrant a comprehensive and detailed evaluation of suggestions such as those made by SEFA (1989). The Pryor Report (1989) indicates that these suggestions, if followed, could lead to increased future timber yields. We recommend that such an evaluation be carried out.

Biological Conservation of the South-east Forests: Report of The Joint Scientific Committee (1990)

In June 1989 the New South Wales and Commonwealth Governments established The Joint Scientific Committee (JSC) to consider Biological Conservation of the South-East Forests. The report of this committee was published in July 1990 (Joint Scientific Committee, 1990). Since the subject of this report is similar to that in the present review we shall summarise and discuss the approach and conclusions reached by the Committee.

The Committee carried out the following steps in order to assess the adequacy of conservation within a region that was larger than but included the South-east

Forest Region, as defined in the present report. The region was first divided into grid cells, each 750 m x 750 m, which were then grouped into "environmental domains" based on similarity in the abiotic attributes of climate, terrain and soil. The species composition of each domain was then determined, thus allowing an assessment of the correlation between the abiotic classification and species distributions. Finally, the Committee determined the extent to which the various domains occur inside and outside of existing reserves and derived maps of areas that would have to be added to the Reserve System in order to satisfy certain conservation criteria.

This approach is, however, both subjective and indirect. There are a number of alternative mathematical methods for assessing the degree of similarity between grid cells and for aggregating the cells into groups (Joint Scientific Committee, 1990). The ultimate number of groups is arbitrary (Joint Scientific Committee, 1990). The methods adopted and the number of groups must be decided subjectively. The approach is indirect in that it assumes a strong correlation between the abiotic attributes of the domain and the patterns of distribution and abundance of animal and plant species. Such a correlation exists (Joint Scientific Committee, 1990) but its strength is unclear.

The Committee recommendation that its "environmental domain analysis should be the primary guide to identify additional areas for reserves" is therefore unjustified. Other useful approaches include the use of Land Systems as in the present study (see also Keith & Sanders, 1988, 1990) and the mapping of plant communities as is presently being carried out by staff of the NSW National Parks and Wildlife Service (D. Keith, personal communication)

In assessing the adequacy of conservation and the need for more reserves the Committee considers that:

- a) a conservation strategy should reserve a representative sample of all environmental domains and their dependent plants and animals;
- b) an optimal national strategy should provide for a small number of large reserves, a network of medium-sized regional reserves, and a large number of small local reserves;
- c) a reserve system should maintain continuity of habitats along environmental gradients, and
- d) design of reserve system should take advantage of opportunities to locate reserves within a matrix of managed forest.

These principles agree generally with ours (see above) but, as stated, are imprecise and need quantification to be useful. It is not clear, for example, what is meant by "representative sample", "small number", "large", or "continuity of habitats".

The Committee considers six related rules for establishing a reserve system. According to these rules the amount of each environmental domain that lies within the reserve system should be at least 5, 10 or 20% of the area available and the minimum reserved area should be either 10 km² (i.e., 1000 ha) or 20 km²

(i.e., 2000 ha). All rules assume that the existing reserves form the basis for any additions to the system. The Committee does not differentiate between areas that are essentially unlogged versus areas that have been logged or cleared. In the context of reservation of the domains, the Committee notes that "a 5 per cent target has often been proposed as an acceptable minimum". Though not stated, the Committee appears to adopt this figure as its minimum for adequate reservation of the environmental domains.

From a consideration of the above rules the Committee concludes that "further reservation is needed to achieve adequate representation of biophysical environments and associated plants and animals in the Eden region". The Committee does not, however, attempt to delineate areas for addition to the reserve system. Instead it presents "indicative" maps which show the areas that would have to be added to the System to satisfy some of the above rules.

The Committee also considers that there "is no scientific evidence that current management practices will result in the extinction of any organism, either plant or animal" and concludes that "it is possible to harvest the forest and maintain an appropriate age series and canopy structure so that conservation values of the forest will not be impaired". However, neither of these conclusions appear to be justified. As argued above, there is good reason to be concerned about the long-term survival of the South-east Forest Region of some species, especially those at the top of the food chain such as Powerful Owl, Sooty Owl and Spotted-tailed Quoll. Unless adequate areas are reserved free from the effects of logging and other unnatural disturbances and logging is carried out in ways compatible with wildlife conservation, some species may indeed become extinct within the Region (Jenkins & Recher, 1990).

Land-use and Land-management Decisions in the South-east Forest Region

Land-use and land-management decisions affecting the South-east Forest Region have never been based on adequate information. Even today our knowledge of the distribution and abundance of plant and animal species and vegetation types is poor (see above).

Past land-use decisions and their justification are poorly documented. Likewise available documentation provides little justification for the location and extent of Flora Reserves and Forest Preserves and no discussion of the adequacy of these Reserves. Furthermore, available documentation relating to the National Estate, while extolling the virtues of the areas listed, provides little indication of which values warrant protection in different parts of the National Estate, no justification for the boundaries and no comparisons with areas not listed (Australian Heritage Commission, 1989).

Land-management decisions are somewhat better documented. The policies and procedures of the Forestry Commission, along with their justification, are available

in reasonable detail (Forestry Commission of NSW, 1976, 1982, 1988a, 1990). Plans of Management are being developed for the National Parks and Nature Reserves of the region by the National Parks and Wildlife Service in conjunction with Management Committees. The preparation of these plans has been scheduled for 1989/90 for the following reserves (J. Starling, personal communication): Bournda Nature Reserve, Nadgee Nature Reserve, and Wadbilliga National Park. No specific schedule has been established for the other reserves in the South-east Forest Region.

There has been and still is little opportunity for interested parties to comment on land-use and land-management proposals. There has been no apparent solicitation of comment on proposals for establishment of National Parks and Flora Reserves. In addition, comments are not generally sought with regard to Regional Plans of Management prepared by the Forestry Commission.

At present comments on proposals are sought and evaluated in only three contexts with respect to the South-east Forest Region, namely Environmental Impact Statements, National Parks & Wildlife Service (NPWS) Plans of Management, and proposed listing of areas by the Australian Heritage Commission on the Register of the National Estate. The Draft Plans of Management for National Parks are placed on public display for periods during which comments are invited. The Plans and the comments are then considered by the Service and the NPWS Advisory Council. This Advisory Council, which includes representatives from a variety of interests, subsequently recommends revised Plans to the Minister for the Environment. The Minister may approve the Plans, which then become legally binding documents, or request further modification of them. Similar systems could be of considerable value in the development of other land-use and land-management proposals.

Comments can also be made on proposals when an Environmental Impact Statement is required. The procedures associated with these EIS's are reasonably well known and will not be described here. However, it should be mentioned that, by its nature, an EIS does not deal evenly with all land-areas within a region nor with all alternative land-use and land-management options. In other words, it is an inherently biased document. The EIS's prepared in connection with logging in the South-east Forest Region are no exceptions to this generalisation.

Comments are also solicited with regard to proposed listing of areas by the Australian Heritage Commission on the Register of the National Estate. The Commission receives nominations for areas to be listed, then announces the boundaries of proposed areas in newspapers and, at the same time, invites objections to the proposed listing. In the case of places which are subject to objection, the Commission engages outside consultants to evaluate the proposed listings along with the objections. The Commission receives reports from these consultants and then decides whether or not to list the areas on the Register.

However, available documentation from the

Commission does not facilitate critical appraisal of its decisions or how they are reached. The original nomination submission regarding an area and the Commission's summary report invariably describe a number of virtues of the area. However, this description is generally subjective and without supporting quantitative information, these documents generally contain no comprehensive comparison between the nominated area and other areas, no information on the nature of any objections is available, the general methods used by the Commission in making its decisions are not clear, and there is no account of how each individual decision is reached.

As steps towards remedying the above problems we recommend the following:

- a) in depth surveys and estimates of resources within the South-east Forest Region (and other regions) (including wildlife, timber, agricultural, cultural, aesthetic and recreational);
- b) increased research on the consequences of alternative land-use and land management decisions (research to-date provides a good indication of areas warranting further attention);
- c) establishment of improved procedures for the preparation of supporting documentation in association with proposals for National Parks, Flora Reserves and National Estate Listing;
- d) consideration by the NPWS Advisory Council of proposed additions to the National Park system;
- e) establishment of similar Advisory Councils for the Forestry Commission and other similar Government Bodies;
- f) establishment of procedures for the preparation of documentation concerning the deliberations of the various Government Bodies regarding environmental decisions and/or recommendations and the deliberations of their Advisory Councils;
- g) establishment of improved procedures whereby comments on proposals can be solicited and evaluated, and
- h) establishment of procedures whereby competing proposals can be compared and combined.

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Glossary

- Forest type* – any group of tree-dominated stands which possess a general similarity in composition and character, includes in broad terms other vegetation types which lack a tree cover (Forestry Commission of NSW, 1989).
- Filter strip* – strip of permanent vegetation at least 20 m wide along each side of a drainage line or banks of a stream to retard the lateral flow of runoff water, causing deposition of transported material and thereby reducing sediment movement (Harris-Daishowa (Australia), 1986a).
- Habitat tree* – a tree retained within logging coupes specifically for the nesting and roosting requirements of animal species requiring tree hollows.
- Integrated logging* – the harvesting of two or more forest products, e.g., sawlogs, mining, timber, pulpwood, etc. in a combined operation (Harris-Daishowa (Australia), 1986a).
- Land systems* – a land system is an area or group of areas, throughout which there is a recurring pattern of topography, soils and vegetation (Christian (1952) in Keith & Sanders, 1988).
- Plant communities* – a group of plants having a characteristic species composition and relative abundance.
- Population biology* – changes in the size and structure of a population (of a particular species) in response to interactions with its environment.
- Reserve system* – all areas classified as either National Park, Nature Reserve, State Recreation Area, State Forest Flora Reserve, Forest Preserve which are reserved from timber utilisation.
- Seed tree* – tree retained within a logging coupe after harvesting operations to provide a seed source for regeneration.
- Selective logging* – a system of logging whereby primarily only the trees suitable for sawlogs are taken.
- Vegetation associations* – a series of climax plant communities which have: i. the same structural characteristics, ii. the same species as dominants in the uppermost stratum, and iii. possibly different floristic composition in lower strata (National Parks & Wildlife Service, 1986a).
- Wilderness* – an area of land approximately 20,000 to 25,000 ha in size with its biological communities not substantially modified by humans or their works, or which can be rehabilitated to approximately its natural state and which can be managed to retain its natural state.
- Wildlife corridor* – 100 m strip of forest centred on major creeks and streams to facilitate wildlife conservation

within logged areas through providing unlogged forest adjacent to the logged forest and connecting areas of unlogged forest.

References

- Ashby E., D. Lunney, J. Robertshaw & R. Harden, in press. The distribution and status of bandicoots in New South Wales. In J.H. Seebeck, P.R. Brown, R.L. Wallis & C.M. Kemper (eds). Bandicoots and Bilbies. Surrey Beatty & Sons, Sydney.
- Auld, T.D., 1986. Population dynamics of the shrub *Acacia suaveolens* (Sm.) Willd.: Fire and the transition to seedlings. Australian Journal of Ecology 11: 373–385.
- Australian Heritage Commission, 1989. Value Tables for Coolangubra, Tantawangalo and Yowaka National Estate Places. Australian Heritage Commission, Canberra.
- Bennett, A.F. & B.J. Baxter, 1989. Diet of the Long-nosed Potoroo, *Potorous tridactylus* (Marsupialia: Potoroidae) in south-western Victoria. Australian Wildlife Research 16: 243–271.
- Benson, D.H., 1985. Maturation periods for fire-sensitive species in Hawkesbury Sandstone vegetation. Cunninghamia 1: 339–341.
- Braithwaite, L.W., 1983. Studies of the arboreal marsupial fauna of eucalypt forests being harvested for woodpulp at Eden, New South Wales. I. The species and distribution of animals. Australian Wildlife Research 10: 219–230.
- Braithwaite, L.W., M.L. Dudzinski & J. Turner, 1983. Studies of the arboreal marsupial fauna of eucalypt forests being harvested for woodpulp at Eden, New South Wales. II. Relationships between the fauna density, richness and diversity. Australian Wildlife Research 10: 231–247.
- Braithwaite, L.W., M. Clayton, L. MacLean & B.S. Parker, 1984. Vertebrate fauna of a 144-ha water catchment within eucalypt forest being harvested for woodpulp at Eden, south-eastern New South Wales. CSIRO Technical Paper No. 35. CSIRO, Australia.
- Braithwaite, L.W., J. Turner & J. Kelly, 1984. Studies of the arboreal marsupial fauna of eucalypt forests being harvested for woodpulp at Eden, New South Wales. III. Relationships between faunal densities, eucalypt occurrence and foliage nutrients and soil parent materials. Australian Wildlife Research 11: 41–48.
- Braithwaite, L.W., D.L. Binns & D. Nowlan, 1988. The distribution of arboreal marsupials in relation to eucalypt forest types in the Eden (N.S.W.) Woodchip Concession Area. Australian Wildlife Research 15: 363–373.
- Broadbent, J.A., 1987. Proposal for a national park on the escarpment and tablelands of the south coast of New South Wales with particular reference to the Tantawangalo Catchment. Report to the Tantawangalo Catchment Protection Association.
- Brunner, H., P.L. Stevens & J.R. Backholder, 1981. Introduced mammals in Victoria. Victorian Naturalist 98: 5–17.
- Burgess, J.S., 1984. Sediment yield change following clearfell logging and wildfire in dry sclerophyll forest in south-east New South Wales. Occasional Paper No. 45. Department of Geography, University of New South Wales at Royal Military College, Duntroon.
- Cameron, J.I. & I.W. Penna, 1988. The Wood and the Trees: A Preliminary Economic Analysis of a Conservation-Oriented Forest Industry Strategy. Australian Conservation

- Foundation, Victoria.
- Campbell, I. & T.J. Doeg, 1989. Impact of timber harvesting and production on streams: a review. *Australian Journal of Marine and Freshwater Research* 40: 519–539.
- Caughley, J., 1979. Native Quolls and Tiger Quolls. Pp. 45–48. In C. Haigh (ed.). *Parks and Wildlife Endangered Animals of New South Wales*. New South Wales Government, Sydney.
- Christian, C.S., 1952. Regional land surveys. *Journal of the Australian Institution of Agriculture Science* 18: 140–146.
- Cuttle, P., 1983. The Brush-tailed Phascogale *Phascogale tapoatafa*. In R. Strahan (ed.). *The Australian Museum Complete Book of Australian Mammals*. Angus & Robertson, Sydney.
- Davey, S.M., 1984. Habitat preferences of arboreal marsupials within a coastal forest in southern New South Wales. Pp 509–516. In A.P. Smith & I.D. Hume (eds). *Possums and Gliders*. Australian Mammal Society, Sydney.
- Dovey, L., 1987. Use of databases, indirect survey and predictive techniques in the discovery of the Long-footed Potoroo in N.S.W. Abstract of the 33rd Scientific Meeting of the Australian Mammal Society, p.16.
- Drinnan, A.N. & F.A.R. Hill, 1984. A study of the distribution and habitat of *Potorous longipes* in East Gippsland, Victoria. *Forests Commission Victoria* (Unpublished). Research Branch Report 248.
- Edgar, ?., 1983. The Spotted-tail Quoll *Dasyurus maculatus*. Pp. 18–19. In R. Strahan (ed.). *The Australian Museum Complete book of Australian Mammals*. Angus & Robertson, Sydney.
- Endangered Species Advisory Committee, 1989. *An Australian National Strategy for the Conservation of Species and Habitats Threatened with Extinction*. Draft for public comment. Australian National Parks and Wildlife Service, Canberra.
- Fleay, D., 1944. Watching the Powerful Owl. *Emu* 44: 97–112.
- Fleay, D., 1968. *Nightwatchmen of Bush and Plain*. Jacaranda Press, Brisbane.
- Forestry Commission of New South Wales, 1976. *Indigenous Forest Policy*. Forestry Commission of New South Wales, Sydney.
- Forestry Commission of New South Wales, 1982. *Eden Native Forest Management Plan*. Forestry Commission of New South Wales, Sydney.
- Forestry Commission of New South Wales, 1986. *Code of Logging Practices for the Eden Region*. Forestry Commission of New South Wales, Sydney.
- Forestry Commission of New South Wales, 1988. *Forestry Operations in Eden Management Area*. Environmental Impact Statement. Forestry Commission of New South Wales, Sydney.
- Forestry Commission of New South Wales, 1989a. *Forest Types in New South Wales*. Research Note No. 17. Forestry Commission of New South Wales, Sydney.
- Forestry Commission of New South Wales, 1989b. *Waratah Creek Flora Reserve No. 139*. Working Plan. Forestry Commission of New South Wales, Sydney.
- Forestry Commission of New South Wales, 1990. *Forestry Operations in Eden Management Area Environmental Impact Statement*. Forestry Commission of New South Wales, Sydney.
- Godsell, J., 1982. The population ecology of the Eastern Quoll *Dasyurus viverrinus* in southern Tasmania. In M. Archer (ed.). *Carnivorous Marsupials*. Royal Zoological Society of New South Wales.
- Harris-Daishowa (Australia), Pty Ltd, 1986a. *Draft Environmental Impact Statement for the Eden (New South Wales) Export Woodchip Operation for the period 1989–2009*. April 1986 Harris-Daishowa (Australia), Pty Ltd, Eden.
- Harris-Daishowa (Australia), Pty Ltd, 1986b. *Final Environmental Impact Statement for the Eden (New South Wales) Export Woodchip Operation for the period 1989–2009*. December, 1986. Harris-Daishowa (Australia), Pty Ltd, Eden.
- Helman, P.M., A.D. Tones, J.J.J. Pigram & J.M.B. Smith, 1976. *Wilderness in Australia, Eastern New South Wales and South-eastern Queensland*. A Report to the Dept. of Environment, Housing and Community and Development and New South Wales Planning and Environmental Commission. Dept of Geography, University of New England, Armidale, New South Wales
- Henry, S.R. & S.A. Craig, 1984. Diet, ranging behaviour and social organisation of the Yellow-bellied Glider (*Petaurus australis* Shaw) in Victoria. Pp. 331–341. In A.P. Smith & I.D. Hume (eds). *Possums and Gliders*. Australian Mammal Society, Sydney.
- Hill, F.A.R. & B.E. Triggs, 1985. *Ecology and distribution of the Long-footed Potoroo (Potorous longipes) – a second preliminary examination*. Research Branch Report 310, State Forests and Lands Service, Victoria (unpublished).
- James, J.W., 1980. Food of the powerful owl *Ninox strenua* in Southeastern Queensland. *Emu* 80: 34–35.
- Jenkins, B. & H.F. Recher, 1990. *Conservation of the Eucalypt Forests in the Eden Region in South-east New South Wales*. University of New England, Department of Ecosystem Management Report.
- Joint Scientific Committee on South-east Forests, 1989. *Interim Report to Senator The Hon. Peter Cook, Minister for Resources, Parliament of the Commonwealth and The Hon. Ian Causley, M.P., Minister for Natural Resources*, New South Wales. Canberra.
- Jordan, R., 1987. *The Ground Parrot in Barren Grounds Nature Reserve*. In Barren Grounds Bird Observatory and Field Studies Centre Report 1984-86. R.A.O.U. Report No. 27, R.A.O.U. Melbourne.
- Kavanagh, R.P., 1984. Seasonal changes in habitat use by gliders and possums in south-east New South Wales. Pp. 527–543. In A.P. Smith & I.D. Hume (eds). *Possums and Gliders*. Australian Mammal Society, Sydney.
- Kavanagh, R.P., 1987. Forest phenology and its effect on foraging behaviour and selection of habitat by the Yellow-bellied Glider *Petaurus australis* Shaw. *Australian Wildlife Research* 14: 371–384.
- Kavanagh, R.P., 1988. The impact of predation by the powerful Owl, *Ninox Strenua*, on a population of the greater glider *Petauroides volans*. *Australian Journal of Ecology* 13: 445–450.
- Kavanagh, R.P. & P. Peake, 1989. Unpublished progress report to World Wildlife fund on survey of Powerful and Sooty Owls in south-east New South Wales.
- Kavanagh, R.P., J.M. Shields, H.F. Recher & W.G. Rohan-Jones, 1985. Bird populations of a logged and unlogged forest mosaic at Eden, New South Wales. Pp. 273–281. In A. Keast, H.F. Recher, H. Ford & D. Saunders (eds). *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management*. Royal Australasian Ornithologists Union, Sydney, 304 pp.
- Keith, D.A. & J.M. Sanders, 1988. *Analysis of Vegetation Patterns and Environment in the Eden Region, New South Wales, South-Eastern Australia*. New South Wales National

- Parks and Wildlife Service Report.
- Kelly, J. & J. Turner, 1978. Soil nutrient – vegetation relationships in the Eden area, N.S.W. 1. Soil nutrient survey. *Australian Forestry* 41(2): 127–134.
- Lunney, D., J. Barker & D. Priddell, 1985. Movements and day roosts of the Chocolate Wattled Bat *Chalinolobus morio* (Gray) (Microchiroptera: Vespertilionidae) in a logged forest. *Australian Mammalogy* 8: 313–317.
- Lunney, D., E. Ashby, J. Grigg & M. O'Connell, 1986a. Food availability and habitat selection of *Sminthopsis leucopus* (Gray) (Marsupialia: Dasyuridae) in logged forest on the south coast of New South Wales. *Australian Mammalogy* 9: 105–110.
- Lunney, D. & J. Barker, 1986a. Survey of reptiles and amphibians of the coastal forests near Bega, New South Wales. *Australian Zoology* 22: 1–9.
- Lunney, D. & J. Barker, 1986b. Mammals of the coastal forests near Bega, New South Wales. I. Survey. *Australian Zoology* 23: 19–28.
- Lunney, D. & J. Barker, 1986c. Mammals of the coastal forests near Bega, New South Wales. II. Annotated Checklist. *Australian Zoology* 23: 41–49.
- Lunney, D., 1987. Effects of logging, fire and drought on possums and gliders in the coastal forests near Bega, N.S.W. *Australian Wildlife Research* 14: 263–274.
- Lunney, D. & E. Ashby, 1987. Population changes in *Sminthopsis leucopus* (Gray) (Marsupialia: Dasyuridae), and other small mammal species, in forest regenerating from logging and fire near Bega, New South Wales. *Australian Wildlife Research* 14: 275–284.
- Lunney, D., J. Barker & T. Leary, 1988. Movements of banded bats (Microchiroptera: Vespertilionidae) in Mumbulla State Forest near Bega, New South Wales. *Australian Mammalogy* 11: 167–169.
- Lunney, D. & T. Leary, 1988. The impact on native mammals of land-use changes and exotic species in the Bega district (New South Wales) since settlement. *Australian Journal of Ecology* 13: 67–92.
- Lunney, D., E. Ashby, J. Grigg & M. O'Connell, 1989. Diets of scincid lizards *Lampropholis quichenoti* (Dumeril & Bibron) and *L. delicata* (De Vis) in Mumbulla State Forest on the south coast of New South Wales. *Australian Wildlife Research* 16: 307–312.
- Lunney, D., J. Barker, D. Priddell & M. O'Connell, 1989. Roost selection by Gould's Long-eared Bat *Nyctophilus gouldi* Tomes (Chiroptera: Vespertilionidae) in logged forest on the south coast of New South Wales. *Australian Wildlife Research* 15: 375–384.
- Lunney, D. & T. Leary, 1989. Movement patterns of the White-footed Dunnart, *Sminthopsis leucopus* (Marsupialia: Dasyuridae), in a logged, burnt forest on the south coast of New South Wales. *Australian Wildlife Research* 16: 207–215.
- Lunney, D. & C. Moon, 1989. An ecological view of the history of logging and fire in Mumbulla State Forest on the south coast of New South Wales. In K. Frawley & N.M. Semple (eds). *Australia's Ever Changing Forest*. Special Publication No 1. Department of Geography and Oceanography. Australian Defence Force Academy: Canberra.
- Mackowksi, C.M., 1984. The ontogeny of hollows in blackbutt (*Eucalyptus pilularis*) and its relevance to the management of forests for possums, gliders and timber. Pp. 553–567. In A.P. Smith & I.D. Hume (eds). *Possums and Gliders*. Surrey Beatty & Sons, Sydney.
- Mansergh, I., 1983. The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia, with particular reference to Victoria. *Australian Zoologist* 21(2): 109–122.
- Margules, C.R., 1987. The Wog Wog Habitat Patch Experiment: Background, Objectives, Experimental Design and Sample Strategy. CSIRO Division of Water and Land Resources Technical Memorandum 85/18.
- Margules, C.R., 1987. Predicted Densities of Arboreal Mammals. Unpublished Research Results. CSIRO, Division of Wildlife and Ecology.
- Margules, C.R., A.O. Nicholls & R.L. Pressey, 1988. Selecting networks of reserves to maximise biological diversity. *Biological Conservation* 43: 63–76.
- Margules, C.R. & J.L. Stein, 1989. Patterns in the distributions of species and the selection of nature reserves. An example from *Eucalyptus* forests in south-eastern New South Wales. *Biological Conservation* 50: 219–238.
- McIlroy, J.C., 1978. The effects of forestry practices on wildlife in Australia: a review. *Australian Forestry* 41: 78–94.
- National Parks and Wildlife Service of New South Wales, 1986a. Eden (New South Wales) Export Woodchip Operation 1989-2009. Environmental Impact Statement (Draft). Harris-Daishowa (Australia) Pty Ltd. NPWS of New South Wales, Sydney.
- National Parks and Wildlife Service of New South Wales, 1987. Assessment Report on the Adequacy of Parks and Reserves in the Eden Woodchip Area. Unpublished Report.
- National Parks and Wildlife Service of New South Wales, 1989. Assessment Report on Proposed Coolangubra and Genoa Wilderness Areas. NPWS Feb. 1989.
- Parnaby, H., 1984. A Review of the Significance of the Bat Fauna of Rainforest and Association Eucalypt Forest in New South Wales. National Parks and Wildlife Service Report.
- Pryor, L.D., 1989. An Assessment of the South-east Forests Economic Package to Protect the National Estate and Jobs Proposed by the South-east Forest Alliance.
- Recher, H.F., S.S. Clark & D. Milledge, 1975. An Assessment of the Potential Impact of the Woodchip Industry on Ecosystems and Wildlife in South-Eastern Australia. Australian Museum; Technical Report 75/1.
- Recher, H.F., 1976. An Interim Report: The Effects of Woodchipping on Wildlife at Eden. Dept. of Environmental Studies, Australian Museum; Technical Report 76/3.
- Recher, H.F., D. Allen & G. Gowing, 1985. The impact of wildfire on birds in an intensively logged forest. In A. Keast, H.F. Recher, H. Ford & D. Saunders (eds). *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation, Management*. R.A.O.U. and Surrey Beatty & Sons, Sydney.
- Recher, N.F., W. Rohan-Jones & P. Smith, 1980. Effects of the Eden Woodchip Industry on Terrestrial Vertebrates with Recommendations for Management. Forestry Commission of New South Wales. Research Note No. 42.
- Recher, H.F., J. Shields, R. Kavanagh & G. Webb, (1987). Retaining remnant mature forest for nature conservation at Eden, New South Wales: a review of theory and practice. Pp. 177–194. In D. Saunders, G.W. Arnold, A.A. Burbridge & A.J.M. Hopkins (eds). *Nature Conservation. The Role of Remnants of Native Vegetation*. Surrey Beatty & Sons Pty Ltd, Sydney.
- Reed, P. & D. Lunney, 1990. Habitat loss: the key problem for the long-term survival of Koalas in New South Wales. In L. D. Lunney, C. Urguhart & P. Reed (eds). *Koala Summit. Managing Koalas in New South Wales*. NPWS of New South Wales, Sydney.

- Saxon, M.J. & C.G. Pascoe, 1989. Report of Surveys for Long-footed Potoroos *Potorous longipes*, in the Sheep Station Creek Area, Bondi State Forest, South-eastern New South Wales. Unpublished Report to National Parks and Wildlife Division. Victorian Dept. of Conservation, Forest and Lands.
- Schodde, R. & I.J. Mason, 1980. Nocturnal Birds of Australia. Lansdowne, Melbourne.
- Scotts, D.J. & J.H. Seebeck, 1989. Ecology of *Potorous longipes* (Marsupialia: Potoroidae), and preliminary recommendations for management of its habitat in Victoria. Arthur Rylah Institute of Environmental Research Technical Report Series No 62.
- Seebeck, J.H., 1976. The diet of the Powerful Owl *Ninox strenua* in Western Victoria. *Emu* 76: 167-170.
- Shields, J. & I. Johnson, 1983. Pine forest, farms and fauna: wildlife on intensively managed land. Pp. 20-29. In *Forest and Timber* 19, 1. Forestry Commission of New South Wales, Sydney.
- Smith, P.J., 1984. The forest avifauna near Bega, New South Wales. I. Differences between forest types. *Emu* 84: 200-210.
- Smith P.J., 1985. Effects of intensive logging on birds in *Eucalyptus* forest near Bega, New South Wales. *Emu* 85: 15-21.
- Smith P.J., 1986. Woodchip logging and birds near Bega, New South Wales. Pp. 259-271. In A. Keast, H.F. Recher, H. Ford & D. Saunders (eds). *Birds of Eucalypt Forest and Woodlands: Ecology, Conservation and Management*. R.A.O.U. and Surrey Beatty & Sons, Sydney.
- Smith, P.J., 1989. Changes in a forest bird community during a period of fire and drought near Bega, New South Wales. *Australian Journal of Ecology* 14: 41-54.
- South-east Forest Alliance, 1988. Alternative Advice to the Minister for Resources on the Final Environmental Impact Statement On Woodchip Exports from Eden Beyond 1989.
- South-east Forest Alliance, 1989. The Peace Plan Economic Alternatives to Logging the National Estate in South-east New South Wales.
- Strahan, R., 1983 (ed.). The Australian Museum Complete Book of Australian Mammals. Angus & Robertson, Sydney.
- Switzer, M.D., J.A. Stein, J.L. Stein, H.A. Nix, K.E. Andrews & B.G. Mackey, 1989. An Environmental Classification of National Estate Places in South-east New South Wales and N.E. Victoria. A Consultative Report to the Australian Heritage Commission. Centre for Resource and Environmental Studies, Australian National University, Canberra.
- Taylor, R.J. & N.M. Savva, 1988. Use of roost sites by four species of bats in State forest in South-Eastern Tasmania. *Australian Wildlife Research* 15: 637-645.
- Total Environment Centre, 1985a. Coolangubra National Park. Total Environment Centre, Sydney.
- Total Environment Centre, 1985b. Tantawangalo National Park. Total Environment Centre, Sydney.
- Total Environment Centre, 1986. Cathcart National Park. A Proposal for Presentation to the New South Wales Minister for Planning and Environment and Minister for Heritage, Hon Bob Carr, M.P. Total Environment Centre, Sydney.
- Tyndale-Biscoe, C.H. & R.F.C. Smith, 1969. Studies on the Marsupial Glider *Schoinobates volans* (Kerr) III. Response to habitat destruction. *Journal of Animal Ecology* 38: 651-659.
- Whelan, R.J. & R.M. Muston, in press. Fire Regimes and management in South-Eastern Australia. *Proceedings of the Tall Timber Fire Ecology Conference* 15.
- Wilderness Working Group, 1986. Report of the Wilderness Working Group to the Minister for Planning and Environment. Sydney.

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APPENDIX 1

Information relating to Tables 1-8

For Tables 2-7 inclusive the following information will assist the interpretation of the tables.

Area Number	Area and Tenure
1	Ben Boyd National Park (NP)
2	Mount Imlay NP
3	Mimosa Rocks NP
4	Nalbaugh NP
5	Nungatta NP
6	Wadbilliga NP
7	Wallaga Lake NP
8	Bermagui Nature Reserve (NR)
9	Bournda NR
10	Egan Peaks NR
11	Nadgee NR
12	Brown Mountain Flora Reserve (FR), Glenbog State Forest (SF)
13	Tennyson Creek FR, Bondi SF
14	Nunnock Swamp FR, Glenbog SF
15	Nullica FR, Nullica SF
16	Nethercote Falls FR, Nullica SF
17	Maxwells FR, Nadgee SF
18	Werrinook FR, Bemboka SF
19	Watergum's Creek FR, Nadgee SF
20	Jingera FR, Nullica SF
21	Waratah Creek FR, Coolangubra SF
22	Bondi Gulf Forest Preserve (FP), Bondi SF
23	Narrabarba Hill FP, Nadgee SF
24	Rockton FP, Bondi SF
25	Myrtle Mountain FP, Yurammie SF
26	Waalimma Mountain FP, Yambulla SF
27	Mt. Poole FP, Yambulla SF
28	Yambulla FP, Yambulla SF
29	Mt. Pericoe FP, Coolangubra SF
30	Bemboka State Forest (SF)
31	Bondi SF
32	Cathcart SF
33	Coolangubra SF
34	East Boyd SF
35	Glenbog SF
36	Mumbulla SF
37	Murrabrine SF
38	Murrah SF
39	Nadgee SF
40	Nullica SF
41	Tanja SF
42	Tantawangalo SF
43	Timbillica SF
44	Yambulla SF
45	Yurammie SF
46	Nalbaugh SF

An area is omitted from the table if no records for an area have been found.

Within any cell (Species x Area combination), if a species has been recorded from that particular area a P is used followed by a reference number (see Reference Section for Tabular Information). UP denotes an unconfirmed presence of a species recorded during survey or a published review of a species distribution. If an area has been surveyed and a species was not recorded this is denoted by NR followed by the relevant reference number. For the Status column the following abbreviations are used R = Rare, UC = Uncommon, and C = Common. If a species is on the CONCOM (Council of Nature Conservation Council Ministers) List of Australian Endangered Vertebrate Fauna the word YES is indicated. If a species is on Schedule 12 or 12A of the NSW National Parks & Wildlife Act, 1974 the relevant part of the Schedule (I, II, III,

IV) is indicated.

For Tables 3 and 8 the areas surveyed by Reference No. 18 relate predominantly to the State Forests indicated, however, parts of some National Parks or Native Reserves are included. For Table 3 Area 24 includes survey information from an area larger than the present Forest Preserve (Ref.8b). As a number of these records are likely to fall within the extension of the current reserve they were not separated in the table.

For Table 8 the Predicted Arboreal Mammal Density classifications were arrived at as follows: Areas were assigned a value of "high" or "low". The date for this classification was derived from the Margules (1987) maps of predicted arboreal mammals densities which contain 4 density classes of total arboreal mammals expressed in numbers of animals per hundred hectares. Areas on the map visually assessed to be composed predominantly of the higher density classes were classified as "high" and composed of the lower density classes as "low". It should be noted that areas classified as low might still have areas of the highest density class and vice versa.

APPENDIX 2

Reference List for Tabular Information

1. Australian Museum Specimen Data Base, 1989.
2. Bell, J.D., T.M. Berra, P.D. Jackson, P.R. Last & R.D. Sloane, 1980. Recent records of the Australian Grayling *Prototroctes maraena* Günther (Pisces: Prototroctidae) with notes on its distribution. Australian Zoology 20(3).
3. Burbidge, A.A. & R.W.G. Jenkins, (eds), 1987. Endangered Vertebrates of Australia and its Island Territories, Australian National Parks & Wildlife Service, Canberra.
4. Burchmore, J.J.. Unpublished draft fish report.
5. Braithwaite, L.W., 1983. Studies on the arboreal marsupial fauna of eucalypt forests being harvested for woodpulp at Eden, New South Wales. I. The species and distribution of animals. Australian Wildlife Research 10: 219-229.
6. Braithwaite, L.W., M. Clayton, L. MacLean & B.S. Parker, 1984. Vertebrate Fauna of a 144-ha Water Catchment within Eucalypt Forest Being Harvested for Woodpulp at Eden, South-eastern New South Wales. CSIRO Division of Wildlife and Rangelands Research Technical Paper No. 35.
7. Concom, 1987. Endangered Vertebrates of Australia and its Island Territories. Australian National Parks & Wildlife Service.
- 7b. Dovey, L., 1987. Use of databases, indirect survey and predictive techniques in the discovery of the Long-footed Potoroo in N.S.W. Abstract of the 33rd Scientific Meeting of the Australian Mammal Society, p. 16
8. Fanning, D. & K. Mills, 1989. Natural Resource Survey of the Southern Portion of Rockton Section Bondi State Forest. Forest Resource Series, No. 6. Forestry Commission of New South Wales.
- 8b. Fanning, D. & B. Rice, 1989. Natural Resource Survey of the Northern Portion of Rockton Section, Bondi State Forest. Forest Resource Series, No. 7. Forestry Commission of New South Wales.
9. Forestry Commission of New South Wales, 1984. Tennyson Creek Flora Reserve No. 14. Working Plan.
10. Forestry Commission of New South Wales, 1988. Watergums Creek Flora Reserve No. 127. Working Plan.
11. Forestry Commission of New South Wales, 1989. Waratah Creek Flora Reserve No. 139. Working Plan.
- 11b. Forestry Commission of New South Wales, 1990. Forestry Operations in Eden Management Area. Environmental Impact Statement.
- 11c. Forestry Commission of New South Wales, 1988. Forestry Operations in Eden Management Area Environmental Impact Statement.
- 11d. Harris-Daishowa (Australia), Pty Ltd, 1986. Draft Environmental Impact Statement for the Eden (New South Wales) Export Woodchip Operation for the period 1989-2009. April 1986 Harris-Daishowa (Australia), Pty Ltd, Eden.
12. Kavanagh, R.P., J.M. Shields, H.F. Recher & W.G. Rohan-Jones, 1985. Bird populations of a logged and unlogged forest mosaic at Eden, New South Wales. Pp 273-281. In A. Keast, H.F. Recher, H. Ford & D. Saunders (eds). Birds of Eucalypt Forests and Woodlands.
13. Kavanagh, R.P., 1988. The impact of predation by the Powerful Owl, *Ninox strenua*, on a population of the Greater Glider, *Petauroides volans*. Australian Journal of Ecology 13: 445-450.
14. Kavanagh R.P. & P. Peake, 1989. Survey of Powerful and Sooty Owls in south-east N.S.W. World Wildlife Fund (Australia), Progress Report. Keith, D.A. & J.M. Sanders, 1988. Analysis of Vegetation Patterns and Environment in the Eden Region, New South Wales, South-Eastern Australia N.S.W. National Parks and Wildlife Service Report.
15. Lunney, D. & J. Barker, 1986. Mammals of the coastal forests near Bega. New South Wales I. Survey. Australian Zoologist 23(2): 19-28.
16. Lunney, D. & J. Barker, 1986. Mammals of the coastal forests near Bega, New South Wales. Australian Zoologist 23(3): 41-49.
17. Lunney, D. & J. Barker, 1986. Survey of reptiles and amphibians of the coastal forests near Bega, N.S.W. Australian Zoologist 22(3): 1-4.
18. Lunney, D., L. Dovey & B. Triggs, personal communication.
19. Harris-Daishowa (Australia), Pty Ltd, 1986. Draft Environmental Impact Statement for the Eden (N.S.W.) Export Woodchip Operation for the Period 1989-2009. Harris-Daishowa (Australia), Pty Ltd, Eden. Margules, C.R., 1987. Predicted Densities of Arboreal Mammals. Unpublished Research Results, CSIRO, Division of Wildlife and Ecology.
20. National Parks and Wildlife Service (NSW), 1989.

- Wildlife Inventory Program (Atlas of NSW Wildlife). National Parks and Wildlife Service (NSW), 1989. Assessment Report on Proposed Coolangubra and Genoa Wilderness Areas.
- National Parks and Wildlife Service (NSW), 1987. An Assessment of the Adequacy of Parks and Reserves in the Eden Woodchip Agreement Area.
21. National Parks and Wildlife Service (NSW), 1974. Endangered Fauna in New South Wales. Schedule 12 and 12A.
 22. Peake, P., personal communication.
 - 22b. Royal Australasian Ornithologist's Union. Atlas of Australian Birds Project Records.
 23. Recher, H.F., W. Rohan-Jones & P. Smith, 1980. Effects of the Eden Woodchip Industry on Terrestrial Vertebrates with Recommendations for Management. Research Note 42. Forestry Commission of New South Wales.
 24. Reed, P., D. Lunney & P. Walker, in press. A 1986-87 survey of the Koala *Phascolarctos cinereus* (Goldfuss) in N.S.W. and an ecological interpretation of its distribution. In A.K. Lee (ed.). Proceedings of the 3rd Symposium on the Biology of the Koala (Melbourne, February 1988).
 25. Reed, P. & D. Lunney, in press. Habitat loss: the key problem for the long-term survival of Koalas in New South Wales. In D. Lunney, C. Urqhart & P. Reed (eds). Koala Summit. Managing Koalas in New South Wales. NPWS, Hurstville.
 26. Richardson, B.A., 1985. The impact of forest road construction on the benthic invertebrate and fish fauna of a coastal stream in southern New South Wales. Bulletin of the Australian Society of Limnology 10: 65-88.
 27. Saxon, M.J. & C.G. Pascoe, 1989. Report of Surveys for Long-footed Potoroos, *Potorous longipes*, in the Sheep Station Creek area, Bondi State Forest South-east N.S.W.
 - 27b. Smith, P., 1985. Effects of Intensive Logging on Birds in Eucalypt Forest Near Bega, New South Wales.
 28. Webb, G.A., 1981. Geographical Distribution of Reptiles and Amphibians in the Southern Eden Forestry Region WT & FRD, Forestry Commission of New South Wales Unpublished Report.
 - Wilderness Working Group, 1986. Report of the Wilderness Working Group to the Minister for Planning and Environment. Sydney.
 29. New South Wales Bird Atlas Records, 1989.

APPENDIX 3

TABLE 1: ESTIMATED AREAS OF UNDISTURBED FOREST WITHIN THE SOUTH-EAST FOREST REGION FOR STATE FORESTS

Data from page 9 of Appendix 2 FCNSW 1988 EIS (Total Areas) and from Appendix 4 Rooding & Harvesting Maps (Undisturbed Areas) See text Section 1.6.1 for explanation of method for calculating areas of Undisturbed Forest

STATE FOREST	TOTAL AREA	UNDISTURBED FOREST AREA	% OF TOTAL WHICH IS UNDISTURBED
NADGEE	23775	5481	23.1
YAMBULLA	51771	20118	38.9
EAST BOYD	20104	6303	31.4
BONDI (PART)	16436	6913	42.1
NUNGATTA	2754	2130	77.3
GNUPA	1353	1353	100
YURAMMIE	9471	3693	39
TANTAWANGALO	15667	13618	86.9
MURRAH	12207	3448	28.2
BERMAGUI	1630	224	13.7
GLENBOG (PART)	22093	14014	63.4
TANJA	875	59	6.7
NULLICA	27430	22906	83.5
COOLANGUBRA (PART)	21858	21033	96.2
MUMBULLA	8803	4065	46.2
CATHCART	4674	4396	94.1
TIMBILICA	8094	2142	26.5
TOWAMBA	1418	1418	100
MURRABRINE	7390	7295	98.7
BEMBOKA	14000	12947	92.5
GLEN ALLEN	327	141	43.1
BROADWATER	161	19	11.8
NALBAUGH (PART)	3687	3019	81.9
BRUCE'S CREEK	911	28	3.1
BOMBALA (PART)	292	70	24

APPENDIX 4

TABLE 2 (PART 1): ESTIMATED LAND SYSTEM AREAS (HECTARES) FOR EACH RESERVE, STATE FOREST AND OTHER LANDS WITHIN THE SOUTH-EAST FOREST REGION

AREA AND TENURE	LAND SYSTEM									
	COASTAL ZONE	COASTAL RANGES	RAINSHADOW VALLEYS	GRANITIC HINTERLAND	WESTERN FLAT COUNTRY	ESCARPMENT	DISSECTED MOUNTAINOUS COUNTRY	WESTERN SANDSTONE PLATEAU	TABLELAND RANGE	TABLELAND
NATIONAL PARKS										
MIMOSA ROCKS	896	3539		746						
BEN BOYD	5367	4094								
NUNGATTA					12			5081	1006	
NALBAUGH					76				3730	
WADBILLIGA (PART)						101	6383		584	
MT. IMLAY		3602							207	
WALLAGA LAKE	365	872								
SUBTOTAL	6628	12107		746	88	101	6383	5081	5527	
NATURE RESERVES										
BOURNDA		5831								
NADGEE	5813	11282								
EGAN PEAKS				1587					558	
GOURA		545								
BERMAGUI	71	747								
BELLBIRD CREEK	53									
SUBTOTAL	5937	18405		1587					558	
STATE RECREATION AREAS										
BOURNDA	1000	1305								
SUBTOTAL	1000	1305								
STATE FORESTS EXCLUDING RESERVED AREAS										
1. YAMBULLA		2403		38905	7561				1202	
2. COOLANGUBRA				3737	2329	2419			9568	
3. BONDI					2718			134	10557	1523
4. MURRABRINE						6390	474			
5. GLENBOG						2054			18275	415
6. NULLICA		21990	402	4071					321	
7. EAST BOYD	482	19622								
8. NADGEE	945	22110								
9. MUMBULLA		5937		2688					178	
10. NALBAUGH									3451	236
11. TIMBILLICA		6756		348						
12. NUNGATTA					2754					
13. CATHCART						553			3140	145
14. BEMBOKA						2845	9924		976	
15. YURAMMIE		6911	865			1055				
16. TANTAWANGALO						2649			11322	271
17. TANJA		736		139						
18. TOWAMBA		571		861						
19. BRUCE'S CREEK		911								
20. GLEN ALLEN									180	147
21. GNUPA		1353								
22. BROADWATER	161									
23. BOMBALA									292	
24. MURRAH	24	12024	61	98						
25. BERMAGUI	60	1570								
SUBTOTAL	1672	102894	1328	50847	15362	17965	10398	134	59462	2737
ABORIGINAL PLACE										
MUMBULLA		494	425	2619					41	
SUBTOTAL		494	425	2619					41	

APPENDIX 4

TABLE 2 (PART 2)

AREA AND TENURE	LAND SYSTEM									
	COASTAL ZONE	COASTAL RANGES	RAINSHADOW VALLEYS	GRANITIC HINTERLAND	WESTERN FLAT COUNTRY	ESCARPMENT	DISSECTED MOUNTAINOUS COUNTRY	WESTERN SANDSTONE PLATEAU	TABLELAND RANGE	TABLELAND
FLORA RESERVES										
MAXWELLS (8)		370								
BROWN MOUNTAIN (5)						303			651	
TENNYSON CREEK (3)									464	
JINGERA (6)		470								
WERRINOOK (14)									255	
WARATAH CREEK (2)									821	59
WATERGUMS CREEK (8)		238								
NETHERCOTE FALLS (6)		146								
NUNNOCK SWAMP (5,16)									1820	
NULLICA (6)		21								
SUBTOTAL		1245				303			4011	59
FOREST PRESERVES										
COOLANGUBRA ESCARPMENT (2,13)						1914			986	
MT. POOLE (1)				226					679	
MT. PERICOE (2)				860						
SIDLINGS SWAMP (11)		990								
MT. WAALIMMA (1)				505					110	
BONDI GULF (3)									276	174
YAMBULLA (1)				180						
ILLAWAMBRA (4)						526				
MYRTLE MTN. (15)		176				464				
ROCKTON (3)					325				325	
NARRABARBA HILL (7)		112								
SUBTOTAL		1278		1771	325	2904			2376	174
PINE PLANTATION										
BONDI									4051	9453
NALBAUGH									445	
GLENBOG									427	
COOLANGUBRA										5094
SUBTOTAL									4923	14547
TOTAL	15237	137264	1753	57570	115775	21737	16781	5215	76898	17517
OTHER LAND (PRIMARILY CLEARED)	12483	37876	107867	10470	8165	15433	1489	455	19492	50523
REGIONAL TOTAL (RT)	27720	175140	109620	68040	23940	37170	18270	5670	96390	68040
% OF RT FOR EACH LAND SYSTEM	4.4	27.8	17.4	10.8	3.8	5.9	2.9	0.9	15.3	10.8
TOTAL RESERVED AREA	13565	34843	425	6723	413	3308	6383	5081	12513	233
% OF LAND SYSTEM RESERVED	48.9	19.9	0.4	9.9	1.7	8.9	34.9	89.6	13.0	0.3
RESERVE SYSTEM INCLUDING COOLANGUBRA WILDERNESS AREA										
TOTAL RESERVED AREA	13565	334843	425	8303	2291	4753	6383	5081	22583	233
% OF LAND SYSTEM RESERVED	48.9	19.9	0.4	12.2	9.6	12.8	34.9	89.6	23.4	0.3
RESERVE SYSTEM INCLUDING ALL OF COOLANGUBRA S.F. PRESENTLY UNRESERVED PLUS THE REST OF CWA										
TOTAL RESERVED AREA	13565	34834	425	10405	3572	5727	6383	5081	25071	233
% OF LAND SYSTEM RESERVED	48.9	19.9	0.4	15.3	14.9	15.4	34.9	89.6	26.0	0.3

APPENDIX 9

TABLE 7: KNOWN RECORDS OF FISH SPECIES FOR EACH RESERVE AND STATE FOREST WITHIN THE SOUTH-EAST FOREST REGION

See text (Information relating to Tables) for explanation of the codes and columns used.

SCIENTIFIC NAME	COMMON NAME	NATIONAL PARKS	NATURE RESERVES	STATE FORESTS				CONCOM	N RESVS	N SF
		1	11	36	38	42	44			
<i>Mordacia mordax</i>	Short-headed Lamprey		P,1	P,26	P,1				1	2
<i>Anguilla australis</i>	Short-finned Eel		P,1	P,26					1	1
<i>Anguilla reinhardtii</i>	Long-finned Eel		P,1	P,26					1	1
<i>Prototroctes maraena</i>	Australian Grayling					UP,4		YES		1
<i>Retropinna semoni</i>	Australian Smelt		P,1	P,26					1	1
<i>Galaxias brevipinnis</i>	Climbing Galaxias						P,1		1	1
<i>Galaxias maculatus</i>	Common Jollytail		P,1	P,26					1	1
<i>Macquaria novemaculeata</i>	Australian Bass									
<i>Favonigobius tamarensis</i>	Tamar River Goby	P,2								
<i>Gobiomorphus coxii</i>	Cox's Gudgeon		P,1	P,26	P,1				1	2
<i>Gobiomorphus australis</i>	Striped Gudgeon		P,1						1	
<i>Hypseleotris compressus</i>	Empirefish		P,1						1	
<i>Philypnodon grandiceps</i>	Flathead Gudgeon	P,2	P,1	P,26					1	1
<i>Philypnodon</i> sp. 2	Dwarf Flathead		P,1							
<i>Pseudaphritis urvillii</i>	Congolli			P,26						1

APPENDIX 10

TABLE 8: CONSERVATION VALUE CRITERIA FOR STATE FORESTS (WITH SUBSTANTIAL AREAS OF UNDISTURBED FORESTS) WITHIN THE SOUTH-EAST FOREST REGION

All areas in hectares.

STATE FOREST (AREA)	UNDISTURBED FOREST AREA	% OF STATE FOREST AREA WHICH IS OLD GROWTH	PREDICTED POORLY CONSERVED LAND SYSTEMS ESTIMATED (AREA)	WILDERNESS	SPECIES OF CONCERN	SOURCE	DENSITY OF ARBOREAL MAMMALS	LINK ABILITY (NUMBER OF EXISTING RESERVES AREA COULD LINK OR EXPAND)
Murrabrine (7,390)	7,295	98.7	Escarpment (6,390)	Has Wilderness Qualities	Koala	24		2
Bemboka (14,000)	12,947	63.4	Escarpment (2,845)	Has Wilderness Qualities	Powerful Owl	14		2
Glenbog (22,093)	14,014	63.4	Escarpment (2,054) Tableland (415)	Has Wilderness Qualities	Koala Powerful Owl	24,25		2
Tantawangalo (15,667)	13,618	86.9	Escarpment (2,649) Tableland (271)	Has Wilderness Qualities	Spotted-tailed Quoll Koala Australian Grayling	18 24 2,4	High	1
Cathcart (4,674)	4,396	94.1	Escarpment (553) Tableland (145)	Has Wilderness Qualities	Koala Powerful Owl	24 14	High	1
Coolangubra A (14,424) Part of Coolangubra Wilderness Area (CWA)	13,934	96.6	Escarpment (1,445) Western Flat Country (1,878) Granitic Hinterland (1,623)	Most of area is part of Coolangubra Wilderness Area (CWA)	Spotted-tailed Quoll Southern Brown Bandicoot White-footed Dunnart Powerful Owl Sooty Owl Squirrel Glider	18 18 1 14 14	High	2
Coolangubra B (7,430) Not part of CWA	7,059	95.0	Granitic Hinterland (2,102) Western Flat Country (452) Escarpment (974)		See Above			2
Nalbaugh A (2,140) Part of CWA	1,904	87.6		Part of CWA			High	2
Nalbaugh B (616) Not part of CWA	181	29.4	Tableland (43)					
Nalbaugh C (913) under Bombala Management Area	—	—						
North Rockton Section of Bondi State Forest Part of CWA (2,565)	2376	92.6	Western Flat Country (829)	Approx 2500 ha of North Rockton is part of CWA	Southern Brown Bandicoot Long Footed Potoroo Platypus Powerful Owl	8,18 18,27 27 14	Low & High	2
Nullica (27,430)	22,906	83.5	Rainshadow Valleys (402) Granitic Hinterland (4071)	Has Wilderness Qualities	Spotted-tailed Quoll Brush-tailed Phascogale Platypus Powerful Owl Sooty Owl	18 22 18,20 14 14	Low	2
Yurammie (9,471)	3,693	39	Rainshadow Valleys (865) Escarpment (1519)		Koala	18,22	Low	1