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NEWS RELEASE - 25 August 93

NEFA proposes Forest Peace Plan

Details of a proposal to resolve forest conflicts in north east NSW and to ensure land use and resource allocations were undertaken in an open and balanced manner, were today released by North East Forest Alliance (NEFA).

"The divisive disputes over the use and management of public forests have gone on for too long. They can now only be solved by adopting an assessment process which environmentalists, the timber industry and the public can have confidence in as 'fair and genuine'," said spokesperson Dailan Pugh.

Mr Pugh said that to achieve a resolution of over a decade of dispute NEFA had proposed to the Fahey Government that a balanced steering committee for north east NSW be established and funded. He said the proposal met the obligations of the Intergovernmental Agreement on the Environment (IGAE), the National Forest Policy Statement (NFPS) and Agenda 21.

He said that this steering committee would:
* oversee the collation of all required natural resource data,
* establish an adequate reserve system,
* identify constraints to be applied to harvesting of forests not required for the reserve system,
* compile an accurate inventory of available timber resources,
* allocate those resources to industry with consideration of community preferences.

"The steering committee is proposed to be comprised of representatives from Federal and State government agencies, conservation groups, and the timber industry. The principal requirement is that there be equal representation from conservation interests and those who profit from resource use."

Mr Pugh said that the proposal also entailed:
* balanced panels of experts to guide the process,
* local advisory panels to ensure the wishes of local people are properly accounted for, and
* a complementary process to address Koori people's concerns.

"It's well past time that a process is adopted that is based on a full and proper scientific assessment of all interest groups' concerns. The Greiner and Fahey Governments have signed agreements to resolve forestry disputes and establish a 'comprehensive adequate and representative reserve system' but have utterly failed to implement them. We are demanding an open and transparent process.

"The Forestry Commission EIS process has failed to be impartial, open or to undertake adequate assessments. Despite these failings and its history of unlawful action, the Commission is attempting to make final decisions on forests' use. The Commission is setting the stage for decades of ongoing costly disputes and the loss of priceless old growth forests," he said.

Mr Pugh said that in 1989 then Minister for Forests, Garry West, had promised to establish a balanced committee in north east NSW, but had failed to deliver.

"We have given up waiting for the Government to develop a proper process and so have prepared this considered and detailed proposal for them. Should the Fahey Government reject this proposal they will send clear messages to the people of NSW that they will not honour their agreements, have no commitment to balanced, open or scientifically valid assessments and would rather another decade of costly, divisive and escalating disputes," Mr Pugh said.

For more information phone Dailan Pugh or John Corkill 02 299 2541

THE WAY FORWARD

SUBMISSION TO THE GOVERNMENT ON:

INSTITUTING MEANINGFUL PUBLIC PARTICIPATION IN FOREST USE AND RESOURCE ALLOCATION IN NORTH EAST NSW

Dailan Pugh
North East Forest Alliance

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1. INTRODUCTION

> *"Inappropriate allocation of land to particular land uses leads to major costs associated with degradation and associated rehabilitation and reconstruction. What we require is a proactive approach associated with a better empathy for the land"* Hobbs and Hopkins, 1990.

There is an urgent need to resolve conflicts over forest use in New South Wales to ensure that: natural values are not unduly compromised; the multiple values of forests are fully considered; and that rural communities and the people of NSW benefit from the wise use of their forests. The conflict will only be resolved when a process, in which all interest groups can have faith, is implemented in an open and accountable manner.

Current assessment processes, such as those in north-east NSW Forestry Commission Environmental Impact Statements (EISs), are not open or accountable and have been proven to be a dismal failure. There is an obligation to implement a process that minimises community conflict, ensures the establishment of the "comprehensive, adequate and representative" reserve system required by the National Forest Policy Statement (NFPS) and ensures ecologically sustainable forest management.

To help ensure community faith in the assessment of north-east NSW's forests the establishment of balanced Regional Steering Committees, regional Technical Working Groups and Bioregional Advisory Committees is advocated. For informed and objective assessments the use of computer Geographic Information Systems (GISs) offer an unprecedented ability to manipulate large quantities of data in an impartial and interactive manner.

North-east NSW is well advanced towards establishing a comprehensive GIS data base which will allow for rational and objective land use planning. There is now a need to channel the resources required into completing that data base, establishing appropriate processes for assessing the data and implementing an environmentally and socially justifiable land use plan which will progress NSW towards sustainable forest management. North-east NSW has the potential to become a model for the rest of NSW and Australia to emulate.

This submission advocates the instigation of alternative processes to resolve ongoing forest disputes and suggests means of facilitating meaningful public involvement in the allocation of public land to specific uses in an open, accountable and just process.

2. PROVIDING INCREASED OPPORTUNITY FOR PUBLIC INVOLVEMENT AND PARTICIPATION IN ENVIRONMENTAL PLANNING PROCESSES

> *"Unless all parties are willing to consult and negotiate with each other, and have a commitment to do so, it is unlikely that any mechanism or procedure could produce an outcome which is seen by all concerned to be reasonable and valid. However, there is even less chance that cooperative attitudes will emerge if the current mechanisms and procedures do not ensure that all interested parties are well informed of the issues and have time to consider them. Participants must also have confidence that their views will be heeded and that the outcome of the process will be explained to them."* House of Representatives Standing Committee on Environment, Recreation and the Arts (1993)

Public participation should be progressed from the current situation where it is often only tokenism to a situation where the public can make an informed and meaningful contribution towards forest management. This would facilitate conflict resolution and progress towards ecologically sustainable forest management. For public participation to be effective it is essential that all required information be collated and made freely available to participants.

Recent public opinion polls conducted in north east NSW have shown that the public have an overriding concern for environmental issues (Centre for Coastal Management 1992, Truyard Pty Ltd 1992, Rogers 1992). The issues of most concern are soil erosion, water quality and the survival of native plants and animals. People want more plantations, consider recreation and tourism values of forests as being important and want a greater say in how their forests are managed. Rogers (1992) found that the majority of people believe that the environment must be protected even if it costs some jobs or involves a personal financial cost, though it was evident from her survey that most people want some form of compromise.

Public participation in forest management is a complex issue fraught with many problems (e.g. Gilmour, Cassells and King 1989, Manidis Roberts Consultants 1992, King and Ingles 1993, Blakesley and Cubit 1993, pers. obs.). The most common and widespread forms of supposed public participation is by way of inviting submissions on draft documents. The establishment of consultative groups, including community representatives, is now becoming more common.

The restriction of public involvement to submissions is unsatisfactory and does not fulfil the requirements for openness and accountability. There is a widespread belief that the often considerable time spent in making submissions is wasted in that the decisions have already been made and little weight is placed upon submissions by the proponent (e.g. Manidis Roberts Consultants 1993). Problems with the submission process are:

* the proposals for which submissions are sought are often seen to have already been decided and submissions often apparently have little effect;

* issues raised in submissions are often ignored or inadequately considered by the assessor;

* public involvement is usually limited to a single event with no prior or future involvement, there is no opportunity to explain or expand upon issues raised in submissions, and often no feedback;

* most people don't have specific additional information on areas/issues and instead have to rely upon the information presented in the document (which is often limited and biased towards the proponents position);

* most members of the public have other commitments and limited time in which to make submissions, a situation exasperated by the plethora of documents on which submissions are sought; and,

* despite attempts at publicity some interested parties do not find out a document is on public display until it is too late.

Manidis Roberts Consultants (1992) undertook a study for the Forestry Commission to develop consultation processes and structures for wider community participation in Forestry Commission management. They made a number of recommendations including that "the public should participate in decision making about policies, land use and forest management" and that a state advisory committee be established.

The Forestry Commission's response (e.g. King and Ingles, 1993) to calls for increased public involvement is that it is "not appropriate to delegate decision-making power to members of the public" and to restrict public involvement to submissions, providing information and expressing opinions. There is no intention to allow the public to have any meaningful involvement in State Forest management.

The author has participated in the Dorrigo, Glen Innes and Grafton community participation processes for Forestry Commission EISs and has discussed the process with people involved in these and other committees. King and Ingles (1993) are correct when they note that some of the participants in the Community Advisory Panels (CAPs) for the Grafton and Casino/Murwillumbah EISs were dissatisfied when they were not "empowered to make ... recommendations" to the Forestry Commission and consultants. This has also been the experience in all such processes. There have been many perceived problems with the various EIS consultative processes including:

* committees/panels were often frustrated by the refusal of consultants and the Forestry Commission to take into consideration issues they raised or act on recommendations made;

* community involvement was not allowed until after the consultant's briefs had already been decided by the Forestry Commission, thereby limiting issues which could be considered;

* only limited and selective information was provided to participants, and mostly not in time to allow it to be properly considered before an issue was discussed;

* there were insufficient meetings and time at meetings to discuss issues;

* many participants had limited knowledge of issues and thus were not able to give them informed consideration;

* there was no independent facilitator (as they are chosen by the Forestry Commission); and,

* minutes of meetings were not comprehensive and were often inaccurate (with no provision for corrections).

There has been a high level of frustration with the token public participation processes instituted by the Forestry Commission which resulted in a large proportion of community representatives reluctantly withdrawing from some EIS Community Advisory Panels, such as the Grafton and Casino/Murwillumbah CAPs.

For dispute resolution processes to work it is considered essential that consultation groups be established in a non-party political manner, that they have balanced representation and that any issue a significant proportion of representatives consider important is adequately addressed. The process will be compromised should any one interest group dominate the committee.

CASE STUDIES IN COMMUNITY CONSULTATION

(i) Conondale Range Consultative Committee

In Queensland a Conondale Range Consultative Committee (Said 1993, pers. comm.) was established to reduce conflict and to achieve sound land use planning through consultation. It comprised a few representatives from each of the Queensland NPWS, Queensland Forest Service, Queensland Timber Board and Queensland Conservation Council, along with independent facilitators. The process was predicated upon a commitment by the state government to increase the size of the national park and involved a comprehensive inventory of scientific and other values, use of Geographic Information System (GIS), provision of all information to participants, decision making by consensus, preparation of a land use plan and identification of issues for further research and review. The draft plan then went through a broader public participation phase involving public meetings and submissions before being finalised by the consultative committee.

(ii) SIRO-MED

CSIRO (Cocks and Ive 1991) have developed a mediation/negotiation support system called SIRO-MED which utilises a GIS coupled with a software package called LUPIS. Nine graduated forest land uses from flora and fauna conservation through selective logging to hardwood plantation forestry are recognised. The process involves seeking stakeholders' agreement on the components of the problem, data acquisition and processing, generation and evaluation of stakeholder plans, blending and mutual adjustment of stakeholder plans and ideally a resultant balanced land use allocation plan. To date the process has only been trialed in the Batemans Bay region of NSW. A two day workshop involving conservation interests and timber production interests, including a simulated negotiating session, was held in late 1990. Participants apparently considered that it had "considerable potential as a mediation support system for assisting in the resolution of forest allocation conflicts".

3. MEETING COMMITMENTS AND RESOLVING CONFLICT

> *"decision-making on the allocation of forest resources (wood, non-wood) appears to favour a perspective that is subjective and political rather than scientific. Political decision-makers have not, in general, adopted an approach in the allocation of these resources based on ecological and environmental principles."* Davey and Norton (1990)

There are state, national and international obligations for the development of meaningful public participation processes, the establishment of "comprehensive, adequate and representative" reserve systems and the implementation of ecologically sustainable forest management (see section 5). The current EIS process is not achieving any of these goals.

The North East Forest Alliance maintains that the State and Federal Governments have not been adequately complied with agreements covering public consultation and dispute resolution. Forest disputes have been a feature of north-east NSW for 15 years, with escalation in recent years. More disputes are developing as the EIS process bungles on. There is a need for the implementation of more appropriate processes to resolve these disputes and enable NSW to progress towards ecologically sustainable forest management - stated as a primary objective of the Forestry Commission in their corporate plan.

We need to use the best information realistically attainable to design a conservation reserve system and identify various uses of, and constraints over, forests to be managed for multiple-purposes for north east NSW. This should be done in an open scientific process with allowance for public scrutiny, consideration of all the options and full awareness of any trade offs. The outcome would be to delineate the requirements for an adequate conservation reserve system and provide the timber industry with resource security.

In order to meet requirements for an ecologically sustainable and socially just future for our forests it is considered necessary to:

* design and implement an adequate, comprehensive and representative reserve system, based on ecological principles and requirements to conserve biodiversity and cultural values into our uncertain future;

* determine the relative values and appropriate allocations of forests not required for the reserve system to the most compatible uses (water catchment, timber production, tourism, bee-keeping, grazing, etc.);

* identify forests suitable for extractive uses (mining, logging) at various intensities, and land suitable for plantations, to provide current and future resource requirements in a sustainable manner;

* identify relevant management constraints and mitigation prescriptions to be applied to management of all forested lands;

* use transparent open processes, with allowance for real and meaningful public participation at both the regional and local levels, to determine land use and resource allocations; and,

* develop a interactive system that can be refined as more information becomes available or circumstances change.

3.1. LAND USE ALLOCATION

Historically NSW national parks have generally been designated over lands useless for other purposes, with emphasis placed upon scenic and recreational values and to a totally inadequate extent biological values (e.g. Hall 1988, Reed 1991, Standing Committee on Environment, Recreation and the Arts 1993). North-east NSW still does not have a comprehensive, adequate or representative reserve system.

The most fundamental issue in forestry disputes is the allocation of public forests to specific uses (e.g. Forestry Commission 1990, RAC 1992, Manidis Roberts Consultants 1992, 1993).

The reserve systems currently being proposed by the Forestry Commission's EIS process are based on the simplistic criteria of reserving 10% of broad forest groupings on Crown lands. The EISs provide an inadequate and biased data base which precludes any valid identification of reserves. The ad hoc EIS process is not rectifying the inadequacies and lack of comprehensiveness inherent in the current reserve system and thus not meeting the requirements of the NFPS.

There is a wealth of expertise and methodologies for the design of reserve systems that is being ignored (e.g. RAC 1992a, DASET 1993). There needs to be the identification of clear and valid criteria to be used in reserve selection and the collection of the required data before reserve systems can be designed with any credibility.

Land use allocation should not only delineate lands required for a "comprehensive, adequate and representative" reserve system, but should identify the values and uses of all lands and categorise them according to required constraints and permissible uses.

3.2 RESOURCE ALLOCATION

Once current and future resources available from public lands have been identified it is important that the use of those resources be for the benefit of local communities as well as the State. The present system of timber resource allocation is resulting in increasing monopolisation of public resources and the concentration of processing into fewer and more centralised facilities. This is having considerable impacts on the socio-economics of many regional communities as local mills are either bought out and their quotas transferred to other mills or local mills are denied access to resources by the Forestry Commission. To maximise the socio-economic benefits of resources to local communities it is essential that communities be allowed to have a say in, and make recommendations for, resource allocation.

3.3 COMPILING AND ASSESSING REQUIRED DATA

Computer Geographic Information Systems (GIS) provide a scientific basis from which to derive credible, impartial and justifiable conclusions - provided that they are based on adequate data. The advantage of using GISs and computer models are that they provide a means of processing large volumes of data, use stated and repeatable methodologies, enable interactive land-use allocation processes and provide baseline data that can easily be improved and updated. The establishment of a regional data base will assist in landuse evaluation and planning for north east NSW well into the future.

For north-east NSW the NPWS is in the process of establishing a comprehensive biological information base using a GIS (Ferrier, 1993). There is still an evident need for a comprehensive resource information base. It is apparent that the adequate completion of these data bases will take some time - particularly as too few resources are being directed into data collection in the required form.

Part of the current problem is the duplication of data collection between different Government agencies and the failure of agencies to share their data. To overcome this inefficiency it is recommended that the respective Government departments, according to their expertise and responsibilities, should be directed to identify significant values, compile required data layers, and develop prescriptions. For example:

* the National Parks and Wildlife Service to prepare required data layers on fauna, flora and cultural values, identify habitat and space requirements to maintain populations of rare and endangered species, identify processes threatening wildlife, and develop prescriptions.

* the Forestry Commission to prepare required data layers on current and projected timber values, disturbance histories, identify areas required and suitable for long-term timber production - including cleared land potentially suitable for plantations, identify plantations and forests in need of silvicultural treatment;

* the Department of Water Resources to prepare required data layers on water catchments, identify current and future domestic, industrial and agricultural water requirements, assess stream quality and identify stream management guide-lines;

* the Tourism Commission to prepare required data layers on recreational and tourism values, identify current and future infrastructure requirements;

* the Department of Agriculture to prepare required data layers on grazing, bee-keeping and other agricultural values, and identify current and future requirements;

* the Department of Conservation and Land Management (soil conservation) to prepare required data layers on land capability, and identify soil management guide-lines.

* the Department of Mineral Resources to prepare the required data layers on mineral resources, and identify current and future resource requirements;

* CSIRO to develop a regional climate change model.

The method should involve each agency entering all required information into computerised Geographic Information System (GIS) data bases and using this data to undertake predictive modelling to complete required data layers. The required data layers then need to be integrated into the one data base to complete modelling, generate the data layers required for final analysis and to then use the computer to manipulate data layers to determine options for land use.

It is recognised that because of the abysmal ignorance of forest wildlife, ecosystem functioning, management impacts and forest productivity that a reasonable approximation of an adequate land allocation system can only be identified with the urgency required if both the State and Federal Governments provide significant resources. Even then it must be recognised that research and monitoring will have to be ongoing and land allocations and management regularly reviewed as new information becomes available.

4. A SUGGESTED PROCESS FOR UNDERTAKING REGIONAL LAND USE AND RESOURCE ALLOCATIONS IN NORTH-EAST NSW

"In the Commission's view, an inefficiently designed and managed reserve system can become a significant cost to all sectors of society. Reserve design analysis is therefore helpful as a means of providing a rational basis for reserve creation, in contrast to the ad hoc procedures that have tended to dominate in the past." RAC (1992b)

We have it within our ability to plan our future so that it is environmentally and economically sustainable. This will entail the recognition of what the future holds if we continue on our present course, identifying adequate means to protect and enhance our environment, and implementing processes and structures that ensure that the future is environmentally, economically and socially responsible.

There are currently available appropriate technologies and processes to resolve conflicts over land use issues and to determine publicly acceptable and responsible forest land use allocation. To implement these it is considered necessary to:

(i) involve the principle stakeholder groups (e.g. conservation and timber production interests) in a balanced steering committee with an independent facilitator;

(ii) collect and process sufficient data to meet stakeholders requirements and enter all data into a GIS for analysis, making all information freely available to participants;

(iii) undertake a land use option analysis and attempt to achieve consensus on a preferred option;

(iv) undertake broad community consultation before finalising the preferred proposal; and,

(v) place a moratorium on works in areas of likely high conservation value pending the completion of the above process.

The use of balanced committees comprised of representatives of the responsible government agencies, industry and conservation groups with an independent facilitator is of broad application in overseeing many of the specific assessments required before a valid land use allocation determination can be made. The identification of interim measures to adopt should be integrated into the same process.

For the participants and the public to have faith in a process it is essential that the concerns of all interest groups are fairly assessed and taken into account. The most sure way of achieving this is to establish "balanced" steering committees, where in respect to the forest debate "balance" means equal representation from those whose prime concern is conservation and those who profit from resource use.

The advantages of restricting participation in such committees to the polarised positions on an issue are that:

* participants can be expected to be more informed on the issues involved;

* there can be a guarantee that there is a balanced representation of views and that no interest group will feel that the process is stacked against them;

* the possibility of negotiated resolution of contentious issues is more feasible; and,

* it can be expected that most of the requirements of other interest groups, which fall between the extremes, will be met.

For a process to be genuine it is essential that the principle interest groups be invited to participate and allowed to appoint their own representatives, rather than individuals being selected by a third party.

It is evident that for such a process to succeed there needs to be a requirement, by way of government direction, that a solution be achieved (Cocks and Ive 1991, Said pers. comm.). The National Forest Policy Statement (Anon 1992) provides the incentive by requiring that for public lands a "*comprehensive, adequate and representative reservation system to protect old-growth forest and wilderness values will be in place by the end of 1995*".

Land-use allocation should be undertaken on a bioregional basis (RAC 1992a, Anon 1992, Standing Committee on Environment, Recreation and the Arts 1993) with bioregions defined by a combination of environmental, biological and social attributes. The NFI, in consultation with the NPWS and Forestry Commission has identified north-east NSW as an appropriate region for planning purposes. It is agreed that north-east NSW as defined by NFI is suitable for broad land-use planning, though it is considered that there is still a need for the identification of bio-regions within north-east NSW and refinement of land-use plans on a bio-regional basis.

It is recommended that for north-east NSW a Regional Steering Committee, regional Technical Working Groups and Bioregional Advisory Panels be established to oversee the collection of all required data, its integration into a regional land-use management plan and the most appropriate allocation of resources. Data collection should primarily be the responsibility of Government agencies and should be undertaken using compatible GISs. The respective Government departments, according to their expertise, should be required to establish environmental, cultural and resource data layers.

There is an evident need to establish a distinct and complimentary process whereby Koori people can identify areas of particular significance to them and ensure they are adequately protected. It should be left to Kooris to decide the most appropriate consultation process, though there is a need for financial assistance and a confidential map based outcome that can be factored into the regional land use plan under Koori supervision.

It is considered that the Department of Planning should have the role of facilitating public land use allocation decisions in the context of regional planning, as allowed for under the EPA Act.

It is considered that if this process is adopted then within two to three years north east NSW could have in place a truly representative and viable reserve system based on the best available scientific information along with community needs. This would be the foundation for an environmentally responsible and sustainable economic future for north east NSW.

The assessment process should include all forest and rural lands, regardless of tenure. Landholders with forests identified as being appropriate or desirable for given uses should be consulted and appropriate strategies for maintaining the values of the forest identified. Private lands with significant environmental values could be purchased, identified as Environmentally Sensitive under the Protected Lands system or subjected to a Conservation Agreement. Interim measures (such as SEPP zoning) will be required to stop panic clearing. Landholders with land identified as being suitable for commercial or environmental plantings should also be consulted and those wishing to participate in plantings identified. Appropriate zoning for timber production in Local Environment Plans would provide security of tenure for plantations.

To minimise irreversible consequences of decisions made in ignorance it is essential to adopt the precautionary principle and be conservative when making decisions that threaten regional biodiversity.

4.1. REGIONAL STEERING COMMITTEE

The initial step should be to establish a Regional Steering Committee for north-east NSW. The Steering Committee should be comprised of a balanced panel representing the Commonwealth, the State and the principle forest interest groups. This committee should be of an efficient size and contain a balanced range of views.

In order to achieve balance it is suggested that single representatives be appointed by the: Department of Environment, Sport, and Territories and Department of Primary Industries and Energy to represent Commonwealth interests; National Parks and Wildlife Service, Forestry Commission of NSW, Department of Conservation and Land Management (soil conservation) and Department of Planning to represent State interests; North East Forest Alliance, North Coast Environment Council, Nature Conservation Council to represent conservation interests; and, Forest Products Association, Forest Protection Society, Construction Forestry Mining and Employees Union to represent the timber industry. An independent facilitator acceptable to all parties should also be appointed.

The Steering Committee would have ultimate responsibility for:

* designing a land use allocation plan or variety of options,
* delineating land suitable for commercial and environmental tree plantings,
* identifying long-term resource availability and requirements for the timber and mining industries,
* preparing prescriptions for wildlife, stream and soil protection, and
* ensuring that the use of public resources is in the best interests of the public.

The Steering Committee's responsibilities should include appointment of regional Technical Working Groups comprised of panel of experts in all relevant fields, the identification of the bioregions which comprise north east NSW, and the establishment of balanced Bioregional Advisory Panels representing local community interests.

In identifying the bio-regions that comprise north east NSW the Steering Committee will have to take into account ecological similarities, water catchment boundaries, existing administrative boundaries, Aboriginal cultural boundaries, and socio-economic relationships.

4.2. REGIONAL TECHNICAL WORKING GROUPS

In line with the Resource Assessment Commission's (1992a) recommendation that 'balanced panel of experts' be established in each bioregion, it is proposed that the Steering Committee oversees the appointment of Technical Working Groups (TWGs) for conservation planning, resource management and socio-economic assessment.

Under the direction of the Steering Committee the TWGs should variously have responsibility for: guiding and reviewing the assessments by the Government agencies; determining the criteria for reserve selection; identifying the social, economic and environmental costs and benefits of various scenarios; identifying future opportunities and requirements; and determining assistance, incentive and adjustment packages required to facilitate required changes.

4.2.1 Conservation TWG

The Conservation TWG should have the responsibility of identifying criteria for reserve selection, environmental protection prescriptions, and consequences of each land use and threatening process. This TWG should be comprised of experts of the highest professional standing in the fields of reserve design, wildlife research and impact assessment. It should be responsible for:

* identifying data requirements and appropriate methodologies for reserve selection,

* compiling existing information on environmental impacts of forest uses, identifying and directing further research, preparing land use management prescriptions.

4.2.2. Resource TWG

The Resource TWG should have responsibility for identifying existing resources and usage as well as future availability of resources and requirements. This TWG should be comprised of experts of the highest professional standing in the fields of soil conservation, water catchment management, forest mensuration, tourism and recreational usage. It should be responsible for:

* identifying data requirements and methodologies for adequate resource assessments,

* identification of industry and market opportunities, including the projected future of the timber and tourism industries under various scenarios.

4.2.3. Socio-economic TWG

The Socio-economic TWG should have the responsibility for determining the social and economic costs, benefits and consequences for each land use. This TWG should be comprised of experts of the highest professional standing in the fields of resource economics, social impact and structural adjustment. It should be responsible for:

* assessing the State and regional economic values of forests;

* identifying communities most dependent on logging for detailed social and economic assessment, identifying the social consequences of the proposed reserve and multiple use options on these communities and formulating appropriate structural adjustment packages;

* identifying the role for Government in facilitating new enterprises and timber-industry restructuring (financing milling and drying equipment, assisting plantation establishment, silvicultural treatment of regrowth, providing infrastructure, assisting research and development etc.);

* identifying the environmental costs of each land use in monetary terms (where possible) and establishing base prices for use of resources (i.e. royalties, agistment fees); and,

* undertaking community attitude surveys.

> ***A SUGGESTED LAND USE AND RESOURCE ALLOCATION PROCESS***
>
> *The allocation of forests to various uses should include these stages;*
>
> *(i) compilation of existing information, identification of gaps in available information and initiation of research to obtain data required;*
>
> *(ii) entering all required information into a computerised Geographic Information System and undertake appropriate analysis,*
>
> *(iii) publishing a report and maps showing data layers - geology, topography, climate, land capability, land tenure, plant communities, old-growth forest types, wilderness, cultural values, actual and predicted distribution of target species, areas required to maintain viable populations of indicator species, predicted impacts of global warming, water resources, recreational potential, grazing potential, forest productivity, forest condition, available timber resources, areas with long-term prospects for timber production, land suitable for plantation establishment, etc.;*
>
> *(iv) undertaking further surveys to validate predictions, designing options for a reserve system based on ecological criteria and identifying areas not considered necessary for the reserve system but which need to be managed under specific constraints;*
>
> *(v) production and public display of a draft report and maps showing options for forest use, this should delineate conservation reserves, multiple-use priority areas and land with potential for plantations;*
>
> *(vi) seek expressions of interest from landholders for managing parts of their lands for conservation purposes, timber production, and establishing commercial plantations;*
>
> *(vii) consideration of public submissions in finalising forest categories and publishing final report;*
>
> *(viii) publishing prospectus of available resources and commercial opportunities and seeking tenders; and,*
>
> *(ix) making tenders publicly available and inviting public submissions, giving particular weight to the preferences of local communities, before deciding allocation of resources.*

4.3. BIOREGIONAL ADVISORY PANELS

In each identified sub-region the Steering Committee should oversee the establishment of a balanced Bio-regional Advisory Panel comprised of representatives of Government agencies and community interest groups selected in a similar manner to the Steering Committee. Such advisory panels will have to have broader representation, including all principle interest groups, and need to retain the assurance that the concerns of all participants will be adequately considered.

Bio-regional Advisory Panels should have responsibility for informing the community, canvassing and seeking responses to issues, identifying community preferences for resource use, and liaising with and advising the Steering Committee. This should include open access to information by all members of the public, public display of all options and draft proposals, public meetings and consideration of public comments. This will enable the refinement of the broad land use plan to take into account more detailed information and community requirements, and ensure that the allocation of resources is in the community interest.

5. RELEVANT GOVERNMENTAL OBLIGATIONS

Aside from legal requirements, there are numerous State, Federal and international obligations for public participation, environmental assessment and ecologically sustainable development which the NSW Government has committed itself to. The current EIS process is either not or inadequately satisfying many of these obligations. It is considered that the process proposed above will meet all these obligations.

5.1 STATE OBLIGATIONS

'Meeting the Environmental Challenge, A Forestry Strategy' states:

"The NSW Government accepts the following principles as a necessary and practical for management of our State Forests:

* Decision-making must be based on a comprehensive information base covering relevant ecological, social and economic attributes of particular forest areas.

* Forests must be managed on an ecologically sustainable basis which maintains the ecosystem and provides for the interests of future generations in respect of both wood supply and environmental benefits.

* Forest management must be economically viable and efficient and must provide for a viable and efficient forest products industry.

* Decision-making must be balanced and open, and provide for public participation in the planning process.

* Forest management must be publicly accountable in ecological, social and economic terms, and responsive to evolving community concerns.

5.2 STATE-FEDERAL OBLIGATIONS

The **'National Forest Policy Statement'** (p6) gives as one of its eleven broad national goals:

" Public awareness, education and involvement. The goals are to foster community understanding of and support for ecologically sustainable forest management in Australia and to provide opportunities for effective public participation in decision making."

and states (p11):

"The Governments' agreed approach to conserving and managing old-growth forests and forested wilderness has five basic elements:

> * Third, until the assessments are completed, forest management agencies will avoid activities that may significantly affect those areas of old-growth forest or wilderness that are likely to have high conservation value.
>
> * Fourth, forested wilderness areas will be protected by means of reserves developed in the broader context of protecting the wilderness values of all lands. ... The Governments agree that, conditional on satisfactory agreement on criteria by the Commonwealth and the States, comprehensive, adequate and representative reservation system to protect old-growth forest and wilderness values will be in place by the end of 1995.

(The '**National Strategy for ESD**' on p31 reiterates these requirements.)

The '**Intergovernmental Agreement on the Environment**' (p19) states:

"The parties agree that policy, legislative and administrative frameworks to determine the permissibility of land use, resource use or development proposals should provide for -

> (i) the application and evaluation of comparable, high quality data which are available to all participants in the process;
>
> (ii) the assessment of the regional cumulative impacts of a series of developments and not simply the consideration of individual development proposals in isolation;
>
> (iii) consideration of the regional implications, where proposals for the use of a resource affect several jurisdictions;
>
> (iv) consultation with affected individuals, groups and organisations;
>
> (v) consideration of all significant impacts;
>
> (vi) mechanisms to resolve conflict and disputes over issues which arise during the process;
>
> (vii) consideration of any international or national implications."

(The '**NFPS**' on p23 reiterates these requirements)

and (p21);

"The parties agree that all levels of Government will ensure that their environmental impact assessment processes are based on the following:

> (iii) assessing authorities will provide all participants in the process with guidance on the criteria for environmental acceptability of potential impacts ...
>
> (xi) mechanisms will be developed to seek to resolve conflicts and disputes over issues which arise for consideration during the course of the assessment process."

The **'National Strategy for Ecologically Sustainable Development'** (p8) gives as one of its guiding principles:

> " decisions and actions should provide for broad community involvement on issues which affect them."

and states (p55):

"Governments will:

> encourage enhanced public involvement and awareness in the planning, management, monitoring and review of Australia's conservation values and protected areas."

and (p64):

"Governments will:

> ensure EIA processes in each jurisdiction are based on: ... public disclosure of information relating to a proposal, where this is not provided on a commercial-in-confidence basis; opportunities for appropriate and adequate public consultation; and development of conflict resolution mechanisms."

and (p104):

"Governments will:

> develop mechanisms to resolve conflicts and disputes over issues which arise during resource allocation and land use decision making
>
> investigate the potential for inclusion of non-legal conflict resolution mechanisms such as voluntary mediation"

5.3. STATE-FEDERAL-INTERNATIONAL OBLIGATIONS

'Agenda 21' states:

"8.3. The overall objective is to improve or restructure the decision-making process so that consideration of socio-economic and environmental issues is fully integrated and a broader range of public participation assured. ... the following objectives are proposed:

> (c) To develop or improve mechanisms to facilitate the involvement of concerned individuals, groups and organisations in decision-making at all levels;"

"8.21. Each country should develop integrated strategies to maximise compliance with its laws and regulations relating to sustainable development ... The strategies should include:

> (a) Enforceable, effective laws, regulations and standards ... incorporating sanctions designed to punish violations, obtain redress and deter future violations;

(d) Mechanisms for appropriate involvement of individuals and groups in the development and enforcement of laws and regulations on environment and development."

"15.6. Governments at the appropriate level, ... should, as appropriate:

(f) Collect, assess and make available relevant and reliable information in a timely manner and in a form suitable for decision making at all levels, with the full support and participation of local and indigenous people and their communities."

"27.5 Society, Governments and international bodies should develop mechanisms to allow non-government organisations to play their partnership role responsibly and effectively in the process of environmentally sound and sustainable development."

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TCO/04787

THE CABINET OFFICE

NEW SOUTH WALES

Mr JR Corkhill
Sydney Co-odinator
North East Forest Alliance
Sydney Branch Office
Suite 313, 375 George Street
SYDNEY 2000

14 SEP 1993

Dear Mr Corkhill,

The Premier has asked me to respond to your recent letter concerning the proposed establishment of a 'roundtable' to resolve disputes over forestry operations in the State forests of north east New South Wales.

The NSW Government remains committed to the principles of ecologically sustainable development, as agreed to by all Governments in the ESD Strategy. These require the integration of environmental and economic considerations in decision making. The Government considers this to be central to enhancing resource certainties for all stakeholders and reducing the unproductive conflicts often generated in debates over the use of our natural resources.

The Government is therefore willing to consider the relative merits of proposals to improve decision making processes in the interests of appropriately balancing environmental and economic imperatives.

To this end, it is proposed that NEFA meet with Government representatives on a 'no prejudice' basis to discuss the roundtable proposal. You will be aware that the Government recently announced the establishment of a Forest Policy Advisory Committee comprising stakeholder interests. It is suggested that the roundtable option be considered at this meeting in the light of this initiative.

Subject to your agreement to the proposed meeting, The Cabinet Office will make the necessary arrangements.

Yours sincerely

Roger B Wilkins
Director General
The Cabinet Office

State Office Block, Macquarie Street, G.P.O. Box 5341, Sydney 2001
Telephone: (02) 228 5555 Fax: 228 3062

GPS 820

TCO/04787

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The Revd The Hon. Fred Nile
E.D., L.Th., M.L.C.
Parliamentary Leader
Call to Australia Group
Legislative Council
Parliament House
SYDNEY NSW 2000

30 August 1993

Mr J R Corkill
Co-ordinator and
Applicant to the Court
North East Forest Alliance
Suite 313
375 George Street
SYDNEY NSW 2001

Dear Mr Corkill

I wish to acknowledge your letter dated 4 August, together with a copy of a letter from your solicitors to the Forestry Commission of NSW relating to the Dorrigo Management Area Environmental Impact Statement (EIS).

I agree that "round table" dispute mediation process is far more desirable than lengthy court cases, which only further divides our Australian society.

In fact, I would prefer to see a semi-permanent advisory structure set up with representatives from all the relevant groups to operate in each of the Forest areas of dispute eg, Dorrigo, South East Forests, etc.

Your comments will be noted.

Yours faithfully

Rev Fred Nile MLC

Forestry Commission of N.S.W.

Forestry Office
Northern Region
PO Box J19
Coffs Harbour NSW 2450

Attention J Tedder
Honorary Secretary
North Coast Environment Council Inc.
Pavans Road
Grassy Head
Via Stuarts Point NSW 2441

Your reference:

Our reference: RO 639

Telephone: 066 528900
Fax. 066 512909

Contact Officer: Mr S Hutson

13.04.1993

Dear James,

Thank you for your letter of the 15th March 1993.

We recognise just as you do, the need to resolve contentious issues associated with the management of State Forests in Northern Region and establishment of meaningful dialogue with interest groups.

To enable further consideration of your proposal it would be appreciated if you could comment or advise on the following points:

(i) the proposed size of the consultative committee and make up?

(ii) to enable a more balanced representation of principal interest groups will NP&WS, CALM, Environmental Planning Authority, graziers, bush fire committees, Chamber of Commerce be invited to participate?

(iii) objectives of the committee? Is it an advisory/consultative /decision making forum?

(iv) anticipated frequency of meetings.

(v) an indication of the scope/areas the committee intends to consider.

I would welcome the opportunity to discuss the matter further with you.

Yours sincerely

for MIKE ROWLAND
Planning Manager
Northern Region

order, in Part 2 of Chapter 6, means, if:

(a) an appeal is made to the Land and Environment Court in accordance with section 169 against an order in the terms of order No. 4 in the Table to section 121 and the Court confirms that order with modifications; or

(b) a council modifies an order in the terms of order No. 4 in the Table to section 121 in accordance with section 145,

the order as so modified.

ordinance means an ordinance in force under this Act.

owner:

(a) in relation to Crown land, means the Crown and includes:

(i) a lessee of land from the Crown; and

(ii) a person to whom the Crown has lawfully contracted to sell the land but in respect of which the purchase price or other consideration for the sale has not been received by the Crown; and

(b) in relation to land other than Crown land, includes:

(i) every person who jointly or severally, whether at law or in equity, is entitled to the land for any estate of freehold in possession; and

(ii) every such person who is entitled to receive, or is in receipt of, or if the land were let to a tenant would be entitled to receive, the rents and profits of the land, whether as beneficial owner, trustee, mortgagee in possession, or otherwise; and

(iii) in the case of land that is the subject of a strata scheme under the Strata Titles Act 1973 or a leasehold strata scheme under the Strata Titles (Leasehold) Act 1986, the body corporate under that scheme; and

(iv) in the case of land that is a community, precinct or neighbourhood parcel within the meaning of the Community Land Development Act 1989, the association for the parcel; and

(v) every person who by this Act is taken to be the owner; and

(c) in Part 2 of Chapter 6, in relation to a building, means the owner of the building or the owner of the land on which the building is erected.

parcel of land, in relation to ratable land, means a portion or parcel of land separately valued under the Valuation of Land Act 1916.

park, in relation to a vehicle, includes stand or wait.

parking authority for a person with disabilities means an authority issued by the Roads and Traffic Authority to a person with disabilities or to a person or organisation in respect of a vehicle used for the conveyance of persons with disabilities.

Pecuniary Interest Tribunal means the Local Government Pecuniary Interest Tribunal established under this Act.

person with disabilities means a person who is unable to walk or who is able to walk only short distances because of permanent loss of the use of one or both legs or other severe permanent medical or physical handicap.

place of public entertainment means:

(a) a drive-in theatre; or

(b) an open-air theatre; or

(c) a theatre or public hall; or

(d) licensed premises.

place of shared accommodation includes a boarding house, a house let in lodgings and a backpackers hostel.

plan of management means a plan of management adopted by a council under Division 1 of Part 2 of Chapter 5 and in force in relation to an area of public land.

political party means a body or organisation, whether or not incorporated, having as one of its objects or activities the promotion of the election to Parliament or to a council of a candidate or candidates endorsed by it or by a body or organisation of which it forms part.

premises means:

(a) any house, tenement or building of any description or any part of it and the appurtenances to it; and

(b) any swimming pool, ship, vessel, boat, punt, lighter, houseboat, tent, van, shed or other structure; and

(c) any land, whether built on or not.

private land means land the fee-simple of which is not vested in the Crown, and land that the Crown has lawfully contracted to sell.

professional or business association means an incorporated or unincorporated body or organisation having as one of its objects or activities the promotion of the economic interests of its members in any occupation.

promote or conduct a public entertainment includes being interested in the proceeds or profits of the entertainment.

MEDIATION -

CAN ALTERNATIVE DISPUTE RESOLUTION (NEGOTIATION/MEDIATION) ENSURE ENVIRONMENTAL PROTECTION IN NEW SOUTH WALES?

1. INTRODUCTION

Alternative dispute resolution is an additional mechanism to existing legal and administrative processes for the resolution of conflict in a variety of public issues, including environmental disputes. It refers to a number of processes including negotiations, which are either assisted or unassisted, mini-trials and mediation. In the view of some commentators, the use of the term Alternative Dispute Resolution (ADR) is misleading because it implies an alternative to existing mechanisms. All those experienced in the use of ADR stress that ADR must sit within the existing legislative, judicial and regulatory framework, as an additional option.

At the outset, the point has to be made that conflict is not inherently negative. The challenge lies in the successful resolution of the conflict with a view to achieving an ecologically sustainable future.

2. BACKGROUND

The NSW Government has shown an interest in one form of ADR - Mediation - and while it is not a totally new process for environmental dispute resolution in Australia, it is being viewed favourably by the current Government.

Expressions of interest in mediation by the NSW Government, and recently by the Queensland Government through the conference - "Public Issues Dispute Resolution", held in Brisbane in February 1991, has been precipitated by:

i. a growing level of environmental disputation over resource use and land use decisions, much of it high profile and politically damaging (eg coastal development, forestry and ocean pollution);

ii. industry complaints about the constraints of environmental regulation; and

iii. perceived but unsubstantiated claims of adverse economic impacts.

What this move to mediation fundamentally fails to recognise is the necessity for legislative and structural changes to take place. In other words, by pushing mediation, and attempting to control the process, governments are failing to acknowledge the public's rights via process and information access to measures which could significantly reduce the need for conflict resolution mechanisms in a wide range of issues.

In the main, implementation of the following processes will go a long way towards averting the need for conflict resolution further down the track:

° Policy setting to achieve ecological sustainability;

° Effective consultation processes in the development of resource use and land use policy and management practices;

° Open standing provisions in relevant legislation to oversee proper implementation of the legislation; and

° The development of adequate scientific information bases on which to plan resource and land management decisions.

All these measures offer powerful opportunities for removing the current level of conflict. Proper resourcing of these primary processes is essential. The innovative application of mediation is currently taking place in the area of policy formulation in the United States. These round-table discussions are described as 'policy dialogs'. (Adler, 1989) This allows interest groups to participate in and arrive at 'legislative or regulatory recommendations which are forwarded to decision makers. (PS Adler, 1989, Mediating Public Disputes)

On Earth Day 1990, the NSW Premier launched his New Environmentalism statement, in which he identified:

° the absence of credible mechanisms to permit a rational resolution of conflicts about land use and natural resource management; and

° a poor and often non-existent information base about the nature and scope of the problems as two reasons for environmental conflict.

Interestingly, some commentators who have considered the opportunities offered by mediation believe that many environmental conflicts exceed the decision making capacity of existing institutions and will require new institutional arrangements for the satisfactory resolution of conflict. The NSW Government has to date failed to acknowledge the qualitatively different nature of environmental as compared with other types of disputes, for example, industrial and commercial disputes. Although the discussion paper for the Queensland conference summarised aspects of the different nature of environmental disputes, there is no clear evidence that this has been recognised by the Government.

It is against this background that current proposals must be evaluated.

3. THE QUALITATIVELY DIFFERENT NATURE OF ENVIRONMENTAL DISPUTES

To date, most experience with alternative dispute resolution mechanisms in Australia has been in the area of industrial, family law and the commercial field. The experience cannot be directly translated to environmental conflict. It is a combination of factors which make environmental disputes intrinsically more difficult to resolve. Frequently these conflicts take place in a complete policy vacuum which only serves to exacerbate their intractibility.

The qualitatively different nature of environmental disputes was an important theme of Sir Ninian Stephen's address to the Brisbane conference. In Sir Ninian's view "there exists no great corpus of law by reference to which these disputes should be resolved so that, when resolved, all parties to the dispute will be left feeling, if not content, at least with the sense that established principles which have gained community acceptance have been applied in their resolution". However, though such principles are not enshrined in international law the Brundtland Report, *Our Common Future*, recommended that the United Nations General Assembly prepare a Universal Declaration and Convention on environmental protection and sustainable development. To this end, the World Commission on Environment and Development Experts Group on Environmental Law has developed a framework which includes the following:

- General Principles, Rights and Responsibilities
  (intergenerational equity, conservation and sustainable use, environmental standards and moritoring etc);

- Principles, Rights and Obligations concerning Transboundary Natural Resources and Environmental Interferences
  (reasonable and equitable use, prevention and abatement, strict liability); and

- State Responsibility and Peaceful Settlement of Disputes.

In the area of industrial and commercial disputes, where forms of alternative dispute resolution have been practiced, it is possible to assess economic gains and losses if a dispute is prolonged or proceeds to litigation. There are tangible trade offs that are easily quantifiable. Parties to a commercial or industrial mediation can more easily negotiate over quantifiable and divisible factors eg lost wages, lost hours, increased wages, improved conditions, company losses due to delay etc.

In environmental disputes, environmental values cannot be economically quantified. Indeed, when considering the values of wilderness, a species etc, it is inappropriate to attribute a monetary value. Furthermore, it is essential to recognise that 'irreversible' impacts on the environment may result from a decision to develop or be the cumulative effect of such decisions. For example, habitat destruction and species loss are irreversible.

While legislation to limit pollution has to date been based on assumptions about the environment's assimiliative capacity, there are limits.

> "Not only are there limits to resources, there are limits to the rate at which the environment can receive wastes and return them in usable form and to its capacity for storing them in innocuous form." (Susskind & Weinstein, 1980)

Decisions to develop, consistently show a failure to recognise and understand complex ecosystems and the concept of interconnectedness, "ecosystems are made up of interdependent components and ecosystems are open and linked to each other. Some consequences are bound to be unpredictable". (Susskind & Weinstein, 1980)

Human intervention in the natural environment has the effect of simplifying and destabilising the environment. Frequently, additional impacts lead to irreversible environmental change. Technological interventions also have the potential to lead to irreversible change.

Some impacts may not become evident for decades. It is difficult to determine a value that should be attached to these adverse impacts that build up or continue for generations. Human capacity to predict the long term impacts of development decisions is at best poorly developed and, in certain cases, the only option, the 'no go' option is one that is not open to mediation.

It is difficult to imagine how matters of intergenerational equity can be represented in an environmental mediation process

The number of interest groups/parties associated with an environmental dispute further increases the complexity of an environmental dispute since it is both 'in the public interest' and usually concerns a physical area of land. As Adler points out "such disputes involve stake-holders from private development interests, government agencies and community and environmental action groups. Across and within these constituencies money, authority, decision-making power, technical expertise, access to information and to the media and communication styles vary considerably". (Adler, 1989)

It is essential that the qualitatively different nature of environmental processes be recognised and acknowledged by all players considering mediation. On the views put forward at the Brisbane conference, this is not acknowledged or understood by governments or the development sector.

4. MEDIATION - WHAT ARE THE ESSENTIAL ELEMENTS?

As Justice Street defines it, mediation is "a structured process which is chosen by the parties as the means through which to reach agreement for the resolution of their dispute ..... It is throughout an entirely voluntary, without prejudice process. Either party is free to walk away from the negotiations at any stage ... The mediator, as such, does not decide any aspect of the dispute or purport to impose an determination on the parties. Inherent within the personal dynamics of a structured mediation is a significantly enhanced prospect of satisfactory agreed resolution of the dispute".

In the view of Gerald W Cormick from the Office of Environmental Mediation at the University of Washington, mediation is "a voluntary process in which those involved in a dispute jointly explore and reconcile their differences. The mediator has no authority to impose a settlement. His or her strength lies in the ability to assist the parties in resolving their own differences. The mediated dispute is settled when the parties reach what they consider to be a workable solution".

Alternative Dispute Resolution - Some Distinctions

Dialogue, and negotiation are not mediation. The NSW Forest Summit Workshop held in January made a distinction between dialogue and mediation. Dialogue is considered constructive, appropriate and can serve to depersonalise conflict, provide information and a clear statement of issues concerning both parties. It may lead to mediation.

Negotiation between parties can be either unassisted or assisted by a third party. The Salamanca Agreement in Tasmania was an **unassisted negotiation**. Unassisted negotiations may or may not involve mediation.

In **assisted negotiations**, a third party in the role of arbitrator has the power to decide the outcome. Parties present their case to the arbitrator as adversaries. There is little communication between the parties and the decision is usually binding. Arbitration is not mediation.

There are different systems of mediation, but a mediator will basically perform the following functions:

1. Establish a good rapport between parties. This can begin at the pre-mediation stage. Mediators will actively address the need to establish and maintain standards of acceptable behaviour and good communication.

2. Understand and address the three satisfaction needs of each party:

   ° procedural
   ° psychological, and
   ° substantive.

3. Have the parties concisely describe what they want.
4. Have the parties generate a set of of options without coming to immediate solutions.

5. Ensure that all relevant parties are being included in the process. Who is deemed 'relevant' may change in the course of mediation.

6. Ask the parties to work out which if any of the canvassed options will best meet their needs.

7. Address the 're-entry problem' ie negotiating parties will have to return to their constituents to gain their support for the outcomes being negotiated.

8. Assist in having a written agreement made. This may or may not be a binding document, but its purpose is to clarify the outcome of the mediation. [from paper prepared by Adrian Stevens, ACF National Liaison Officer]

Who's Pushing The Mediation Agenda? How Do They See It?

In NSW, the agenda on mediation is in part being run by the Department of State Development and significantly by the Minister, John Hannaford. His interest can be traced to a trip to the United States as Chair of the Legislative Council's Inquiry into Coastal Development. At this time, conflict over the Government's handling of coastal development was at a politically damaging peak.

The NSW Cabinet Office has jointly with the Queensland Government developed a bulky discussion document "Public Issue Dispute Resolution" for the Brisbane Conference. Mr Garry Sturgess, Director General of the NSW Cabinet Office is known to favour mediation strategies.

Another important player is the Australian Commercial Disputes Centre (ACDC). ACDC began in 1986 on the initiative of Sir Laurence Street, formerly NSW Chief Justice. The Centre receives Government financial assistance. It has worked in the commercial dispute area exclusively, providing both mediation, consultancy and mediation training (at commercial rates). In the past year it has expanded its interest to the environmental field and indeed has proposed a name change to reflect this broadening interest. ACDC is currently facilitating a Public Decision Making and Dispute Resolution Group comprising predominantly members of the legal, planning and local government fields. Recently, a number of environment groups have been invited to nominate a member of this group. The Environmental Defenders Office are observers on this group.

Another and far more important role being played by ACDC is its consultancy to the NSW Department of State Development to jointly promote, develop and establish a mediation process in the area of environment planning, in particular in the areas of local government and public interest disputes.

As well, the Department of State Development and the Australian Commercial Disputes Centre (ACDC) jointly sponsored Dr Peter Adler, Director of the Centre for Alternative Dispute Resolution, Supreme Court of Hawaii, to discuss mediation with business groups, government departments etc.

From statements to date, it is clear that NSW's inability to recognise that failure to articulate clear environmental policies for ecological sustainability, and to facilitate public participation has lead to the current level of public dispute and dissatisfaction. It is Hannaford's view that mediation "has the potential to become an integral part of the entire environmental decision-making process from the initiation of a development proposal through to the appeal hearing, whether the outcome be determined by a Commission of Inquiry, a Court or by environmental mediation as a strategy in its own right". [Personal communication 3/1/91]

However, if development has the potential to create environmental conflict, it could be because planning legislation is allowing inappropriate development.; and/or Environmental Impact Statements are grossly

inadequate and frequently a rubber stamp for further inappropriate development. The public participation and consultation process needs to be more rigorous, independent and required to commence at a much earlier phase.
For example, the NSW Department of State Development's industry development strategy offered an opportunity for full public consultation. Fourteen different industry sectors have been targetted for development including the chemical, telecommunications, tourism, pulp and paper and coal industries. Each industry sector Task Force (dominated by industry interests) presented a report promoting that industry's future development. Only after the reports are developed by industry has the community been invited to submit its position. There is no established mechanism for resolving the final strategy with broad public involvement. The initial planning stage is the appropriate time to begin an equally balanced, equally resourced consultation program which potentially avoids future conflict.

Another insight into the State Development Minister's position comes from *Directions in Government, September 1990*, - "Mediation is not a tactic to distract attention from the issues. On the contrary, it is a tactic for harmony, to engage the community right from the start in the concept and design stages of development so that the needs of both the community and the developer can be recognised as a project progresses if it even starts". Effectively, what is being proposed is a never ending round of mediation for individual development proposals.

It is not possible to ignore the conflict of interest that exists for the Minister. The main objectives for this portfolio are economic ones. The Minister stated in a letter to peak groups, " It is generally agreed that the time and cost involved with traditional legal processes are significant disincentives to investment in NSW". ACF is not aware of any credible, independent evidence to support this position. A number of industry reports have made claims about the negative effects of environmental assessment required for development projects. Interestingly, the Minister's position paper also states, "Mediation should never be seen as a substitution for legislation or the courts.'"(3/1/91) This is the view held by many important commentators in the field.

Federal Moves

The Resource Assessment Commission (RAC) has produced a discussion paper *The Potential Role of Mediation in the Resource Assessment Commission Inquiry Process* (Boer et al, 1991), which concludes that mediation could be introduced into the RAC's procedures without amendments to the Act. The paper concludes mediation "can assist in the identification of environmental, cultural, social, industry, economic and other values, as well as in assessing the losses and benefits of alternative uses of resources. The approaches to mediation emphasised in the full report relate primarily to the formulation of public policy in the specific context of resource and environmental issues".

"Mediation, thoughtfully applied to both processes and the resolution of specific problems, has enormous potential to assist the Commission in fulfilling its difficult charter in terms of the resolution of national resource issues and the search for ecologically sustainable development." (Boer et al, 1991)

5. US MOVES TO MEDIATION - DO THEY TRANSLATE?

It is appropriate to highlight the perceived reasons for a shift to the use of alternative dispute resolution mechanisms in the US. The literature identifies, among others the following reasons:

- the growth in the number and intensity of environmental disputes combined with the reduced ability of social, political and legal institutions to resolve the disputes;
- the liberalisation of standing provisions and the litigious nature of the US;
- the view of some commentators that Government, particularly Congress, has become captured by special

interest groups and a failure to govern has placed enormous burdens on the legal system; and

- the recognition that both environmental and business interests have borne substantial costs directly attributable to the delays caused by extended environmental litigation. (Susskind & Weinstein, 1980)

In summary, the costs of environmental conflict; dissatisfaction with traditional approaches to dispute resolution; and the success of some preliminary consensus methods have been behind moves to alternative dispute resolution mechanisms. (Susskind & Weinstein, 1980)

6. US EXPERIENCE - HOW SUCCESSFUL IS MEDIATION REALLY?

It is worthwhile taking a closer look at success claims for mediation in environmental dispute resolution.

A briefing paper from John Hannaford cites an unreferenced 1986 survey which covered over 200 land and natural resource disputes in the US where mediation was tried.

> "82% of those conflicts involved federal or state agencies and units of local government in the United States. Local citizens' groups were at the table in about half the attempts.
>
> Close to 80% of the disputes reached agreement through mediation. Furthermore, when the public officials with the authority to implement agreements participated directly in the negotiations, resulting agreements were fully implemented 85% of the time."

This reference fails to indicate what percentage of the total number of conflicts actually had relevant government officials participating in the mediation process. At the very least it is a completely inadequate basis on which to claim success for mediation.

Importantly, there are other views. Gail Bingham is a widely recognised US expert in the field of environmental mediation. The following analysis offers some interesting insights.

> Bingham's 1986 study of environmental mediation identified 161 mediated cases, of which 115 were site specific and 46 were policy cases. Surprisingly, only 21 per cent of the site-specific cases she studied involved environmental groups and private industry.
> Overall, environmental groups participated in 35 per cent of those cases studied, private corporations in 34 per cent and agencies of federal, state and local governments in 82 per cent.
>
> As Bingham points out, although the participants reached agreement on almost 90 per cent of these issues, <u>few of those agreements were successfully implemented, and some environmentalists criticized the results</u>. [My emphasis]

A 1983 study - Settling Things: Six Case Studies in Environmental Mediation - concluded that such techniques could be successfully only 10% of the time (Wald, 1985).

In the view of one US judge "negotiation rarely eliminates court action altogether. Rather, *it only changes the nature of the subsequent judicial proceedings.*" (Wald, 1985)

It is clear that there are differing opinions on the success of mediation. It is certain that if governments attempt to mandate the process it will effectively alienate the environment movement and fail to minimise public disputes.

7. Dr PETER ADLER'S VIEW OF MEDIATION

Dr Peter Adler is currently the Director, Centre for Alternative Dispute Resolution, Supreme Court of Hawaii. In this position he is responsible for the management of mediation services in public interest disputes, including environment disputes. In February, he addressed a small number of environmental lawyers and campaigners and frankly outlined his view of mediation.
In Adler's experience, mediation is:

- a voluntary process only, not one where parties are coerced into participation;
- not a process that is mandated or forced by government;
- a complement to, not an alternative to existing decision making procedures (ie legislative, judicial, administrative, regulatory);
- a process which requires that players are clear about their objectives;
- a process which does not preclude the right to continue all other campaign activities;
- entered into because it is considered a strategic option following consideration of who is suggesting the process, their possible motives, the sincerity of their proposals including consideration of whether there is an attempt to in fact, remove something from the players;
- a process which may or may not involve lawyers, preferably in an advisory role and with principals as the main players;
- a process which if an agreement is reached and while not binding, on institutional bodies, laws etc can be used to apply pressure for change; and
- a process which is moving from an ad hoc experimentation to institutionalised experimentation in the US.

8. A ROLE FOR MEDIATION?

The following questions should be carefully considered by environmentalists:

- Can mediation enhance environmental protection and assist in achieving an ecologically sustainable future?
- Do similar.conditions to the US prevail in Australia to support the successful introduction of mediation processes?
- Are there underlying causes of conflict which will not be addressed by mediation techniques?
- Is there a role for mediation? If so, what is it? and
- What ought to be the features of an Australian mediation process?

These are matters for consideration by the Australian environment movement as a whole and ought to be considered in the context of the particular political, administrative and legal circumstances prevailing in this country.

Suffice to say at this early stage there is a level of concern and scepticism about the motives of the NSW

Government in actively promoting mediation.

This concern is prompted by the Government's failure to:

i) recognise and address the underlying causes of environmental conflict;

ii) address ecologically sustainable development and set its policies in this context;

iii) recognise the qualitatively differently nature of environmental disputes;

iv) adequately involve the environment movement in its project to "promote, develop and establish a mediation process";

v) consult with affected parties on its choice of the Australian Commercial Disputes Centre as the appropriate body with which to jointly develop mediation processes; and

vi) to indicate what level of involvement government departments, statutory authorities and local authorities would agree to have, and how binding agreements established through mediation would be on these instrumentalities.

9. WHAT TO CONSIDER PRIOR TO ENTERING MEDIATION?

The following is a checklist to consider.

1. What should trigger mediation:

    ° because the Premier or a Minister says so;

    ° because the Judge directs it, as an alternative;

    ° because it is an adjunct or alternative to an existing legal case;

    ° because the level of conflict is such that someone could be killed, or;

    ° because all the issues will be properly considered and appropriate information made available to all parties;

    ° because you believe that environmental protection will be ensured.

2. Are there other avenues that have not been adequately pursued that will equally advance the cause of environmental protection?

3. Will the successful outcome of a mediation process be used as an excuse not to change a flawed policy or piece of legislation which was the inherent cause of the conflict?

4. Do you consider your issue non-negotiable or is your group prepared to compromise?

5. Will you have balanced representation in the mediation process?

6. Will all the parties agree to a moratorium during the entire mediation process?

7. Are all parties going to be equally resourced to participate in the mediation process?

8. Will your participation be funded in a way that you consider acceptable?

9. Are you sure that all the parties to the mediation have been identified?
   Does that include government agencies etc?
   Will they agree to be bound by the outcomes of the mediation?
   Will there be an opportunity during the process for other identified parties to enter?

10. Is sufficient information available to identify all the issues?

11. If not, will funding be available to satisfactorily identify all the information?

12. Will the information be obtained on an independent basis freely available to all?
    Will your group be guaranteed input into any reports prepared?
    Will there be consensus on report content and the opportunity to view reports prior to publication?

13. Are you considering mediation because your morale is affected by perceived adverse public opinion or a developer PR campaign?

14. Are you, as an opinion leader, being deliberately pressured into mediation to weaken your campaign?

15. Is mediation fully supported by all members of your group?

16. Will the outcomes be binding through legal and legislative process?

17. Will the mediation lead to the development of norms and guidelines, policy change and legislative action so that the potential for future disputes is minimised?

Paper prepared by:

Sue Salmon
NSW Campaign Co-ordinator
Australian Conservation Foundation

12.4.1991

Appendices:

A. Case studies
B. Where, When and How to Use Mediated Negotiations: A Checklist for the Potential Participant - Gerald W Cormick.

PARLIAMENT OF NEW SOUTH WALES
LEGISLATIVE ASSEMBLY
PAM ALLAN M.P.
MEMBER FOR BLACKTOWN
SHADOW MINISTER FOR PLANNING AND ENVIRONMENT
SHADOW MINISTER FOR WOMEN'S AFFAIRS

Electorate Office
35 Boomerang Place
Seven Hills 2147
Tel: (02) 622 3110
Fax: (02) 831 2130
All correspondence to
P.O. Box 592
Seven Hills 2147

Mr. J. Corkill
Sydney Co-ordinator
North East Forest Alliance
Suite 313
373 George St
SYDNEY 2000

Dear John,

Thank you for sending me a copy of NEFA's "The Way Forward".

I have given copies to both my Parliamentary Colleagues, Craig Knowles, M.P. Member for Moorebank and Kim Yeadon, M.P. Member for Granville.

Could you contact my office on 622-3110 to arrange a meeting to discuss the document during the current Parliamentary session.

Yours sincerely,

Pam Allan

Pam Allan
Member for Blacktown
Shadow Minister for Planning
and Environment
Shadow Minister for Women's Affairs
25 / October, 1993.

2pm Thursday subject to confirmation

Your reference
Our reference J.Halkett:imh

5 October, 1993

Mr John R Corkill
Sydney Co-ordinator
North East Forest Alliance
Suite 313
375 George St
SYDNEY NSW 2000

STATE FORESTS
MANAGING • CARING • SUSTAINING

State Forests of
New South Wales

Building 2
423 Pennant Hills Road
Pennant Hills NSW 2120
Phone (02) 980 4100
Fax (02) 484 1310

Dear Mr Corkill

Thank you for your letter of 25 August 1993 and the submission by Mr D Pugh on resolving forest conflict in North East NSW. I appreciate the effort Mr Pugh has taken to prepare the submission, and your desire to see the issues resolved.

As you will be aware the Forestry Commission has been reorganised as State Forests of NSW and has undergone some further structural changes. A new Board of Governance has been established and a Forest Policy Advisory Committee, comprising representatives from Government, public bodies, industry and conservation interests has been created to provide independent advice to the Minister through the Department of Conservation of Land Management.

The opportunity to be a representative on the committee was recently advertised. Four conservationists/environmentalists will have the opportunity to serve on the committee.

Clearly, the decision-making and policy setting environment has changed quite dramatically since Mr Pugh prepared his paper. In addition to changes in the corporate structure of this organisation, the Natural Resources Audit Council (NRAC) has been established. NRAC will play a key role in assimilating resource information by co-ordinating the data collection activities of Government agencies. This will facilitate the compilation of data and enable the Government to determine what data deficiencies exist, as discussed in Mr Pugh's submission. NRAC will also review issues on land use options prior to decisions being made by the Government.

Public participation in the environmental planning and forest management process is the prerogative of the whole community and not simply the combatants or stakeholders. While there have been problems with the quality of public participation in the past, State Forests continues to be committed to seeking the views of the wider public and considering concerns raised.

I believe that public participation has worked reasonably well in most Environmental Impact Statement (EIS) areas and that the process of public participation will improve in the future. I would suggest that the role of public participation is to allow the community an opportunity to make a contribution to forest management. This is to be clearly distinguished from the role of Government which is to finally determine policy and make strategic planning decisions. I do not believe that it is appropriate that decision making responsibility be given to advisory or consultative groups.

Mr Pugh's submission makes reference to the issue of "comprehensive, adequate and representative reserve system". This begs the question of what is "adequate" and "representative". This question is currently the focus of a Reserve Criteria Working Group that operates under the auspices of the Australian Forestry Council and Australia New Zealand Environment and Conservation Council (AFC/ANZECC). I am confident that this working group will produce a workable and agreeable result.

State Forests is committed to a commercial approach in its operations, as indicated in the current corporate plan and seen through the creation of the Board of Governance. An aspect of this approach is the deregulation of log supply, not regulation as Mr Pugh proposes. Full community consultation should allow the voice of local communities to be heard on this issue, but a commercial focus will be a strong plank of Government policy.

The model for conflict resolution proposed by Mr Pugh through the setting up of various committees and technical working groups is very similar to the South East Forests Regional Consultative Committee (SEFRCC). The SEFRCC was set up jointly by Commonwealth and State governments and broad community consultation was involved, although I understand the conservation movement refused to participate. Various working groups were formed and research studies undertaken (including one by CSRIO). However, at the end of the day, there was still not a satisfactory resolution of all the areas of conflict.

State Forests is committed to an equitable community consultation process as part of its EIS programme. The Minister's recent offer for environmentalists to be involved on the Advisory Committee should be a welcome opportunity and a forum in which your views may be considered.

I appreciate the effort that Mr Pugh has taken in his submission. Many of his suggestions are, in fact, already in place and others will be considered as the Forest Policy Advisory Committee begins its deliberations.

Yours sincerely

JOHN HALKETT
Acting Managing Director

a:Corkill/Halkett:imh

Copy: **Commissioner for Forests**

ATTN JOHN CORKHILL

FROM DOUGLAS HEAD

1. 9 93

DEAR JOHN,

Re: The Way Forward

Briefing

I WOULD APPRECIATE TAKING UP YOUR OFFER OF A BRIEFING. PLEASE CONTACT ME TO ARRANGE DETAILS (065) 856151

I WILL BE OUT TILL THIS AFTERNOON - SAY 2PM.

REGARDS

NRB R/33: MW

THE CABINET OFFICE

NEW SOUTH WALES

Mr J.R. Corkill
Sydney Co-ordinator
North East Forest Alliance
Sydney Branch Office
Suite 313, 375 George Street
SYDNEY 2000

3 1 AUG 1993

Dear Mr Corkill

The Premier has asked me to acknowledge receipt of your recent letter concerning the resolution of forest conflict in north east New South Wales State forests.

Inquiries are being made and a response will be forwarded as soon as possible.

Yours sincerely

FOR Roger B Wilkins
Director-General
The Cabinet Office

State Office Block, Macquarie Street, G.P.O. Box 5341, Sydney 2001
Telephone: (02) 228 5555 Fax: 228 3062

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

OFFICE OF THE DIRECTOR-GENERAL

2 3 AUG 1993

Mr J R Corkill
Co-ordinator
North East Forest Alliance
Suite 313, 375 George Street
SYDNEY 2000

Dear Mr Corkill

I refer to your letter concerning your offer of a roundtable dispute mediation process relating to the Dorrigo Management Area Environmental Impact Statement. Thank you for including in your correspondence a copy of the letter to the Forestry Commissioner from Woolf Associates, Solicitors in regard to this matter.

Your suggestion of such a process has considerable merit and should it proceed I would be pleased to be involved. I look forward to receiving the draft detailed proposal prepared by your colleague, Mr Dailan Pugh.

Yours sincerely

W A WATKINS
Director-General and
Commissioner of Soil Conservation

The Department of Conservation and Land Management incorporates:
Soil Conservation Service, Crown Lands Service, Land Information Centre, Land Titles Office, Valuer-General's Office, and Forestry Policy Unit.
23–33 Bridge Street Sydney NSW 2000 GPO Box 39 Sydney NSW 2001 Phone (02) 228 6321 Fax (02) 231 3280

PUBLIC ISSUE
DISPUTE RESOLUTION

NATIONAL CONFERENCE

Address by

The Honourable
NICK GREINER, MP

Sheraton Brisbane Hotel
18-19 February 1991

A conference sponsored by the Queensland Government in conjunction with the Commission of Inquiry into the Conservation, Management and Use of Fraser Island and the Great Sandy Region.

ADDRESS BY THE HON. NICK GREINER M.P.

PREMIER OF NEW SOUTH WALES

RESOLVING ENVIRONMENTAL CONFLICT :

A POLITICAL IMPERATIVE FOR THE 1990S

SHERATON HOTEL, BRISBANE

19 FEBRUARY 1991

DISTINGUISHED GUESTS
LADIES AND GENTLEMEN

I WELCOME THE OPPORTUNITY TO PARTICIPATE IN THIS LANDMARK CONFERENCE WHICH IS CLEARLY A VERY POSITIVE STEP ALONG THE ROAD OF OUR CO-OPERATIVE EFFORTS TO SOLVE ONE OF THE MOST PRESSING PROBLEMS OUR COMMUNITY FACES TODAY.

THERE IS NO DOUBT THAT THE PERSISTENT FAILURE TO FIND WAYS TO SATISFACTORILY RESOLVE ENVIRONMENTAL CONFLICT IS COSTING AUSTRALIA DEARLY.

ECONOMIC OPPORTUNITIES ARE FOREGONE, COMMUNITY TENSIONS ARE EXACERBATED, ENORMOUS COSTS ARE INCURRED IN OFTEN LENGTHY AND INEFFECTIVE COURT BATTLES.

ONE WAY OR ANOTHER, WE ALL END UP PAYING.

AT THE BEGINNING OF A PARTICULARLY TESTING DECADE FOR AUSTRALIA, IT IS ESSENTIAL WE FIND MORE EFFECTIVE WAYS TO RESOLVE THESE DISPUTES.

THERE SEEM TO ME TO BE THREE IMPERATIVES DRIVING REFORM OF ENVIRONMENTAL DISPUTE RESOLUTION PROCESSES.

THE FIRST IS ECONOMIC. WE CAN NO LONGER AFFORD TO RECKLESSLY SQUANDER OPPORTUNITIES FOR LEGITIMATE AND NECESSARY GROWTH BY BECOMING BOGGED DOWN IN DISPUTES THAT DELAY, OR DENY, THE SENSIBLE AND PRODUCTIVE USE OF OUR NATURAL RESOURCES.

SECOND, WE MUST ACKNOWLEDGE THAT WE CANNOT CONDONE UNRESTRAINED DEVELOPMENT OR IRRESPONSIBLE USE OF OUR NATURAL RESOURCE BASE. OUR ENVIRONMENT HAS A VALUE WHICH MUST BE WEIGHED FAR MORE HEAVILY THAN IN THE PAST.

THIRD, WE MUST RECOGNISE THAT EXISTING DISPUTE RESOLUTION MECHANISMS HAVE LARGELY FAILED TO SATISFY THE DEMANDS OF GOVERNMENT AND COMMUNITY ALIKE.

IN PARTICULAR, THE SHORTCOMINGS OF WHAT ARE ESSENTIALLY LEGALISTIC AND BUREAUCRATIC DISPUTE RESOLUTION PROCEDURES ARE BECOMING INCREASINGLY EVIDENT.

ENVIRONMENTAL CONFLICTS ARE NOT PRIMARILY ABOUT LEGAL OR ADMINISTRATIVE ISSUES. THEY ARE ABOUT COMPETING VALUES AND INTERESTS.

THE OBJECTIVE MUST BE TO SEARCH FOR MECHANISMS FOR RESOLVING CONFLICT WHICH RESPECT BOTH OUR ECONOMIC AMBITIONS AS WELL AS THE ENVIRONMENTAL IMPERATIVES.

ABOVE ALL, WE NEED MECHANISMS WHICH INCREASE OUR CAPACITY TO DEAL WITH WHAT ARE SIMPLY CONFLICTING PRIORITIES.

IT IS AGAINST THIS BACKGROUND I WISH TO ADDRESS FOUR QUESTIONS.

FIRST, WHY DOES ENVIRONMENTAL CONFLICT ARISE?

SECOND, WHY ARE OUR PRESENT SYSTEMS NOT WORKING - AT LEAST, NOT WORKING ADEQUATELY?

THIRD, HOW CAN WE FASHION BETTER TOOLS FOR RESOLVING ENVIRONMENTAL CONFLICT?

FOURTH, WHAT SORT OF MECHANISM DO WE NEED TO ESTABLISH SO THAT GOVERNMENTS CAN CONFIDENTLY MAKE DECISIONS ABOUT THE BEST USE OF RESOURCES?

NEW SOUTH WALES DOES NOT HAVE ALL THE ANSWERS TO ALL OF THESE QUESTIONS.

HOWEVER, I BELIEVE WE ARE GOING IN THE RIGHT DIRECTION. WE ARE LOOKING CRITICALLY AT SOME OF OUR TRADITIONAL DISPUTE RESOLUTION MECHANISMS AND, FRANKLY, I MUST ADMIT THAT THEY ARE ONLY MODERATELY SUCCESSFUL IN PREVENTING DISPUTES OR CREATING THE RIGHT CIRCUMSTANCES FOR CONSIDERED AND SENSIBLE DECISION MAKING.

IN NEW SOUTH WALES WE HAVE BECOME CONSCIOUS OF THE NEED TO DEVELOP A MORE EFFECTIVE AND DIVERSE MIX OF POLICY RESPONSES TO ENVIRONMENTAL ISSUES. IN SHORT, WE HAVE ACKNOWLEDGED THE NEED TO ADDRESS NOT SO MUCH THE PUBLIC FACE OF THE PROBLEM, BUT RATHER THE UNDERLYING CAUSES.

THESE ARE:

FIRST, THE ABSENCE OF ADEQUATE INSTITUTIONS TO PROTECT OUR BASIC "COMMON" RESOURCES, SUCH AS AIR AND WATER.

SECOND, AN INADEQUATE INFORMATION BASE WHICH FAILS TO IDENTIFY MUCH OF WHAT WE NEED TO KNOW ABOUT THE NATURE AND SCOPE OF PROBLEMS.

THIRD, THE ABSENCE OF CREDIBLE MECHANISMS TO PERMIT A RATIONAL RESOLUTION OF CONFLICTS ABOUT LAND USE AND NATURAL RESOURCE MANAGEMENT - SOMETHING OF CRUCIAL INTEREST TO THOSE ATTENDING THIS FORUM.

IN ATTEMPTING TO ADDRESS THESE UNDERLYING CAUSES, WE AS A GOVERNMENT HAVE COMMITTED OURSELVES TO A THOROUGH AND RATIONAL ANALYSIS OF THE PROBLEM, RATHER THAN LOOKING FOR POLITICALLY PAINLESS, QUICK FIXES AND EASY RESPONSES.

THIS HAS NOT ALWAYS SATISFIED THE DEEP GREEN LOBBY. HOWEVER, IT IS THE ONLY WAY WE CAN EFFECTIVELY ACHIEVE A BALANCE BETWEEN CONFLICTING COMMUNITY DEMANDS OVER WHAT CONSTITUTES THE BEST USE OF OUR NATURAL RESOURCES.

NEW SOUTH WALES HAS LEARNT A NUMBER OF LESSONS IN THE REVIEW PROCESS WHICH ARE WORTH CONSIDERING IN THIS FORUM.

IF I HAD TO SUMMARISE WHAT STRIKES ME AS WRONG WITH THE CURRENT SYSTEM, IT COMES DOWN TO TWO FAIRLY SIMPLE PROPOSITIONS. FIRST, WE HAVE FAILED TO CLEARLY DEFINE ROLES AND RESPONSIBILITIES IN THE PROCESS. SECOND, WE HAVE VERY OFTEN ASSIGNED INAPPROPRIATE ROLES.

LET ME EXPLAIN BY WAY OF EXAMPLE. IN NEW SOUTH WALES IT IS QUITE POSSIBLE THAT AT THE END OF THE DAY IT WILL BE JUDGES WHO FINALLY DECIDE WHETHER OR NOT A DEVELOPMENT PROPOSAL IS ACCEPTABLE, AND WHETHER IT SHOULD GO AHEAD.

NOW, I'M NOT HAVING A GO AT JUDGES, BUT IT STRIKES ME AS VERY ODD THAT WE SHOULD THINK THAT LAWYERS ARE BEST PLACED TO MAKE A DECISION ABOUT WHETHER A DEVELOPMENT IS GOOD FOR SOCIETY.

TAKE ANOTHER EXAMPLE. THERE ARE PLANNING DECISIONS THAT ARE ESSENTIALLY LOCAL MATTERS, THAT HAVE ENDED UP WITH THE MINISTER FOR PLANNING, OR THE LAND AND ENVIRONMENT COURT. WORSE STILL, THERE ARE PLANNING ISSUES THAT HAVE BEEN DETERMINED BY THE FEDERAL TREASURER, OSTENSIBLY UNDER FOREIGN INVESTMENT GUIDELINES.

SOMETIMES THE PROBLEM IS THAT STATE OR FEDERAL MINISTERS WANT TO BUY IN FOR PERCEIVED POLITICAL GAIN. IN OTHER CASES, LOCAL GOVERNMENT HAS FOUND THE LOCAL POLITICS ALL TOO HARD AND HAS BEEN HAPPY TO PASS A TOUGH DECISION UPSTAIRS.

SO, WE END UP WITH A SYSTEM THAT CAN BE PAINFULLY AND EXPENSIVELY SLOW AND WHICH GENERATES <u>MORE</u> CONFLICT RATHER THAN REDUCING IT. IN MEDICINE THERE IS A TERM - IATROGENIC - WHICH IS USED TO REFER TO A DISEASE CAUSED BY THE TREATMENT PRESCRIBED BY THE PHYSICIAN. I REGRET THAT SOME OF THE SYSTEMS WE HAVE DESIGNED TO RESOLVE CONFLICT IN LAND-USE DECISIONS HAVE AN IATROGENIC EFFECT.

IF YOU ADD THAT TO THE DIMENSION OF PUBLIC PARTICIPATION IN THE DECISION-MAKING PROCESS, AND THE ENORMOUS VARIETY OF INTERESTS AND VALUES THAT ARE REPRESENTED IN THE COMMUNITY, IT IS SCARCELY SURPRISING THAT THERE IS DEEP COMMUNITY DISSATISFACTION WITH ASPECTS OF OUR PLANNING SYSTEMS.

ONE CONCLUSION, THEN, IS THAT IN ORDER TO MINIMISE CONFLICT WE NEED TO DEFINE, AT A MUCH EARLIER STAGE, WHO ARE THE LEGITIMATE PLAYERS IN A DISPUTE.

ANOTHER FAIRLY FUNDAMENTAL POINT WE NEED TO APPRECIATE AT THE OUTSET IS THIS: THERE IS NOT GOING TO BE ANY SINGLE RIGHT ANSWER IN ENVIRONMENTAL DISPUTES. SCIENTISTS AND OTHER EXPERTS ARE NOT GOING TO BE ABLE TO DELIVER THE DEFINITIVE ANSWER. THEY SHOULD NOT BE ASKED TO TELL US WHETHER TRADE-OFFS ARE ACCEPTABLE OR NOT. THEY SHOULD NOT BE ASKED TO TELL US WHAT VALUES AND WEIGHTS WE SHOULD ASCRIBE TO DIFFERENT CONSEQUENCES. AT MOST, THEY CAN ONLY TELL US WHAT THE IMPLICATIONS OF DIFFERENT DECISIONS MIGHT BE.

AT THE END OF THE DAY THESE VALUE JUDGEMENTS ARE POLITICAL DECISIONS - NOT IN THE PARTY POLITICAL SENSE, BUT IN THE SENSE THAT IT IS ONE OF THOSE DECISIONS THAT IN A DEMOCRACY WE HAVE CHOSEN TO RESOLVE BY MAJORITY RULE THROUGH OUR ELECTED REPRESENTATIVES.

WHAT EXPERTS CAN AND CANNOT DELIVER IS ILLUSTRATED IN THE DISPUTE OVER THE SOUTH EAST FORESTS OF NSW. WHAT THE SCIENTISTS COULD DO, AND DID DO IN THIS CASE, WAS TO SAY WHAT THE OPTIONS WERE AND WHAT THE IMPLICATIONS OF THOSE OPTIONS WERE FOR THE TIMBER INDUSTRY AND FOR THE ENVIRONMENT. BUT THE ULTIMATE DECISION WAS ONE FOR THE ELECTED REPRESENTATIVES, MY GOVERNMENT AND THE COMMONWEALTH GOVERNMENT.

IF WE DO NOT RECOGNISE AND CONFRONT THIS FUNDAMENTAL FEATURE OF PLANNING AND ENVIRONMENTAL DISPUTES, WE ARE IN DANGER OF DISTORTING AND SKEWING THE DISPUTE - PRETENDING IT IS A SCIENTIFIC DISPUTE OR LEGAL DISPUTE WHEN THESE ARE ONLY ASPECTS OF THE PROBLEM.

DOES THAT MEAN POLITICIANS AND GOVERNMENTS SHOULD GO AROUND TRYING TO SETTLE ENVIRONMENTAL AND PLANNING DISPUTES?

I THINK THE ANSWER IS NO. WHERE A DISPUTE OR A PROPOSAL HAS WIDESPREAD AND DISPARATE EFFECTS ACROSS A LARGE SECTOR OF THE COMMUNITY, THEN GOVERNMENTS MAY HAVE TO BE INVOLVED.

HOWEVER, THERE IS ALL TOO OFTEN AN EXPECTATION OR DEMAND THAT GOVERNMENTS SHOULD INTERVENE IN WHAT ARE PRIMARILY PRIVATE DISPUTES, FOR EXAMPLE, DISPUTES BETWEEN PRIVATE INDIVIDUALS OR GROUPS WHO HAVE DIFFERENT INTERESTS OR OPINIONS. THESE DISPUTES CAN AND SHOULD BE RESOLVED BETWEEN THE PARTIES INVOLVED.

ATTEMPTS ARE OFTEN MADE TO DRAW GOVERNMENTS INTO ESSENTIALLY PRIVATE DISPUTES BY CLAIMING THAT THE 'PUBLIC INTEREST' IS AT STAKE. IT IS TIME TO RECOGNISE THAT IN MANY CASES THERE IS NO SUCH THING AS THE PUBLIC INTEREST. THERE ARE SIMPLY DIFFERENT PEOPLE OR GROUPS OF PEOPLE WITH DIFFERENT INTERESTS, WHICH CANNOT ALL BE MET.

IN THESE CASES THE OBLIGATION OF GOVERNMENT IS NO MORE THAN TO ENSURE THAT SYSTEMS ARE IN PLACE TO ALLOW THESE DISPUTES TO BE SETTLED IN AN ORDERLY, EFFICIENT AND FAIR MANNER.

AS IN LEGAL DISPUTES, THE BEST AND FAIREST RESOLUTION IS SOMETIMES SIMPLY WHATEVER RESOLUTION COMES OUT OF A FAIR AND RATIONAL PROCESS.

IF I AM RIGHT ABOUT THE IMPORTANCE OF CLARIFYING ROLES IN DISPUTES, THEN PERHAPS THE MOST DIFFICULT AND THE MOST CRUCIAL ISSUE IS: WHO ARE THE "LEGITIMATE DISPUTANTS" IN AN ENVIRONMENTAL OR PLANNING DISPUTE?

THAT QUESTION OFTEN COMES UP DIRECTLY IN THE COURTS AS THE QUESTION, 'DOES THIS PERSON HAVE SUFFICIENT INTEREST TO BE HEARD IN THIS CASE?" BUT IT IS NOT ONLY RELEVANT IN THE COURTS.

VARIOUS GROUPS HAVE COMPLAINED TO ME AT DIFFERENT TIMES THAT THE CURRENT LAW IN NSW IS TOO GENEROUS IN ALLOWING ANYONE TO COME FORWARD AND CHALLENGE DEVELOPMENT PROPOSALS. THE COMPLAINT HAS BEEN THAT PUBLIC PARTICIPATION WITHOUT CONSTRAINT HAS PRODUCED AN INEFFICIENT APPROVAL PROCESS.

ON THE OTHER HAND, ENVIRONMENTAL GROUPS IN PARTICULAR HAVE ARGUED THAT PUBLIC PARTICIPATION THROUGH THE ENVIRONMENTAL IMPACT STATEMENT PROCESS IS JUST A PUBLIC RELATIONS EXERCISE, AS THERE IS NO REAL ASSESSMENT OF THOSE IMPACTS AGAINST OBJECTIVE OR ACCEPTED STANDARDS.

IN A SENSE BOTH VIEWPOINTS MAY HAVE SOME VALIDITY. PERHAPS IF ENVIRONMENTAL IMPACTS WERE MORE OBJECTIVELY AND RIGOROUSLY DEFINED THROUGH THE ASSESSMENT PROCESS, IT WOULD BE MUCH MORE APPARENT WHO REALLY WAS AFFECTED, AND IN WHAT WAYS.

IT COULD ALSO BE ARGUED THAT THE CURRENT APPROACH INVOKES THE ENVIRONMENTAL IMPACT STATEMENT TOO READILY AND IN INAPPROPRIATE CIRCUMSTANCES, SO THAT IT HAS BEEN DEVALUED AS A CURRENCY. FOR EXAMPLE, IS IT REALLY NECESSARY TO GO THROUGH AN EIS PROCESS IF YOU WANT TO MAKE RELATIVELY MINOR EXTENSIONS TO YOUR MINING ACTIVITIES, GIVEN THAT THE ORIGINAL MINING PROPOSAL HAS ALREADY BEEN SUBJECT TO AN EIS?

IT IS ALSO WORTH CONSIDERING THAT UNLIMITED RIGHTS OF PUBLIC PARTICIPATION WILL INEVITABLY PUSH DECISION MAKING INTO THE POLITICAL ARENA. THAT WILL BE SO SIMPLY BECAUSE THERE WILL BE NO INCENTIVE FOR PRIVATE OR NEGOTIATED SETTLEMENT - YOU CANNOT ARRIVE AT A PRIVATE OR NEGOTIATED SETTLEMENT WITH EVERYONE IN SOCIETY.

BY THE SAME TOKEN, YOU CANNOT ALLOW PRIVATE PARTIES TO "DO A DEAL" THAT REALLY DOES HAVE AN ADVERSE IMPACT ON PEOPLE WHO ARE NOT PARTY TO THE AGREEMENT.

THE TRICK IS TO DEVELOP SYSTEMS FOR IDENTIFYING EARLY IN THE PROCESS, WHAT KIND OF DISPUTE WE ARE DEALING WITH, AND THE PARTIES WHO WILL BE RECOGNISED AS HAVING A LEGITIMATE INTEREST.

THERE IS A GROWING AWARENESS IN GOVERNMENT THAT UNTIL WE INTRODUCE APPROPRIATE STRUCTURES AND PROCESSES THROUGH WHICH THE RIGHTS OF ALL PARTIES CAN BE DEFINED, EXERCISED AND ENFORCED, WE WILL ALWAYS CONTINUE TO HAVE CONFLICT OVER ENVIRONMENTAL ISSUES.

AS I HAVE PREVIOUSLY POINTED OUT, GOVERNMENTS MUST FIRST GET THEIR OWN HOUSE IN ORDER. RIGHTS BETWEEN LEVELS OF GOVERNMENT ARE POORLY DEFINED. DISPUTES OVER ENVIRONMENTAL ISSUES ARE OFTEN NOT SO MUCH A REFLECTION OF IDEOLOGICAL DIFFERENCES, AS A RESULT OF AMBIGUOUSLY AND POORLY DEFINED INTERGOVERNMENTAL 'RIGHTS'.

IN SHORT, IT HAS NOT BEEN SUFFICIENTLY CLEAR WHICH LEVEL OF GOVERNMENT SHOULD HAVE THE RIGHT AND RESPONSIBILITY TO SET OR IMPLEMENT POLICY ON LAND USE AND MANAGEMENT ISSUES. WHILE THESE INTERESTS REMAIN UNCLEAR, GOVERNMENTS MAY CONTINUE TO DENY RESPONSIBILITY FOR ENVIRONMENTAL DISPUTES OR TO HAGGLE ABOUT WH0 MAY LEGITIMATELY INTERVENE TO BRING ABOUT THEIR RESOLUTION.

DISPUTES BETWEEN SOME STATES AND THE COMMONWEALTH OVER NATIONAL ESTATE AND WORLD HERITAGE LISTINGS SHOW HOW THINGS CAN GO WRONG BETWEEN GOVERNMENTS WHEN 'INTERESTS' ARE NOT ADEQUATELY DEFINED.

FORTUNATELY, THE NEED FOR A BETTER AND MORE COMPREHENSIVE DEFINITION OF THE INTERESTS OF GOVERNMENTS IN THE ENVIRONMENT HAS BEEN RECOGNISED. THE SPECIAL PREMIERS' CONFERENCE HELD IN OCTOBER LAST YEAR SAW THE STATE AND COMMONWEALTH HEADS AGREE TO PROCEED WITH THE DEVELOPMENT OF AN INTERGOVERNMENTAL AGREEMENT ON THE ENVIRONMENT.

THIS AGREEMENT WILL PROVIDE A SHARPER DEFINITION OF RIGHTS AND IDENTIFY AREAS IN WHICH BOTH TIER'S OF GOVERNMENT CAN PRODUCTIVELY WORK TOGETHER. FOR EXAMPLE, IT IS ENVISAGED THAT STATES AND THE COMMONWEALTH WILL CO-OPERATIVELY SET NATIONAL AIR AND WATER QUALITY GUIDELINES. INITIATIVES WILL ALSO BE UNDERTAKEN TO PROTECT ENDANGERED SPECIES IN RECOGNITION THAT SPECIES HABITATS IN AUSTRALIA DO NOT FOLLOW STATE BOUNDARIES.

THE PROBLEMS THAT RESULT FROM THE INADEQUATE DEFINITION OF RIGHTS ARE MOST APPARENT IN THE QUALITY OF ENVIRONMENTAL PROTECTION THAT HAS BEEN AFFORDED TO OUR 'COMMON' RESOURCES, SUCH AS THE OCEANS OR THE ATMOSPHERE.

THESE RESOURCES HAVE BEEN SUBJECT TO SOME OF THE WORST ENVIRONMENTAL DEGRADATION BECAUSE THERE HAS BEEN NO OBVIOUS OWNER. THE RESULT IS THAT RESOURCE USERS HAVE HAD VIRTUALLY NO CONSTRAINTS AND NOT BEEN CALLED TO ACCOUNT FOR THE ENVIRONMENTAL IMPACT OF THEIR ACTIVITIES.

NO-ONE HAS A CLEAR RIGHT TO USE THE RESOURCE NOR RESPONSIBILITY FOR ITS PROTECTION.

AS LONG AS THERE ARE POORLY DEFINED INTERESTS, USERS OF THESE RESOURCES WILL CONTINUE TO AVOID THE ENVIRONMENTAL COSTS OF THEIR ACTIONS AND ENVIRONMENTAL INTERESTS CAN DO LITTLE BUT CRY OUT FOR GOVERNMENT INTERVENTION.

THIS REALISATION HAS PROMPTED NSW TO LOOK AT PROPERTY RIGHTS MODELS, WHEREBY USER AND ENVIRONMENTAL INTERESTS ALIKE WILL HAVE A CLEARLY DEFINED AND ENFORCEABLE STAKE IN THE USE AND MANAGEMENT OF COMMON RESOURCES.

IT IS HOPED THAT THE PROPERTY RIGHTS APPROACH WILL FORESTALL SOME CONFLICTS BUT EQUALLY IMPORTANT, PROVIDE A COHERENT AND RATIONAL SYSTEM FOR THE RESOLUTION OF CONFLICTS.

I AM NOT SAYING THAT THAT PROPERTY RIGHTS MODEL IS A PANACEA FOR RESOLVING ENVIRONMENTAL DISPUTES. FOR EXAMPLE, IT IS OBVIOUSLY EXTREMELY DIFFICULT IN SOME CASES TO IDENTIFY AND COST ENVIRONMENTAL IMPACTS. THESE VALUES WILL ALSO CHANGE OVER TIME. HOWEVER, CIRCUMSTANCES DEMAND CONSIDERATION OF SOME NEW AND CREATIVE OPTIONS RATHER THAN NAIVE AND RIGID ADHERENCE TO THE OLD WAYS.

I AM ALSO NOT NAIVELY SUGGESTING THAT ANY ONE SINGLE SOLUTION WILL SUFFICE.

IN SOME INSTANCES DIRECT GOVERNMENT REGULATION WILL BE THE BEST WAY OF ESTABLISHING ACCEPTABLE LIMITS ON ENVIRONMENTAL IMPACTS. THIS RECOGNITION IS REFLECTED IN NEW SOUTH WALES' COMPREHENSIVE POLLUTION CONTROL REGULATIONS.

HOWEVER, IN SOME CASES THE GOVERNMENT CAN BEST ADOPT THE ROLE OF A FACILITATOR AND ASSIST IN ESTABLISHING INSTITUTIONAL FRAMEWORKS AND SETTING PARAMETERS THAT

ALLOW MARKET MECHANISMS TO ACHIEVE ENVIRONMENTAL GOALS.

MOST OF THE PROBLEMS WHICH FIND THEIR WAY ONTO THE AGENDA IN THE ENVIRONMENTAL DEBATE STEM FROM THE FIRST LAW OF ECONOMICS - LIMITED RESOURCES TRYING TO MEET UNLIMITED DEMANDS. IN SOME CIRCUMSTANCES, WE ARE NOW ACKNOWLEDGING THAT THE MARKET PROVIDES US WITH A MECHANISM TO ALLOCATE THOSE RESOURCES IN A WAY WHICH MAXIMISES COMMUNITY WELFARE, RATHER THAN MEETING PURELY SECTIONAL AND SOMETIMES SELFISH DEMANDS. MARKETS CAN OFTEN MAKE DECISIONS THAT POLITICIANS LACK THE WILL OR ADEQUATE INFORMATION TO MAKE.

LET ME GIVE AN EXAMPLE.

IMAGINE IF POLITICIANS AND BUREAUCRATS HAD BEEN FORCED TO DECIDE ON THE PRIORITY BETWEEN COTTON AND OTHER USES OF IRRIGATION WATER. THERE WOULD BE PRESS ARTICLES, PUBLIC MEETINGS, QUESTIONS IN PARLIAMENT AND COMMUNITY DISPUTE AND DIVISION. MERELY CAVING IN TO THE LOUDEST VOICE IN CASES SUCH AS THIS CAN HAVE SIGNIFICANT ADVERSE IMPACTS ON THE COMMUNITY. USE OF MARKET FORCES IN THE NSW IRRIGATION INDUSTRY HAS MITIGATED AGAINST THE NEED FOR A 'POLITICAL' DECISION. INSTEAD, IN ONE YEAR SOME 1500 IRRIGATORS HAVE QUIETLY AND EFFICIENTLY TRADED THEIR WATER LICENCES TO HIGHER VALUE PURPOSES.

WASTE OF THE RESOURCE HAS BEEN MINIMISED BECAUSE ITS REAL COST AND THE ENVIRONMENTAL IMPACTS OF OVER USE ARE INCREASINGLY BEING FACTORED INTO THE WATER CHARGE.

WHILE CONSIDERATION AND USE OF MARKETS IN NSW IS STILL IN THE EMBRYONIC STAGE, EARLY INDICATIONS ARE THAT THE MARKET PROCESS IS CAPABLE OF EFFECTIVELY ALLOCATING ENVIRONMENTAL RIGHTS TO FORESTALL OR REDUCE ENVIRONMENTAL CONFLICT.

IN EFFECT, WITH APPROPRIATE PARAMETERS IN PLACE, MARKETS CAN BE USED TO CREATE AN ENVIRONMENTAL CONSCIENCE WHERE NONE EXISTED. FOR EXAMPLE, UNDER THE GOVERNMENT'S POLLUTER PAYS PRINCIPLE, THE SYDNEY WATER BOARD'S TRADE WASTE DISPOSAL CHARGES IMPOSES COSTS ON INDUSTRIES WHICH DISPOSE OF EFFLUENT THROUGH THE SEWERS. CHARGES INCREASE IN ACCORDANCE WITH THE VOLUME AND TOXICITY OF THE EFFLUENT DISCHARGED. THIS PROVIDES A SIGNIFICANT FINANCIAL INCENTIVE TO INDUSTRY TO REDUCE POLLUTION.

AT THE VERY LEAST, EXPERIENCE IN NSW SUGGESTS THAT MARKET MECHANISMS WARRANT THE SERIOUS CONSIDERATION OF OTHER GOVERNMENTS THAT HAVE ACKNOWLEDGED THAT THE DISPUTE RESOLUTION PROCESS IS FLAWED. ON A SMALL PROMOTIONAL NOTE, THE NSW CABINET OFFICE AND THE DEPARTMENT OF WATER RESOURCES HAVE ARRANGED FOR A NUMBER OF INTERNATIONAL AND AUSTRALIAN EXPERTS TO EXPLORE THESE ISSUES AT A MAJOR CONFERENCE TO BE HELD IN SYDNEY NEXT MONTH.

IN CONSIDERING ENVIRONMENTAL DISPUTE RESOLUTION MECHANISMS GOVERNMENT MUST ALSO EXAMINE THE PROCEDURES THAT SHAPE THE USE AND MANAGEMENT OF PUBLIC RESOURCES.

STATE GOVERNMENTS ARE TRADITIONALLY THE OWNER/MANAGER OF LARGE TRACTS OF LAND. WHERE NATURAL RESOURCES ARE IN PUBLIC OWNERSHIP, ALLOCATING SCARCE RESOURCES AMONGST COMPETING DEMANDS OFTEN CANNOT BE LEFT TO THE MARKET PLACE.

INEVITABLY, THERE WILL BE DISPUTES BOTH WITHIN GOVERNMENT AND ACROSS THE COMMUNITY OVER HOW TO BEST MANAGE STATE OWNED NATURAL RESOURCES. I AM SURE NSW IS NOT UNIQUE IN THIS REGARD.

INDEED, SOME OF THE MOST MEDIA WORTHY ENVIRONMENTAL DISPUTES HAVE FOCUSSED UPON THE DECISIONS GOVERNMENTS HAVE MADE IN RELATION TO THE USE AND MANAGEMENT OF STATE-OWNED LANDS.

THE CHALLENGE HERE IS TO FIND A WAY TO FORESTALL THESE DISPUTES OR RESOLVE THEM AS QUICKLY AS POSSIBLE IN THE LONG TERM BEST INTERESTS OF THE WHOLE COMMUNITY. THIS IS ESSENTIAL IF GOVERNMENT IS TO BE AN EFFECTIVE MANAGER AND CUSTODIAN OF PUBLICLY OWNED RESOURCES.

HOWEVER, DESPITE SOME SIGNIFICANT PROGRESS WE HAVE BEEN MAKING IN NEW SOUTH WALES, MORE NEEDS TO BE DONE TO ENSURE GOVERNMENTS ARE ABLE TO MAKE EFFECTIVE AND LONG TERM DECISIONS REGARDING THE USE OF PUBLICLY OWNED NATURAL RESOURCES.

MANY DECISIONS ABOUT STATE OWNED RESOURCES ARE MADE BY INDIVIDUAL RESOURCE MANAGEMENT BODIES WITHOUT ADEQUATE CONSIDERATION FOR THE OVERALL STATE OR NATIONAL INTEREST.

IN SHORT, THERE EXISTS NO DECISION-MAKING MECHANISM CAPABLE OF ACCOUNTING FOR COMPETING INTERESTS ON A 'WHOLE OF RESOURCE' BASIS.

IN ADDITION, THERE IS A DEFICIENT AND POORLY CO-ORDINATED INFORMATION BASE ON OUR NATURAL RESOURCES WHICH MAKES IT DIFFICULT TO PROVIDE A COMMON AND ACCEPTED INVENTORY ON THE <u>STATUS</u> OR <u>VALUE</u> OF STATE OWNED RESOURCES.

GIVEN THIS, THERE IS A NEED FOR A MECHANISM WHICH ENSURES THAT THE TRUE COSTS AND BENEFITS OF ALTERNATIVE SOLUTIONS ARE PROPERLY UNDERSTOOD AND CONVEYED TO DECISION MAKERS, AND TO THE GENERAL PUBLIC, SO THAT THE ECONOMIC AND ENVIRONMENTAL CONSEQUENCES OF DECISIONS ON THE USE OF STATE-OWNED RESOURCES CAN BE FULLY CONSIDERED.

IDEALLY, THIS MECHANISM WOULD ALSO BE CAPABLE OF STEPPING BACK FROM SPECIFIC ENVIRONMENTAL DISPUTES TO IDENTIFY UNDERLYING CAUSES OF CONFLICT AND TO LAY THE FOUNDATIONS FOR STRATEGIC NATURAL RESOURCE DECISIONS AND POLICIES.

IN RESPONSE TO THIS NEED, MY GOVERNMENT IS CURRENTLY LOOKING AT THE ESTABLISHMENT OF A COUNCIL FOR THE MANAGEMENT OF STATE-OWNED NATURAL RESOURCES THAT WILL PERFORM THE FOLLOWING THREE FUNCTIONS:

* FIRST, IT MUST GATHER CREDIBLE, RELIABLE INFORMATION ABOUT ENVIRONMENTAL AND ECONOMIC QUALITIES OF STATE-OWNED NATURAL RESOURCES.

* SECONDLY, IT MUST BE ABLE TO ASSESS CLAIMS AND COUNTER CLAIMS ON BEHALF OF THE COMMUNITY AS TO WHAT CONSTITUTES THE MOST APPROPRIATE USE OF THESE RESOURCES.

* THIRDLY, IT MUST OFFER UP A PROCEDURE WHICH ALLOWS FOR RESOLUTION OF INEVITABLE CONFLICTS AS THEY ARISE IN A FAIR, OPEN AND SENSIBLE MANNER.

IN ACHIEVING THESE FUNCTIONS, IT MUST, ABOVE ALL, BE CAPABLE NOT ONLY OF LOOKING ENVIRONMENTALLY AT ECONOMIC ISSUES, BUT ALSO ECONOMICALLY AT ENVIRONMENTAL ISSUES.

THE EMPHASIS IN THE CONFLICT RESOLUTION MUST BE EQUALITY OF PROCESS. WHAT MATTERS, AS WITH THE CRIMINAL JUSTICE SYSTEM, IS THAT THE INTEGRITY OF THE PROCESS THAT PEOPLE GO THROUGH TO GET A RESULT, WHATEVER IT MIGHT BE, IS SEEN TO BE OPEN, FAIR AND RIGOROUSLY CONSISTENT.

TO ENSURE REAL AND PERCEIVED INDEPENDENCE, ALL PARTIES INVOLVED IN A DISPUTE MUST HAVE A CLEAR EXPECTATION THAT THEIR CLAIMS WILL BE SUBJECT TO THE SAME RIGOUR AND OBJECTIVE ANALYSIS AS THEIR OPPONENTS.

AS JUSTICE STEWART, CHAIRMAN OF THE RESOURCE ASSESSMENT COMMISSION, PUT IN A SPEECH LAST YEAR, INTERESTED PARTIES MUST BE SEEN TO HAVE THE INTELLECTUAL COURAGE TO SUBMIT THEIR OWN ARGUMENTS TO THE SAME KIND OF SCRUTINY THEY EXPECT OTHERS TO ACCEPT.

HOWEVER, WE ACKNOWLEDGE THAT SUCH A PROCESS CANNOT ALWAYS BALANCE COMPETING CLAIMS. THERE WILL ALWAYS REMAIN INTRACTABLE CONFLICTS FOR WHICH NO AMOUNT OF ASSESSMENT OR PUBLIC AIRING WILL RECONCILE CERTAIN OF THE INTERESTS INVOLVED.

IN THESE INSTANCES, IT IS ESSENTIAL THE MECHANISMS OPERATE TO HAND OVER TO THE POLITICAL PROCESS A CLEAR PICTURE OF THE NATURE OF THE CONFLICT, THE FACTS AND FIGURES, AND A FULL EXPLORATION OF THE IMPLICATIONS OF THE AVAILABLE SOLUTIONS.

IN CLOSING, I NOTE THAT AN UNFORTUNATE MYTH HAS DEVELOPED IN RECENT YEARS THAT SOMEWHERE, SOMEHOW, THERE IS A PROCESS WHICH CAN MAGICALLY DELIVER PAINLESS, COSTLESS DECISIONS ABOUT HOW TO USE OUR SCARCE AND PRECIOUS NATURAL RESOURCES. THIS IS A NAIVE FALLACY THAT IGNORES THE VERY POLITICAL NATURE OF THE ENVIRONMENTAL DISPUTE.

I AM SURE THAT THE PROBLEMS I HAVE SPOKEN OF ARE NOT UNIQUE TO NSW. IT IS ALL TOO EASY TO GET LOST IN THE PROBLEM AT HAND AND TO CONTINUE TO CONFRONT ENVIRONMENTAL DISPUTES ON A CASE BY CASE BASIS, OR TO LOOK TO THE JUDICIARY FOR SALVATION.

NSW HAS LEARNT SOME VERY SIMPLE LESSONS. FIRST, GOVERNMENTS SHOULD AVOID MAKING DISPUTES MORE COMPLEX THAN THEY REALLY ARE AND LOOK AT THE REAL CAUSES OF DISPUTATION.

SECOND, LAWYERS AND BUREAUCRATS AND OTHER EXPERTS CANNOT PROVIDE THE ANSWERS TO WHAT ARE ESSENTIALLY QUESTIONS ABOUT VALUES.

THIRD, GOVERNMENTS SHOULD AVOID THE PRESSURE AND TEMPTATION TO BECOME INVOLVED IN PRIVATE DISPUTES THAT CAN BE RESOLVED BY OTHER MEANS. GOVERNMENTS SHOULD, HOWEVER, ENSURE THAT SYSTEMS ARE IN PLACE TO ENSURE THAT AN ORDERLY, EFFICIENT AND FAIR SETTLEMENT CAN OCCUR.

FOURTH, GOVERNMENTS NEED TO BECOME BETTER MANAGERS OF PUBLICLY OWNED RESOURCES. DECISION MAKING PROCESSES REQUIRE ONGOING REVIEW TO ENSURE THAT THEY ARE RESPONSIVE TO THE ECONOMY AND THE ENVIRONMENT.

FINALLY, RESOLUTION MECHANISMS MUST ALLOW FOR LEGITIMATE POLITICAL INTERVENTION AS A FINAL SOLUTION TO CONFLICT. THIS WILL OFTEN BE NECESSARY WHERE SOCIETY AS A WHOLE HAS A DIRECT STAKE AND WHERE VALUE QUESTIONS ARISE OVER HOW TO BEST UTILISE AND MANAGE PUBLICLY OWNED NATURAL RESOURCES.

I COMMEND MR GOSS AND THE QUEENSLAND GOVERNMENT FOR THEIR EFFORTS IN ARRANGING THIS IMPORTANT CONFERENCE AND HAVE BEEN VERY PLEASED TO OFFER THE SUPPORT AND ASSISTANCE OF MY ADMINISTRATION.

Intro Foreword Overview

THE WAY FORWARD

RESOLVING FOREST CONFLICT IN NORTHERN NEW SOUTH WALES

Prepared by: Dailan Pugh, November 1992, for the NORTH EAST FOREST ALLIANCE

SUMMARY

NORTH EAST NEW SOUTH WALES

map.

North east New South Wales is defined for the purpose of this strategy as the area from the Queensland border in the north to the Hunter River in the south, and from the coast to the New England Highway in the west.

Together with the contiguous area in south east Queensland this region is of international significance and one of the most biologically diverse regions in Australia, encompassing the evolutionary hub of the wet subtropics and the overlap between Australia's predominately northern and southern flora ~~and~~ fauna. It supports the greatest diversity of birds, marsupials, frogs and a variety of other animal and plant groups of anywhere in Australia.

Macleay McPherson

The total area of north east NSW is about 8 million hectares, of which almost 50% retains a cover of natural vegetation, predominately forest. Most of the remnant vegetation has been severely degraded by a combination of logging, burning, grazing and mining, facilitating the invasion of a plethora of introduced plants and animals.

THE PROBLEM

> "In a pattern repeated across Australia, twenty or thirty years sees species decline from abundance to extinction ... there is evidence that birds are declining in abundance with an increasing number of local extinctions. If these suggestions are correct, and we seen no reason to doubt their accuracy, then we do not have the time to wait for the trends to be quantified. If the observations are correct, then we will be able to observe the rapid extinction of species throughout Australia in the next few decades."
>
> Recher and Lim, 1990.

basic biology

Within ecosystems the innumerable components inter-relate in a myriad of ways to form the whole. Climate and soils are the basis upon which ecosystems develop. Plants provide the framework of ecosystems, they convert solar energy trapped by their leaves and nutrients drawn from the earth, with the assistance of mycorrhizal fungi, into the carbohydrates upon which animals depend. In return the fauna assist nutrient cycling, pollinate plants, disperse plant and fungi propagules, control sap-sucking and herbivorous invertebrates, and perform other necessary functions which we are yet to comprehend.

As we continue to decimate ecosystems and eliminate species the repercussions spread throughout the forests, further impairing their ability to function.

OUR EXTINCTION RECORD

Of those species present in New South Wales when Europeans invaded 26 mammals, 11 birds, one frog, 19 plants and an unknown diversity of invertebrates have been lost from the state. This is only the beginning with 49 mammals, 88 birds, 14 frogs, 15 reptiles, 4 fish and 222 plants currently in danger of becoming additions to this rapidly growing list. North east NSW has the dubious distinction of having the highest number of endangered plants in Australia and the highest number of endangered animals in NSW. It is imperative that urgent action is taken if there is a desire to save these species.

Our impact on the natural environment is increasing at an exponential rate, as human populations multiply, new technologies foster new and greater impacts, and the last of our remnants of unmodified ecosystems are laid seige. One of the most frightening considerations is the fact that the consequences of our past and present actions will not become apparent for many years, decades or, in some instances, centuries. Australian ecosystems and species have not yet reached equilibrium with the changes already instigated.

THE THREATS TO BIODIVERSITY

The key factors affecting the ability of a range of native species to persist in New South Wales are habitat loss, fragmentation and degradation. Logging, prescribed burning, road construction, stock grazing, mining and chemical usage have all been found to significantly affect an array of native species. Overshadowing and compounding these impacts are global warming, increasing ultraviolet-B radiation, the buildup of toxic chemicals in foodchains, and displacement of native species by introduced species.

greenhouse effect sea level rises.

The very basis of ecosystems, the soil, has been found to be significantly degraded by the disturbances associated with logging, roading and frequent burning. The soil's structure is being degraded by compaction and loss of organic matter, large quantities of nutrients are being lost in logs and smoke, and destabilised soils are slipping and washing into streams. creating pollution + exacerbating downstream effects

Old-growth forests are fundamental to the basis for maintaining clean and reliable stream flows in north east NSW. As the forests are progressively converted to regrowth, stream flows are declining and becoming less reliable due to the increased transpiration of regrowth. As roading and logging extends onto steeper and more unstable slopes to seek out the remaining old-growth stands, erosion and consequent stream degradation rapidly worsen.

Human ~~People's~~ impacts upon the forest environment are significant, pretending otherwise is not only denying reality but also dangerous. It is imperative that human impacts be recognised and appropriate measures taken urgently to ammeliorate negative impacts and begin redressing the wrong we are doing.

A ROGUE AGENCY OUT OF CONTROL

The Forestry Commission is a law unto itself, it continues with its archaic practices ignoring the recommendations of its own wildlife researchers, the damning report of the NSW Public Accounts Committee, the recommendations of the Federal Resource Assessment Commission, the recommendations of the Soil Conservation Service, and public opinion. It is so entrenched into its "British colonial bureaucracy of the 1950's" (PAC 1990) mentality that it appears unable to respond to the need for change and instead is just digging in deeper and cutting down quicker. ?

?? The Commissions corporate culture

The Forestry Commission has managed public forests predominantly for wood production with wildlife, soil conservation, and stream protection considered constraints and environmental protection measures at best tokenism. Recommendations and findings by research foresters, let alone other ecological researchers, has been regularly ignored by the Commission because they are considered to interfere with timber production. In attempts to justify their practices, the Commission has resorted to propaganda which has been found to often contradict the results of their own research or have no scientific credibility. selectively reported distorted

eg. habitat trees retained per ha.

The Forestry Commission blunders on in intentioned ignorance - returning to remove the old growth remnants from previously logged forests as they rapidly polish off the few remaining tall old growth forests. Their vision of converting the readily accessible forests to tree-farms, while they plunder the less accessible forests for whatever they can get, has almost been fulfilled. The end is within sight.

FOREST RESOURCES ABUSED

In order to maintain a supply of sawntimber, as tall old-growth forests are progressively eliminated, trees previously passesd over as unsuitable are being sought out and logging has extended on to steeper slopes. Total volumes of timber production though has continued to increase due to the removal of ever increasing volumes of woodchips. + previously overlooked filter strips corridors etc.

As the squeeze on the sawn eucalypt timber market tightens the large mills that control the industry are expanding export woodchipping, ~~sometimes~~ with visions of monstrous 'world-scale' proposed pulp mills ~~in the distance~~. Careful Conservative and high value use of our timber resource is discounted because of the perceived need to compete on a world market of large volumes of timber obtained in the cheapest manner possible.

the following scenario appears likely as an projection extension of status quo;

Over the next decade ~~as~~ the few remaining tall old growth forests will be ~~are~~ cut out, pine from plantations and composite timber products will capture more of the market, overseas eucalypt plantations will come on stream, and elimination of tariff barriers will further increase~~s~~ the competitiveness of imported timber - the NSW sawn timber and woodchip industry will inevitably undergo major upheaval as present timber markets dwindle.

THE SOLUTION

"Inappropriate allocation of land to particular land uses leads to major costs associated with degradation and associated rehabilitation and reconstruction. What we require is a proactive approach associated with a better empathy for the land"

Hobbs and Hopkins, 1990.

We have ~~it~~ within our ability the capacity to plan our future so that it is environmentally and economically sustainable. This will entail several steps (1) the recognition of what the future holds if we continue on our pesent course, (2) identify~~ing~~ adequate means of protecting and enhancing our environment, and (3) implementing processes and means of ensuring that the future is environmentally, economically and socially acceptable.

Recent public opinion polls conducted in north east NSW (ref. UNE et al) have shown ~~proven~~ that that the public have an overiding concern for environmental issues, ~~with~~ the issues of most concern are apparently ~~being~~ soil erosion, water quality, and native plants and animals. The majority of people believe that the environment must be protected even if it costs jobs or involves a personal financial cost. It is also clear that people want more plantations, see recreation and tourism values of forests as being important and want more say in how their forests are managed.

In order to meet community desires and ecological necessities following ~~there are~~ four ~~requirements~~ recommendations are made for achieving rational forest management in northern NSW:

1. ~~ensure~~ the establishment of an adequate reserve system ~~that is~~ based on ecological requirements to enable the survival of as many species into our uncertain future as possible;

2. ~~undertake~~ a full assessment of available resources and future public and industry requirements before allocating forests (including land suitable for plantations) to specific long-term uses (e.g. water generation, tourism, timber production);

3. ~~manage~~ forests used for exploitation (timber production, tourism, grazing, bee farming, etc.) to be managed under the constraints imposed by the natural environment and other appropriate uses; and ?

4. ~~undertake~~ a forest assessment and allocation process to be undertaken in an open and balanced manner with full allowance for meaningful public involvement.

transparent impartial

A STEERING COMMITTEE TO REPRESENT COMMUNITY VIEWS.

To achieve this it is proposed that a balanced Steering Committee, comprised of representatives of all major interest groups (Federal, State and community), be established for north east NSW. It is critical that this committee be apolitical and

include a balanced range of community attitudes to ensure that the process is indeed impartial and based on science and not retoric.
rhetoric

The Steering Committee's responsibilities should include appointment of a Regional Advisory Panel comprised of ~~a balanced~~ panel of experts in all relevant fields, the identification of the bio-regions which comprise north east NSW, and the establishment of ~~balanced~~ Bio-regional Committees representing local community interests.
Priority Actions needed

Under the direction of the Steering Committee and Regional Advisory Panel the respective Government departments, according to their expertise, should be required to: identify environmental, cultural, timber, water, recreational, soil, and agricultural values and potential; design a conservation reserve system; delineate land suitable for reaforestation; asses long-term resource requirements for exploitative industries; and prepare wildlife, stream and soil management guidelines.

The Regional Advisory Committee should have responsibility for: guiding and reviewing the assessments by the Government agencies; making input to assist in identifying the social, economic and environmental costs and benefits of various scenarios; identifying future oportunities and requirements; and determining assistance, incentive and adjustment packages required to facilitate required changes.

To ensure that the process of identifying forest values and prefered options is undertaken in a scientifically and socially justifiable manner it is imperative that adequate data be collected and entered into a computerised Geographic Information System for analysis, with the public allowed access to the data and all analysis undertaken in an open manner. Recommendations, proposals for forest-use classifications and resource allocations should be made available in draft form for public submissions.

PROTECTING THE ENVIRONMENT AND JOBS

> "Australia has the resources, the knowledge, the skills and the people to reconstruct degraded environments and restore endangered species. Australians may not feel morally responsible nor have the will to act, but these are political and social challenges, not ecological or technical problems.".
>
> Recher and Lim ,1990.

DESIGNING AN Australian ADEQUATE ~~RESERVE~~ RESERVE SYSTEM

It is clearly recognised that on ecological grounds NSW, or any other state, still does not have an adequate reserve system. Given our ignorance of many species' requirements, ecosystem functioning and the impacts of habitat modification, it is essential that the highest priority be given to establishing a regional system of retained wildlife habitat, ~~which ensures the provision of adequate, and~~ suitably linked, ~~habitat~~ to support viable populations of all species sensitive to forest uses in perpetuity

6

and ~~the~~ a comprehensive reservation of viable and representative examples of all forest ecosystems in their least disturbed state.

In designing an adequate reserve system it is essential to take account of old-growth forests, wilderness, rainforests, requirements of species sensitive to disturbances associated with the human use of ecosystems, the long-term consequences of atmospheric changes (global warming, ozone depletion, acid rain), water resources and human values (cultural, spiritual, aethetic, genetic, recreational).

To overcome the ignorance in which decisions affecting the survival of endangered species are made there is a need to initiate? research on the host of endangered species and threatening processes affecting them in north east NSW.

forgotten / specific

Summary

The most extensive economic uses made of north east NSW's forests are for timber production and grazing. Both these uses are incompatible with the maintenance of the forest's biodiversity and thus are the major economic constraints to achieving an adequate reserve system. As there is no shortage of grazing land and no shortage of regrowth forests the key to overcomming this conflict is to facilitate the transition of the timber industry into regrowth forests and plantations before the pogrom of the few remnants of tall old-growth forests and their dependent inhabitants is complete. It is feasible to restructure northern NSW's timber industry into an ecologically and economically sustainable timber industry if there is the will to do so.

their privileged position in the / maintain status quo / to

In general north east NSW's timber industry is resisting the need to restructure due to their desire to maximise short-term profits by logging the remaining tall old-growth forests and exporting the maximum volume amount of woodchips ~~they can~~ before overseas plantations come fully on stream. ~~This is facilitated by the~~ This industry ... low royalties charged for timber from native forests, which don't represent the true value of the resource or the environmental costs associated with its removal, means that in effect they NE timber industry receive a massive public subsidy. This manifests as an economic disincentive for millers to change their inefficient methods of operation or establish plantations.

In Australia it is estimated that 11% of hardwood sawlogs are comming from old-growth forest while in NSW the estimate is 48%. While north east NSW's large sawmillers claim they need to log old-growth forests, in fact in many areas the transition to regrowth forests has been achieved without much difficulty.

Australia currently exports over 5 million tonnes of timber and imports 2.7 million tonnes of timber products, but because 95% of Australia exports is as low-value woodchips our total exports are worth only a quarter of our imports. This is not the way of a 'clever country.'

The conversion of north east NSW's dying timber industry into an efficient and inovative industry based on ecologically sustainable principles necessitates unprecedented restructuring into an industry for the future. This requires the initiation of a massive plantation programme, a shift to regrowth forests, increasing the productivity of selected regrowth forests by thinning, re-tooling mills (some have already begun this process), and developing new products and markets.

Opportunities exist for the manufacture of speciality purpose hardwood products, composite wood products (e.g. laminated veneers, 'Valwood', 'Scrimber', fibre boards), and paper manufacture aimed at import replacement or production of ethanol as a diesel blend based on fibre crops (including plantations), crop-residues and recycled feedstock. These and other potential products suitable for sustainable industries in north east NSW require considerable research and development.

wildlife
Apart from meeting soil conservation, micro climate modification, aesthetic objectives,

There is a need to initiate a massive reafforestation scheme in north east NSW ~~to~~ provide a resource base for speciality purpose rainforest and eucalypt timbers and economically competitive high volume timber products. Most urgently strategic plantings are urgently required to reverse land degradation, increase farm productivity, improve water quality, provide links between remnants of native vegetation and enhance the survival of endangered species. Plantations can help ameliorate other major environmental problems by acting as sinks for the absorption of carbon dioxide and being utilised for land-based disposal of sewerage. Plantations have social benefits in that they provide meaningful and worthwhile employment and encourage optimism about the future. reallocate could

Transferable skills development, rural economic input.

It is important to note that our remnant old-growth forests have economic values other than, and often incompatible with, timber production. These include: recreation and tourism; maintenance of high quality and reliable water supplies; provision of genetic material of potential value for medicinal, food and timber crops; breeding areas for maintenance of species necessary to maintain ecosystem processes (e.g. pollination, invertebrate control).

Tourism surpasses wool and coal exports as the largest earner of foreign exchange for Australia, with international visitation expected to double by the end of the century. The backbone of the NSW tourism industry is domestic tourism which represents some 86% of tourism expenditure. Tourism's "raison d'etre" is an unpolluted environment of high quality, with north east NSW's parks and reserves experiencing visitation rates now in the order of 2.3 million "visitor days" per annum. This is estimated to directly provide 4 700 jobs in the region and indirectly contribute to many more as tourists attracted to the region by its natural attractions spend considerable time in off-park activities.

Based on research that indicates that water yields rapidly decline to some 50% of pre-logging levels 25-30 years after logging and then slowly recover in line with forest maturity, a Victorian study determined that the economic worth of water from the forests of the Thomson Dam catchment had a 'Net Present Value' of $147 million above continued logging under the current

, corporate entities

system. It is thus evident that water catchment values of old-growth forests can outweigh those of timber production.

new

oriented Timber

There is an oportunity to restructure our timber industry ~~into one of~~ the future instead of the past. There is a fundamental ~~problem~~ in providing financial assistance to industry to achieve ~~this~~ when they have already been susidised for too long ~~and have~~ often invested in mills on the basis that once they ~~log out~~ the ~~old-growth~~ they will close down anyway. Though there is a need to provide employment for those whose jobs may be threatened if mills are unwilling or unable to undertake the transition to regrowth forests and plantations.

difficulty restructuring

directly

OCT resource is logged

has been made

There is scope for generating, with Government assistance, significant employment in providing and improving the resource base and technology for the timber industry of the future.

There are extensive areas of pine plantations (i.e. Walcha-Nundle) established at great expense to taxpayers which Forestry Commission mismanagement has left unthinned and unprunned and thus of degraded quality. The Commission can not find millers willing to undertake commercial thinning or logging in these areas because of the poor quality of the resource, thus non-commercial thinning and prunning is urgently required to at least salvage part of this costly resource and bring some of these plantations into commercial production.

Similarly there are extensive areas of regrowth eucalypt forests suitable for long-term timber production in which the Commission has done nothing to improve ~~their~~ quality and productivity. The productivity of many of these stands can be dramatically improved and rotation times significantly reduced by thinning programmes.

There is also a necessity for extensive plantings for environmental purposes, timber production and to rehabilitate the extensive areas of State Forests and National Parks where regeneration has failed following logging. Integral to such a reaforestation programme is research into the most appropriate species and genotypes for plantings. ~~and~~ the development of value-added products and markets for timber obtained from regrowth forests and plantations.

Further research could address

Each year at least $100 million is allocated to the Pacific Highway in north east NSW, which only represents a fraction of the money spent on infrastructure in the region each year. The equivalent of less than one months spending on the Pacific Highway would most likely be sufficient to undertake the required research and assessment process outlined in this strategy, while a few months more spending may be sufficient to put north east NSW's forests onto an ecologically sustainable footing for decades to come. Can we afford not to do it?

MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

PRELIMINARY REPORT

Dailan Pugh
North East Forest Alliance
March 1992

MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

Preliminary report

"Apart from the hostile influence of man, the organic and the inorganic world are, as I have remarked, bound together by such mutual relations and adaptions as secure, if not the absolute permanence and equilibrium of both, a long continuance of the established conditions of each at any given time and place, or at least, a very slow and gradual succession of changes in those conditions. But man is everywhere a disturbing agent. Wherever he plants his foot, the harmonies of nature are turned to discords. The proportions and accommodations which insured the stability of existing arrangements are overthrown. Indigenous vegetable and animal species are extirpated, and supplanted by others of foreign origin, spontaneous production is forbidden or restricted, and the face of the earth is either laid bare or covered with a new and reluctant growth of vegetable forms, and with alien tribes of animal life."

G. P. Marsh, 1877.

INTRODUCTION

The Forestry Act 1916, National Parks and Wildlife Act 1974 and Environmental Planning and Assessment Act 1979 have all conferred a statutory duty upon the responsible government departments to ensure the conservation of fauna in N.S.W. In the main these departments have abrogated this duty and it has been up to concerned citizens to apply the law where possible. Because of the Forestry Commission's refusal to manage the fauna on the lands it controls in a responsible manner, and the Department of Planning's refusal to ensure the Forestry Commission complied with the Environmental Planning and Assessment Act's requirements to adequately assess the environment before commencement of an activity and prepare an Environmental Impact Statement if their proposed activities were likely to have a significant impact, the Forestry Commission has seriously degraded the faunal values of vast tracts of forests, fostered division in the community and been dragged before the Land and Environment Court on numerous occasions since 1980.

The Land and Environment Court ruling on Corkill vs. Forestry Commission (1991) over three compartments in Chaelundi State Forest, the subsequent ruling of the Court of Appeal and the Endangered Fauna (Interim Protection) Act have clearly established the National Parks and Wildlife Service's responsibility to ensure the conservation and survival of native vertebrate fauna throughout N.S.W. There is thus an unprecedented opportunity for the National Parks and Wildlife Service to develop a comprehensive strategy to protect fauna across all land tenures through both ensuring an adequate reserve system and designing mitigation measures to lessen the impact of developments and activities upon fauna.

It remains to be seen as to whether the National Parks and Wildlife Service will adequately implement their duty to ensure the conservation of fauna throughout the state or whether political interference, lack of resources, lack of resolve and inadequate knowledge of fauna will combine to allow the destruction of our unique fauna to continue unabated. It is hoped that it will not be again necessary for concerned citizens to drag a government department through the courts in order to get them to fulfil their legal responsibilities. Unfortunately history has a way of repeating itself.

It is evident that because of the abysmal lack of knowledge on Australian fauna and the impact of habitat modification upon apparently sensitive species, any conservation strategy can only be based on the best available information at this time and must be modified as more information becomes available. Given that habitat alteration is exponentially worsening and the fact that yet more species are undoubtedly doomed to extinction as changes already wrought upon their habitats become fully manifest it is imperative that a cautious and conservative approach be adopted.

While it is essential that fauna be conserved across the whole of N.S.W. throughout all habitats, this report focuses on forest dependent vertebrate fauna. Many of the principles and recommendations contained herein are applicable to other habitats.

This report is comprised of a summary and recommendations, a detailed background document which is comprised of a variety of extracts and summaries from the scientific literature, a still incomplete list of target species with some notes, and an outline of the legislation.

The report is basically a working document that will be expanded and improved as my limited time allows. Any comments or additional references will be gratefully received.

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March 1992

MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

PRELIMINARY REPORT

MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

PRELIMINARY REPORT
D. Pugh March 1992

DISCUSSION AND RECOMMENDATIONS

Over the last two centuries Australians have led the world in eliminating species from the planet. Over this time New South Wales has suffered the loss of some 11 species of birds and 26 species of mammals. The genetic diversity within numerous species has similarly been dramatically reduced through the obliteration of populations of species. It is evident that the populations of a variety of other species have already been reduced below critical thresholds and that their extinction is inevitable.

To date the majority of extinctions have occurred in the more open habitats of western NSW where the impacts of humans and the animals they introduced was most rapid. The nature and integrity of forested areas has better enabled their inhabitants to withstand the onslaught, but as logging and roading extends into the remaining tall old growth forests many more species are being pushed to the brink of extinction.

Within ecosystems the innumerable components inter-relate in a myriad of ways to form the whole. Vertebrate fauna are key components of forest ecosystems. They pollinate plants, disperse plant and fungi propagules, control herbivorous invertebrates and perform other necessary functions which we are yet to comprehend. As we continue to eliminate vertebrates the repercussions spread throughout the forest and the ecosystem's functioning is further impaired.

The key factors affecting the ability of a range of native fauna to persist in New South Wales are habitat loss, habitat fragmentation and habitat degradation. Logging, prescribed burning, road construction, stock grazing, mining and chemical usage have all been found to significantly affect an array of native fauna. Overshadowing and compounding these impacts are global warming, increasing ultra-violet radiation, the buildup of toxic chemicals in foodchains, and displacement of native species by introduced species.

Habitat can be lost by clearing or by being rendered unsuitable by the loss of habitat components upon which a species relies. Habitat is degraded when components upon which a species depends are diminished but still sufficient to allow a species to persist (even if only temporarily). When considering the persistence of species in degraded habitats it is essential to consider whether the habitat has been rendered sub-optimal or marginal. If the later is the case then individuals encountered in that area may be non-breeding colonists from optimal habitat elsewhere.

As habitat suitable for a species becomes fragmented or degraded other species from more open habitats, or introduced from other countries, may invade to compete with or prey upon resident species (Jarman 1986, Saunders 1990, Andrews 1990, Neave and Norton 1990, Benett 1990, Gilmore 1990). These effects can penetrate well into intact habitat due to the edge effect (Andrews 1990, Bennett 1990, Gilmore 1990).

Fragmentation of populations of a species by unsuitable habitats can disrupt or stop gene flow between remnant populations (Andrews 1990, Barnett, How and Humphreys 1978, Bennett 1990). Entire populations of some species may have already been reduced to such an extent that their long-term viability can only be assured by active and costly management (Clark, Backhouse and Lacy 1991). Many isolated populations may also be suffering the same fate (e.g. Dunning and Smith 1986)

The full ramifications of changes already wrought upon the environment have yet to become fully manifest (e.g. declining numbers of habitat trees and large logs, global warming) and populations of many species can be expected to continue declining for many decades even after activities contributing to their demise cease (e.g. Gilmore 1990).

Disturbance to an ecosystem makes it more vulnerable to invasion by other species and susceptible to climatic changes. Population declines in, or loss of species from, an ecosystem can disrupt the ecosystem's functioning and cause imbalances which may take many years to become apparent (e.g. Bell Miners killing regrowth, Currawongs decimating small bird populations, Dingo control leading to increases in foxes and further declines in medium sized mammals).

The frequency at which disturbances recur is a major determinant of ecosystem potential and the ability of species to persist. If the frequency of disturbance is such that the structural components a species is dependent upon are unable to fully recover before the next disturbance then the impacts will compound the effects upon that species, with each disturbance lessening its ability to persist.

Conservation of natural ecosystems and processes is hampered by our ignorance of animal's requirements and failure to expend significant resources on gaining the required knowledge upon which to make informed decisions. Of the numerous forest vertebrates threatened by forestry activities only a few have been subjected to detailed studies, and for even those few it is evident that we still don't know enough to determine the consequences of what is being done to them.

In intentioned ignorance the Forestry Commission blunders on, returning to remove the old growth remnants from previously logged forests or flattening the alternate old growth coupes,

while they rapidly polish off the few remaining tall old growth forests. Their vision of converting the readily accessible forests to tree-farms, while they plunder the less accessible forests for whatever they can get, has almost been fulfilled. The end is within sight.

While it is undoubtedly too late for some species it is time to stop this madness. We must ensure the establishment of an adequate reserve system, which will undoubtedly encompass most of the remaining tall old growth forests, and do everything possible to preserve the faunal values of the other forests.

A conservative approach to the conservation of forest vertebrates requires that for all species sensitive to forestry activities sufficient habitat is retained free of adverse disturbance to ensure their survival into our uncertain future. To maximise species chances to adapt to environmental changes it is essential to preserve genetic diversity within species by maintaining populations throughout a species range.

Those forests not required for an adequate reserve system still need to be managed to maintain fauna diversity and ecosystem functioning.

Given the abysmal ignorance of most species' demography and habitat requirements, it is necessary to select a number of key species that represent the entire range of organisms to use in determining reservations to conserve minimum viable populations (Possingham 1990), monitoring impacts of forestry practices (Norton and Lindemayer 1990, Milledge, Palmer and Nelson 1991), and modeling impacts of global warming (Busby 1988). A primary research requirement at this time is thus to identify key species, their demography and habitat requirements.

REGIONAL SYSTEM OF RETAINED HABITAT

The state needs to be separated into definable regions within which the aim should be to preserve the existing biodiversity. Given our ignorance of species requirements, ecosystem functioning and impacts of habitat modification it is essential that the highest priority be given to establishing a regional system of retained habitat which ensures the provision of adequate, and suitably linked, habitat to support viable populations of all target species.

A regional system of retained habitat should be comprised of adequate areas reserved from exploitation as legislated reserves, sites of significance and wildlife corridors. Such a system can be complemented by enhanced retention of habitat components and specific fauna prescriptions in unreserved areas.

Where feasible (ie State Forests) reserves should be buffered by habitat subject to a lesser degree of disturbance than normal (e.g. forest logged to a reduced intensity). This is particularly important for small reserves and wildlife corridors.

Legislated Reserves

One of the principle objectives in the establishment of an adequate reserve system should be to ensure the reservation of sufficient habitat to preserve minimum viable populations of all species significantly affected by human activities.

An effective population size needs to maintain genetic variability in perpetuity and provide the genetic means for continued ability to adapt to environmental changes and pressures (Tyndale-Biscoe and Calaby 1975, Mackowski 1986, Dunning and Smith 1986, Davey 1989, Davey and Norton 1990, Possingham 1990). Natural population fluctuations, catastrophes such as fire, drought and disease, along with global warming need to be accounted for in assessing the minimum population of a species needed for it to survive into our uncertain future (e.g. Tyndale-Biscoe and Calaby 1975, Davey 1989, Possingham 1990).

Assessments of minimum viable population sizes span a range from several hundred to tens of thousands, depending on the species (Tyndale-Biscoe and Calaby 1975, Davey 1990, Possingham 1990).

The emphasis should be upon reserving major source areas (e.g. areas with high population densities of target species), refuge areas (areas species are already restricted to, become periodically restricted to, or are predicted to become restricted to as the result of global warming or other factors) and areas with a high diversity of target species.

Faunal diversity and greater population densities of a variety of species have been found to be correlated with more fertile soils and moister sites (Recher, Rohan-Jones and Smith 1980, Binns 1981, Mackowski 1983, Neave and Norton 1990, Recher *et al.* 1991), and moderate slopes (Neave and Norton 1990).

Many wildlife researchers have noted the importance of reserving large areas of old growth forest free from logging activities (e.g. Shaw 1983, Shields and Kavanagh 1985, Loyn 1985, Dunning and Smith 1986, Lunney, Cullis and Eby 1987, Norton and Lindenmayer 1990, Bennett 1990, Milledge, Palmer and Nelson 1991).

The requirements of migratory and wide ranging species need to be considered in reserve design. It is essential that reserves incorporate significant altitudinal and latitudinal variation to account for the predicted future requirements of fauna resultant from global warming (Busby 1988, Arnold 1988, Main 1988, Page 1989, Norton and Lindemayer 1990)

Where possible reserves should be as large as feasible (Tyndale-Biscoe and Calaby 1975, Davey 1989, Bennett 1990) and have a minimum edge to area ratio (Bennett 1990, Gilmore 1990).

Sites of significance

Sites of particular botanical and zoological significance outside major legislated reserves need to be identified and given appropriate protection. Sites of zoological significance should be those with outstanding faunal values or containing populations of nominated threatened, vulnerable and rare fauna (Kavanagh and Webb 1989, Davey and Norton 1990). These sites should be identified in the Fauna Impact Statement process and managed as wildlife priority areas.

Sites of significance could be designated as Flora Reserves or protected under the Preferred Management Priority system if on State Forests. On private lands they could be designated as Environmentally Sensitive under the Protected Lands mapping system or a Conservation Agreement could be entered into with the landholder.

Wildlife Corridors

Corridors of forest need to be retained or established to provide multiple pathways for the dispersal of fauna throughout forests to allow: (i) genetic exchange between isolated populations (Dunning and Smith 1986, Bennett 1990, Saunders 1990), (ii) dispersal to required resources (Saunders 1990, Moon 1990), (iii) preservation of populations of some species in otherwise unsuitable habitat (Kavanagh 1985a, 1985b, Dunning and Smith 1986, Kavanagh and Webb 1989, Bennett 1990), (iv) for required resources for species utilizing adjacent habitats (Bennett 1990), and (v) for migration of species in response to predicted global warming (Busby 1988, Arnold 1988, Main 1988, Page 1989).

Wildlife corridors should be as wide as possible and where possible established in natural forest which has preferably not been subject to severe perturbation.

In general the Forestry Commission relies upon modified streamside retention strips (implemented for erosion mitigation purposes) for wildlife corridors. These may be strips of vegetation 20 metres each side of streams with catchments in excess of 30 or 100 hectares, which may or may not be subject to logging (but not entered by machinery), or "wildlife corridors" comprised of strips 40 metres wide with the outer 20 m subject to modified harvesting. In some instances (e.g. Eden region) 100 m + strips may be retained.

Narrow riparian strips do not provide habitat suitable or adequate for a variety of species (Mackowski 1984, Kavanagh 1985b, Shields and Kavanagh 1985, Dunning and Smith 1986, Bennett 1990, Gilmore 1990, Recher *et al.* 1991). Even where suitable habitat is encompassed corridors with a total width of 200 m have been found inadequate for some species (Kavanagh 1985b).

When designing wildlife corridors it is essential to consider: (i) the species being targeted, their ecology, habitat requirements, and dispersal ability (Bennett 1990), (ii) the edge effect and its impact on suitability of the corridor for target species (Bennett 1990, Saunders 1990, Recher *et al.* 1991), (iii) the pathways actually utilized by species for movement (Davey 1989), and (iv) the necessity of species to migrate in response to global warming (Busby 1988, Arnold 1988, Main 1988, Page 1989).

An adequate wildlife corridor system should encompass: (i) multiple pathways linking retained habitat (Bennett 1990), (ii) reservation of larger areas of suitable habitat at periodic intervals along corridors (Bennett 1990, Recher *et al.* 1991), (iii) linked riparian and ridge corridors sampling suitable habitat for a full range of target species (Recher, Rhonan-Jones and Smith 1980, Dunning and Smith 1986, Conservation, Forests and Lands 1989, Bennett 1990, Recher *et al.* 1991) and (iv) a hierarchy of corridors comprised of broad regional corridors established to restore links between isolated forests, major wildlife corridors within production forests to link important reserved areas and a network of smaller wildlife corridors forming common linkages in the system of retained habitat (Bennett 1990).

While it is essential that wildlife corridor design be based on the actual requirements of target species, as interim measures the minimum width of regional corridors should be at least 200-400 m wide (Saunders 1990, A.H.C. and C.A.L.M. 1992), major wildlife corridors at least 150 m wide (A.H.C. and C.A.L.M. 1992) and smaller wildlife corridors (incorporating all filter strips) at least 80-100 m wide (Recher, Rohan-Jones and Smith 1980, Dunning and Smith 1986, Kavanagh 1989b, Bennett 1990). Davey (1989) recommends not stipulating constant width and enabling boundaries to maximise the structural and species diversity. Recher, Rohan-Jones and Smith 1980 recommend that the riparian environment should be retained intact. Where rainforest occurs in riparian situations the incorporation of their buffer zones into the corridor system will greatly enhance the corridors value for non-rainforest species. Wildlife corridors should not be subject to logging (Recher, Rhonan-Jones and Smith 1980, Conservation, Forests and Lands 1989, Bennet 1990, A.H.C. and C.A.L.M. 1992).

In designing wildlife corridors it is essential to consider the effects of barriers to movement and strategies to facilitate movement across potential barriers (Andrews 1990, Bennett 1990, Saunders 1990). For example it is essential that movement of fauna be taken into account in highway and railway design by the provision of fauna underpasses (Andrews 1990). Forest roads should have fauna underpasses incorporated as well as ensuring that at strategic locations tree crowns can touch across roads to facilitate movement of arboreal species. Measures need to be identified to ensure that underpasses don't act as funnels to

concentrate prey for predators (Andrews 1990). Where possible corridors should not be situated along a road or railway, when they are they should be on one side to maximise effectiveness and minimise fatalities (Saunders 1990).

MULTIPLE USE MANAGEMENT

The Forestry Commission has managed its forests predominantly for wood production with wildlife considered a constraint and wildlife management at best incidental (Dunning and Smith 1986, Mackowski 1987, Davey and Norton 1990). Recommendations and research findings by research foresters have been regularly ignored by the Commission because they are considered to interfere with timber production. In attempts to justify their approach the Commission has resorted to propaganda which has been found to often contradict the results of their own research or have no scientific credibility.

Normal logging practices have been found to have a significant impact on wildlife, causing elimination or severe reductions of a variety of species in logged areas (Tyndale-Biscoe and Calaby 1975, Kavanagh 1985a, 1985b, Shields and Kavanagh 1985, Loyn 1985, Dunning and Smith 1986, Kavanagh and Webb 1989). Species most effected are considered to be those requiring tree-hollows for denning, roosting and/or nesting, eucalypt canopy feeders, nectivorous species, moist ground litter feeders, trunk and bark foraging species, species dependent upon large logs, species reliant upon reliable moisture regimes in gullies and low order streams, and species with narrow habitat requirements (variously Recher, Rhonan-Jones and Smith 1980, Loyn 1985, Shields and Kavanagh 1985, Dunning and Smith 1986, Mackowski 1987, Kavanagh and Webb 1989, Gilmore 1990, Recher *et al.* 1991). Logging has also been found to cause significant declines in some species in nearby unlogged areas (Dunning and Smith 1986, Kavanagh and Webb 1989) and affect fauna outside the region being logged (Recher, Rohan-Jones and Smith 1980).

The impact of logging has been found to be significantly compounded by the common practices of post-logging burning (McIlroy 1978, Rohan-Jones 1981, Recher, Allen and Gowing 1985, Dunning and Smith 1986) and other prescribed burning (Cowley 1971, Rohan-Jones 1981, Shields and Kavanagh 1985, Wilson *et al.* 1990, Moon 1990). Associated roading is also considered to be a major impact (Barnett, How and Humphreys 1978, Andrews 1990, Bennett 1990, Gilmore 1990). Other forestry practices such as application of herbicides and fertilizers, grazing, 1080 baiting and, conversion of native forest to plantations all contribute to the very significant impact of forestry operations on wildlife.

There is a dearth of research on the long term consequences of such disturbances upon fauna. Research to attempt to identify longer term consequences have often compared different sites where site variables can not be adequately accounted for and, as noted by Recher, Rohan-Jones and Smith (1980) "It is possible that some populations of dependent fauna we presently record in buffer strips, on reserves and in regenerating forest are derived from animals bred in the large area of mature forest that remains... There may come a time in the logging cycle when the area of mature forest is reduced to a level where the numbers of animals produced are insufficient to maintain these populations. If this critical point is reached, there would be a precipitous decline in species number and abundance, leaving little scope for remedial action."

Habitat tree retention prescriptions

Hollow-bearing trees, and with them hollow-dependent species, have already been decimated within vast tracts of forests. The problems such fauna are facing is expected to exponentially worsen as the few remaining tall old-growth forests continue to be felled and currently retained trees (in both forests and pastoral lands) die-out without potential replacement trees being available. The full ramifications of changes already wrought will take a century or more to become fully manifest.

To mitigate the impact of logging operations upon some hollow-dependent fauna it is necessary to manage for provision of habitat (hollow-bearing) trees in perpetuity (Recher, Rohan-Jones and Smith 1980, Mackowski 1984, 1987). While this requirement has been clearly identified to the Forestry Commission, Mackowski's (1987) concern that there would be a lack of implementation has been fully justified. Current blanket prescriptions in NSW vary from clumps of 5 habitat trees per 15 ha to 5 per 5 ha, though in individual cases foresters are being forced to retain higher numbers and distribute them more evenly through the logging area. It is reprehensible that there are still no provisions to retain potential replacement trees for the future.

Current prescriptions are a farce because (i) a clump of habitat trees may effectively only be equivalent to one tree for territorial species (Smith and Lindenmayer 1988), (ii) retained trees are more vulnerable to windthrow and post-logging burning (Recher, Rohan-Jones and Smith 1980, Mackowski 1987, Smith and Lindenmayer 1988, Milledge, Palmer and Nelson 1991), (iii) some retained trees have been observed to be already dead or burnt out at the base and unlikely to remain standing for long (pers. obs.), (iv) there is no provision for replacements as retained trees drop out of the system (Mackowski 1984, 1987), (v) there is no attempt to asses the usage of specific trees before delineation (Kavanagh 1989b), and (vi) there is generally no attempt to assess species densities and requirements prior to determining prescriptions for an area.

To determine habitat tree retention prescriptions for an area it is necessary to consider: (i) the habitat requirements and demography of the target species (including various species interactions), (ii) that only one large species may occupy a given tree (Lindenmayer *et al.* 1991), (iii) the type and position of hollows and their suitability for target species (Lindenmayer *et al.* 1991, Mackowski 1987, Davey 1989), (iv) the species of trees involved and their hollow-development characteristics (Davey 1989, Mackowski 1987), (v) the need for a uniform distribution of habitat trees (Dunning and Smith 1986, Mackowski 1987, Smith and Lindenmayer 1988), (vi) the area in a regional context (Mackowski 1984), (vii) the full range of species which utilise hollows in the area and their seasonal use (Davey 1989), (viii) the actual trees which are utilized by specified species (Recher, Rohan-Jones and Smith 1980, Kavanagh 1989b), (ix) the retention of sufficient potential replacement trees to maintain the prescribed number of habitat trees in perpetuity (Recher, Rohan-Jones and Smith 1980, Mackowski 1984, 1987).

It is feasible that management aimed at providing hollows in perpetuity should only need to focus on species requiring larger hollows and endangered species. Some such species would be Greater Glider, Yellow-bellied Glider, Squirrel Glider, Powerful Owl, Sooty Owl, Masked Owl, Yellow-tailed Black Cockatoo, Red-tailed Black Cockatoo, Gang-gang Cockatoo, Glossy Black Cockatoo and a variety of bats. Kavanagh (1989b) recommends the employment of a specialist nest finder for owls, such a concept could be expanded to identify habitat trees for most of these species before trees are felled.

In old-growth forests hollow-availability is not generally considered to be a limiting factor for most species of hollow dependent species but rather other resources that are limiting populations (Dunning and Smith 1986, Mackowski 1984, 1987). It is in logged forests that hollows do become a limiting factor. As well as managing for provision of hollow-bearing trees in perpetuity it is crucial to determine other limiting resources for target species, the recovery time of such resources and when population recovery can be expected.

Many forests have been denuded of habitat trees. To enhance such forests for nature conservation and maintenance of ecosystem functioning they need to be managed for the return of adequate stockings of habitat trees (Mackowski 1987). To determine adequate stockings for already disturbed areas it will be necessary to extrapolate from 'undisturbed' forests of similar type and productivity.

The concept of habitat tree needs to be expanded to include trees offering other critical resources for target species, for example trees tapped for sap or relied upon for abundant nectar at critical times by Yellow-bellied Gliders or the preferred individual food trees of Koalas or Glossy Black Cockatoos. Importantly the supply of large logs in perpetuity needs to be evaluated, target species dependent upon large logs for critical resources identified, their habitat requirements delineated, and the findings incorporated into habitat-tree retention prescriptions.

Habitat trees and their successors should be clearly marked in the field and monitored over time to determine their effectiveness (Recher, Rohan-Jones and Smith 1980, Mackowski 1987).

Suggested procedures to maintain habitat trees in perpetuity are:

1) Undertake surveys in representative old growth forests of each forest type to determine average densities of hollow-dependent and 'large log'- dependent fauna. Assess habitat tree/log requirements to maintain the full array of fauna.

2) Develop models predicting development of hollows in tree species and formation of logs, and their use by target species, in relation to size class (e.g. Mackowski 1984, 1987, Davey 1989). Combine this with models of stand dynamics and proposed silvicultural practices to determine prescriptions for habitat tree provision in perpetuity for each forest type (e.g. Mackowski 1984, 1987).

3) Undertake site-specific surveys to determine target species' presence, habitat requirements and densities. Where possible identify particular trees used by select target species (e.g. Kavanagh 1989b). Use actual findings as a basis for prescriptions with allowance made for predicted and potential occurrences and requirements,

4) Permanently mark habitat trees, and their replacements (Mackowski 1987). Monitor their effectiveness and accuracy of predictions at selected sites over time. Adjust prescriptions as required.

Prescribed burning

A single fire event has been found to have a significant effect upon fauna that inhabit or utilize the ground and shrub stratum (Cowley 1971, Fox and McKay 1981, Recher, Allen and Gowing 1985, Dunning and Smith 1986, Lunney, Cullis and Eby 1987, Wilson *et al.* 1990).

Species of small ground mammals exhibit a replacement sequence in reaching maximum abundance following fire, variously species may reach maximum abundance after one to eight years, with populations of some species found to be still increasing after six to eight years or even after 30 years (Fox and McKay 1981, Wilson *et al.* 1990). Populations of some species may be eliminated by fire (Wilson *et al.* 1990) and others may not establish populations in burnt areas for many years (Fox and McKay 1981, Lunney, Cullis and Eby 1987, Wilson *et al.* 1990).

Post-logging burns are commonly utilized to dispose of logging debris and encourage eucalypt regeneration. Such burning has been found to greatly compound the impact of logging operations on fauna (Recher, Allen and Gowing 1985, Dunning and Smith 1986), and is considered to have a greater impact on some small ground mammals and reptiles than logging (Shields and Kavanagh 1985, Dunning and Smith 1986). Post-logging burning leaves many large logs but due to their often being elevated by branches and other debris they commonly are severely charred, which can render them

unsuitable for many invertebrates and consequently vertebrates. Repeated burning gradually eliminates large logs.

Post-logging burns are of questionable silvicultural value and tractor clearing has been advocated to create the desired disturbance for regeneration (Dunning and Smith 1986), though this can have other undesirable consequences on soils (e.g. compaction). Kavanagh and Webb (1989) found that without burning the clearfelling of patches in their 50% canopy retention treatment resulted in better regeneration than the 'normally logged' treatment.

While populations of some species may recover in parallel with the rate of post-fire revegetation (Recher, Allen and Gowing 1985) it is considered that frequent burning (e.g. control burning) can result in degraded habitat and the loss of habitat components upon which species rely (Cowley 1971, McIlroy 1978, Leigh and Holgate 1979, Rohan-Jones 1981, Moon 1990, Wilson et al. 1990), such as understorey structure and plant species (Cowley 1971, McIlroy 1978, Leigh and Holgate 1979), habitat trees (Rohan-Jones 1981, Mackowski 1987), large logs and litter (McIlroy 1978, Dunning and Smith 1986). It is apparent that some of these habitat components may be restored within a few years but also that many will take many decades or centuries to be replaced.

The Forestry Commission prescribe burns some areas of forest every year (near plantations), every second year (high-risk areas near some roads or tourist facilities) or on frequencies of up to 5-7 years. Their ideal frequency is often not achieved due to labour and funding constraints. The greatest source of non-prescribed burns are graziers with forest-leases who burn vast tracts of forest (often in spring when peak flowering and breeding occurs) as frequently as every year. Grazier's fires must be stopped as a matter of urgency, if necessary their leases should be revoked.

Fuel reduction burns should be well planned, taking into account the frequency, area burnt, timing and intensity of fires (Wilson *et al.* 1990), and the demography, habitat requirements and responses to burning of target species. It is essential that a proper evaluation of burning and its impact on wildlife be undertaken and mitigation measures devised.

Roading

Roads (and other disturbance corridors and barriers) create avenues for the introduction and dispersal of non-forest and introduced species into forests (Dunning and Smith 1986, Richards and Tidemann 1988, Anon 1988, Andrews 1990, Bennett 1990, Gilmore 1990), isolate or restrict movement between populations of some species (Barnett, How and Humphreys 1978, Andrews 1990, Bennett 1990), are significant causes of mortality (Andrews 1990, Bennett 1990, Moon 1990), and have many other deleterious impacts on fauna (Andrews 1990, Bennett 1990).

Introduced predators, such as Foxes and Cats, have had a devastating impact on native wildlife (Jarman 1986, Kinnear 1987, Anon 1988, Bennett 1990, Eason and Frampton 1991, Potter 1991), affecting small and young mammals, birds, reptiles and invertebrates. They have been implicated in the extinction of an array of species. Forests in their pristine state are relatively resilient to invasion and it is roading that is facilitating their spread and hunting efficiency throughout forests.

There is an obvious need to consider wildlife in road planning. Fauna underpasses and overpasses must be incorporated into road design to; facilitate genetic exchange between isolated populations, minimise disruption to social organization, provide access to required resources, and enable migration. Further measures to minimise the impacts of roads are to: retain extensive areas of natural vegetation free of roads (i.e. Wilderness Areas); minimise road clearances through natural areas; close and revegetate forest roads not required for management purposes immediately after use, and; identify effective means of reducing road fatalities.

Rainforest protection

The Forestry Commission is still phasing out 'general purpose' rainforest logging and replacing it with unspecified 'speciality purpose' logging. Their restrictive definition of rainforest is based on aerial photograph interpretation where 20% canopy cover (or in practice even less) by eucalypts or Brush Box is considered sufficient to classify a forest as non-rainforest. This, coupled with often inaccurate typing, is not an acceptable ecological basis upon which to classify rainforest. As a consequence rainforest is still being logged on a 'maximum economic utilization' basis, and surviving rainforest species killed in post-logging burns. There is a need to define rainforests on an ecological basis (Cameron 1991).

The Forestry Commission is allowing logging to occur up to rainforest margins (by their definition) and is regularly constructing roads through rainforest. Logging of rainforest buffer zones has been found to make the rainforest significantly more vulnerable to fire incursions (Cameron 1991, Roberts 1991). The Victorian government has adopted a policy of not allowing logging within 20 m of rainforest where it is "generally linear in shape" and 40 m of other stands. For long-term fire protection Cameron (1990) recommends an unlogged buffer zone of at least 100 m around rainforest, and Roberts (1991) recommends a buffer of "two or three mature tree heights."

1080 baiting

Vast areas of NSW's forest and pastoral lands are aerially or trail baited with fresh meat injected with 1080 or factory prepared 1080 'crackle' baits every year, in efforts to control

wild dogs and Dingoes. Additional baiting with 1080 takes place to control rabbits and other herbivores.

1080 baiting for 'wild dogs' has been found to be taken by a variety of non-target animals, with birds and reptiles taking a large proportion (McIlroy 1986, Allen *et al.* 1991). Carnivorous marsupials have been found to be the most susceptible non-target species to 1080 (McIlroy 1982, Calver *et al.* 1989), with baiting's impact on quolls being the most concern (e.g. Calver *et al.* 1989). Active suppression of Dingoes can enable Foxes greater ingress into forested areas (Jarman 1986).

1080 baiting has been used to reduce fox predation on rock wallabies and found to greatly enhance their breeding success, even though poisoned foxes were rapidly replaced by immigrant foxes (Kinnear 1987).

Burying of meat baits has been found to make them far more target specific and significantly reduce their impacts on non-target species (Allen *et al.* 1989), though there is obviously far more research required to determine the effectiveness of this method. Burying of baits coupled with the retrieval of uneaten baits and poisoned animals four days later has been suggested as a responsible method (Anon 1988).

1080 rabbit etc. baiting is of greater concern because of the direct impact it can have on native herbivorous mammals and the further indirect impact on carnivores feeding on poisoned carcases.

1080 baiting is extensively utilized in State Forests, National Parks and on private lands for control of Dingoes and/or grazing pests (e.g. rabbits, wallabies). There has never been an Environmental Impact Statement prepared for 1080 baiting, even though it is an activity likely to have a significant impact upon the environment and thus an E.I.S. is required by the Environmental Planning and Assessment Act 1979. No further 1080 baiting should be allowed until the E.P.A. Act has been complied with and a Fauna Impact Statement prepared.

Other prescriptions

Grazing, chemical usage, mining and introduced diseases all have significant environmental impacts and their impacts on wildlife need to be fully considered and assessed for planned developments and activities.

1.0 CONSERVATION OF FOREST VERTEBRATE FAUNA IN NSW

Tyndale-Biscoe and Calaby (1975) state "The *Eucalyptus* forests of southeastern Australia and Tasmania support a rich and varied fauna of mammals and birds and together form the single most important refuge for wildlife in Australia. A greater number of mammal species are found in these forests than in any other broad category of habitat..."

McIlroy (1978) notes that within Australia 16% of birds and 17% of mammals are confined to rainforest and 16% of birds and 35% of mammals are confined to sclerophyll forest.

Neave and Norton (1990) state "The major threat to forest fauna arises through the fragmentation and loss of their habitat... The species at greatest risk of extinction are those which appear least resilient to habitat modification... The long-term viability of now disjunct populations of fauna may be compromised further by many factors including predation by introduced carnivores such as foxes... and episodic extreme events like fire, drought and outbreaks of disease... Additional problems include the inadequacy of the existing nature conservation reserves within forests... and the inconsistent regimes of forest management across State borders and land tenures".

Recher (1986) considers that to guarantee the rehabilitation and survival of forest wildlife there is a need to implement practices designed specifically to manage wildlife. He states "It is not enough to set aside samples of forest for nature conservation and expect these, by themselves, to ensure the survival of Australia's forest biota."

Recher (1986) emphasises the need to integrate wildlife conservation and management on private lands with those on Crown Lands and states "The lack of regional and national planning for forest wildlife planning can not be allowed to continue."

Bennett (1990) states "Reserved areas are vitally important for nature conservation, and it is essential that a representative set of natural ecosystems be protected with nature conservation as the primary objective. Nevertheless, this intensive approach is by itself is insufficient. We cannot rely on nature conservation reserves alone for the long-term protection and preservation of wildlife communities. We must develop a broader perspective and manage fauna at a regional, statewide and national scale, that includes lands used for a range of other purposes."

Norton and Lindenmayer (1990) state "Australia needs a coherent strategy to integrate the management of wildlife across all forested lands. The destruction and degradation of forested lands on the Australian continent since European settlement can be attributed to a variety of factors including the need for settlements to survive, ignorance, poor planning and lack of

concern for the environment. But these reasons will become lame if used any longer."

Davey and Norton (1990) state "It is clear that historical patterns of forest-use have had a significant, often detrimental, impact on the population status of many native, forest wildlife. At the same time, knowledge of the effect of these practices on most wildlife is not available. Many more species may have become extinct than is recognized."

Davey and Norton (1990) state "decision-making on the allocation of forest resources (wood, non-wood) appears to favour a perspective that is subjective and political rather than scientific. Political decision-makers have not, in general, adopted an approach in the allocation of these resources based on ecological and environmental principles."

Shaw (1983) states the general goals of wildlife conservation in state forests of Victoria are to: manage in order to maintain the diversity of species which are indigenous to that state's forests, and; manage for featured species (i.e. species of special social or ecological significance).

Loyn (1985) considers the primary objective of wildlife conservation is to ensure that no species becomes extinct or reduced in range. He states it is desirable "to conserve all species in major forest blocks and to do this populations must be maintained above critical levels needed for long-term survival."

1.1 THE BENEFITS OF MAINTAINING THE DIVERSITY OF FAUNA.

Gilmore (1990) states "There is increasing evidence that vertebrate wildlife are essential components of forest ecosystems and contribute to their long term stability and productivity. Vertebrate roles include: facilitating long distance pollen dispersal and outcrossing compared to Honey bees (*Apis mellifera*) and other insects...; consumers of herbivorous arthropods...; dispersers of fungal and higher plant spores and seeds... Passage through an animal's alimentary canal facilitates the germination of mycorrhizal fungal spores ... and the germination of seeds."

1.1.1 INVERTEBRATE CONTROL

Cowley (1971) notes that the majority of land birds are insect eaters, and each occupies an ecological niche relatively free from the competition of other species, stating "The combined effect of these birds on the insect population must be tremendous." He cites the beneficial effects of Pied Currawongs feeding on phasmatids, Yellow-tailed Black Cockatoos on wood boring insect larvae and cockatoos on the larvae of cerambyoid beetles and cossid moths. He notes that forests are the breeding areas for many species that spend most of their time in surrounding farm and pasture land.

A major problem associated with severe disturbance (particularly logging) of forests is the proliferation of the aggressive and territorial Bell Miners *Manorina melanophrys*. They exclude other birds while undertaking "farming" of psyllids, this results in the consequent death of regrowth trees.

Loyn (1985) found that when Bell Miners were removed from a psyllid-infested stand of mixed eucalypts there was an immediate influx of other birds which controlled the psyllids. He notes that the invading species were birds that are more abundant in mature forest than regrowth.

1.1.2 POLLINATION AND PROPAGULE DISPERSAL

Cowley (1971) notes the honeyeaters and lorikeets are important agents in the cross pollination of eucalypts, melaleucas, banksias and grevilleas.

Cowley (1971) notes the Mistletoe Bird is well known for its role in the spread of mistletoe.

Richards and Tidemann (1988) state "There is definitely a close relationship between fruit bats and the reproduction of many of their food trees, primarily through the pollination of flowers as nectar is consumed, and the dispersal of seeds in fruits that are eaten. These processes are vital to rainforest for the continued survival of some tree species and to the general cycle of rainforest regeneration."

Claridge (1990) notes the importance of the symbyotic relationship between mycorrhizae ('fungus-roots') and plants. He notes that hypogeal fungi usually contain their reproductive spores in buried indehiscent fruiting bodies and thus most probably rely upon the potoroos, bettongs and bandicoots which feed upon them to disperse their spores. He cites American research which has identified a similar relationship in coniferous forests.

1.1.3 OTHER BENEFITS

Cowley (1971) notes "The Superb Lyrebird is thought by some ecologists to play an important part in aerating the soil in mountain forests. It has been estimated that their scratchings in certain areas are equivalent to digging the entire forest floor once every two years."

1.2 STRATEGIES FOR MAINTAINING FAUNA DIVERSITY

Cowley (1971) stated "Our immediate objective should be to recognise, classify and conserve the widest possible variety of habitats, and by so doing conserve the greatest possible diversity of species." and "Single purpose reserves can readily

be justified in certain cases, for example where there are rare or endangered species..."

Shaw (1983) suggests a number of measures that can be adopted until research provides the information needed to develop more specific guide-lines: planning to provide appropriate reserves and corridors of old growth timber; providing a range of uncut vegetation reserves which includes at least some that are 2 000 to 20 000 ha in size; considering and planning the arrangement of corridors and reserves in a regional, state and national context; providing buffer strips to corridors that are harvested on a selective cut rather than clear cut; and, focusing wildlife conservation on species of special significance.

Loyn (1985) considers three strategies to provide for species that require old trees or patches of old forest: leave enough trees for them on individual harvested areas; extend the rotation so that there is time for regrowth to develop suitable habitat and be recolonised by breeding populations before it is harvested again; and retain strips and patches of old forest within a mosaic of harvested areas. He considers the later strategy to be most effective.

Recher (1986) cites a number of positive management initiatives: establishment of fauna priority areas; lessening the impact of logging on forest types with a restricted distribution or which are rich in species: establishment of corridors to link drainages and allow movement between nature conservation areas; harvesting forests with high wildlife values on a longer cutting cycle; and, retention of known habitat trees and suitable developing habitat trees.

Davey (1989) considers that within production forest viability of strategic areas will relate to availability of habitat trees, movement corridors and the maintenance of reserves managed for the conservation of wildlife species. He emphasises the value of disturbed forests for conservation of many species and, where required, the manipulation of reserves to meet prescribed wildlife objectives.

Davey (1989) considers that it is necessary for a manager to work within a defined region covering all land tenures (which may extend across State or other boundaries) within which areas of wildlife priority or significance can be identified and managed accordingly.

Dunning and Smith (1986) consider "There are three approaches to conserving arboreal mammals in logged forest; (i) preservation in unlogged reserves or corridor systems; (ii) preservation within logged areas by appropriate rotation and spatial organisation of logging coupes; and (iii) conservation within logged compartments by modification of logging practice and reduction of logging intensity to maintain species and their essential resources at a lower but stable density."

Dunning and Smith (1986) state "The first approach is useful for disturbance intolerant species with broad habitat requirements, the second for species with good dispersal capability dependent on particular successional stages after disturbance and the third for disturbance tolerant species dependent on mature forest."

Dunning and Smith (1986) recommend that the conservation of arboreal mammals and reptiles in their study area may best be achieved by designation of three zones of management: (i) an unlogged rainforest gully corridor system and unlogged moist hardwood ridgetop corridor system; (ii) a moist hardwood zone where logging intensity is low (33% canopy retention); and (iii) a logged moist hardwood zone with the retention of 4-5 hollow nest trees per hectare."

Lunney, Cullis and Eby (1987) recommend a number of options for conserving small mammals, (i) minimizing fire, including control burning, (ii) retaining unlogged forest with dense ground cover, (iii) extending the time over which alternate coupes are logged, to avoid creating a forest of uniform regrowth, and (iv) minimizing disturbance to the ground cover by heavy machinery in the retrieval of logs.

Norton and Lindemayer (1990) propose "the following set of ideal and minimum goals for forest wildlife management:

1. identify the full range of forest ecosystems remaining within the forest estate;

2. determine precisely the size and spatial arrangement of the remaining forest ecosystems;

3. assess the degree to which each forest ecosystem has been, or is being, modified by human practices;

4. establish the current land tenure of these forest ecosystems;

5. quantitatively evaluate the representativeness and viability (in terms of the identified range, size, spatial configuration and degree of modification of forest ecosystems) of the present conservation reserve network within native forests;

6. identify all forest species and determine their geographic range within the remaining native forests. This will need to be undertaken sequentially with perhaps an initial focus on key vertebrate and invertebrate groups...;

7. characterise the variation in genetic diversity exhibited by populations of all species across their geographic range;

8. determine the minimum habitat requirements (i.e. shelter, breeding, food) for the conservation of all forest species;

9. develop and implement a conservation strategy (e.g. revise the existing conservation reserve network, promote a conservation ethic for the use of lands outside the reserve network...) to accommodate all the needs identified in points 5. to 8.; and

10. establish a reliable, scientifically-based infrastructure which permits the strategy in point 9. to be monitored and updated regularly."

Norton and Lindemayer (1990) consider that: (i) the first two management goals could be addressed by the establishment of a geographic information system containing both environmental (e.g. climate, terrain, substrate) and biological data (e.g. location of remaining forest cover, reliable records of plant and animal distributions, forest floristics and structure), (ii) the third goal requires the development of a generally-accepted classification, (iii) the forth goal is readily achievable, (iv) the fifth goal relies on the success of other goals, and (v) goals 6, 7 and 8 depend upon identifying all forest species, their habitat requirements and degree of genetic variability within and between populations. They consider that because the geographic distribution, habitat requirements and genetic variability of almost all forest fauna are not well known, it is necessary to evaluate the possibility of using key species (indicator, keystone and mobile link species) or groups of species that may be indicative of the well-being of ecosystems *in toto* or known important components of ecosystems.

Milledge, Palmer and Nelson (1991) suggest that Yellow-bellied Glider and Sooty Owl, because of their sensitivity to forest perturbation, would make good management indicators in Mountain Ash and possibly Brown Barrel forests. They don't consider the Greater Glider a good indicator. They state "Whether management for the Sooty Owl and Yellow-bellied Glider will cater for other sensitive species in Mountain Ash forest needs detailed investigation."

Norton and Lindenmayer (1990) state "While knowledge of forest ecosystems and wildlife is limited, a number of practical steps can be readily adopted to facilitate more integrated conservation and management. These include a conservative use of forests and the need for more strategic and systematic research and planning. Current forest uses that are not, or do not appear to be, sustainable in the long term should be minimised or stopped. These include extensive forest clearing and the logging of old growth forests on fertile soils. At the same time, it is essential to quantitatively evaluate and upgrade the existing conservation reserve system within forests and to encourage more conservative land-use practices in forests outside of parks and reserves. Without the adoption of these steps in the short-term, it is unlikely that the ecological integrity of many forest ecosystems will be maintained in the long-term. As a consequence, considerable genetic diversity within species will be lost and the probability that forest wildlife will become extinct will continue to increase."

Davey and Norton (1990) consider "that both drought and fire needed to be considered within a wildlife planning framework, particularly in forests subject to logging."

1.3 THE URGENT NEED FOR RESEARCH

Tyndale-Biscoe and Calaby (1975) state "However, it is by no means a simple matter to ascribe a status to a particular species without a thorough study of its life history and ecology. Very few species of the forests we are considering have been so studied. Indeed it is still not possible to say with any precision what species occur in a given forest, how many of each species, nor what the minimum requirements of space and habitat are for long term survival of any species. To do this, inventories of species need to be prepared for selected areas throughout the range of forests and the requirements of each species determined. These later include short term or continuous requisites for individual survival, such as food, shelter and space, and long term requisites for the species' survival. The latter include special breeding grounds, refuges from drought or fire and space for a population of sufficient size to ensure genetic diversity and gene flow. Factors involved in this are density, mobility, fecundity, longevity and social organisation of the species."

Shaw (1983) considers the task of integrating wildlife considerations into forest management practices should be approached at two levels; research to answer basic biological questions concerning forest animals and the effects of forestry on wildlife, and management to translate research findings into actual forest management policies.

Richards and Tidemann (1988) emphasise that although bats constitute one-quartre of Australia's mammal fauna they have received the least attention from scientists, stating "we are still learning the basic biology of our bats, and have not yet even established the full complement of species inhabiting Australia."

Davey (1989) notes "Whilst some information is becoming available, the knowledge necessary to make a sound prediction on the consequences of forest operations upon wildlife does not yet exist."

Davey (1989) outlines some of the research required to enable rational fauna management: an adequate vegetation classification which can be used to delineate faunal habitat across Australian forests; information about the temporal resources of species; differentation/discrimination/identification of critical limiting factors to which a species responds; an understanding of the effects of habitat manipulation on target species; information on behavioural traits associated with physiological requirements; demographic studies of species; and information to enable

accurate prediction of the sizes of populations of forest wildlife.

Davey and Norton (1990) note the paucity of information available on wildlife and outline in some detail the research and planning systems they consider required to achieve scientific and rational forest planning and management for wildlife. They note "Few studies have addressed satisfactorily the meshing of an ecological understanding of wildlife into a forest planning framework. Such an approach, while considered necessary..., is still in its infancy."

Davey and Norton (1990) note "To understand population dynamics, data are required on the life histories (e.g. fecundity, mortality, dispersal) of, at least in the first instance, forest-dependent taxa or species considered to be indicators of biological diversity, guilds or ecosystem stability (e.g. owls, native marsupial carnivores). These types of information are critical for the viable management of functional forest ecosystems and wildlife in fragmented habitats or those subject to recurrent disturbance... Such data are a prerequisite for the determination of minimum viable population size or the planning and management of wildlife corridors."

Norton and Lindenmayer (1990) consider the central requirement to establish a coherent approach to wildlife conservation "is the need to establish a systematic research and management framework to identify important gaps in knowledge and to help set priorities for funding." They identify a number of issues that need to be addressed, including: (i) the feasibility and rationale for using indicators, keystone species and mobile link species, (ii) the effects of fragmentation, including edge effects, (iii) the role of forest corridors and the creation of new habitat in linking and enhancing viability of forest fragments, and (iv) establishing benchmark sites for monitoring ecosystem and population fluxes through time.

There are two major deficiencies with the majority of research into the effects of logging on fauna, (i) very few are comparisons of the same sites pre-logging and post-logging, most comparisons are between sites selected for their similar attributes with no certainty of the variables, and (ii) many sites are within close proximity to unlogged areas.

Gilmore (1990) states "Clearly we need to be able to specify the composition and structure of future stands under all potential management options, and to know what a particular part of the mosaic represents in terms of its suitability as habitat. A long term modelling and simulation capability must be developed, before it can be claimed that our planning and management is based more on science than faith.", and "How forest resources and dependent populations of wildlife are going to fluctuate in space and time, over timespans of several hundred years, needs to be determined. A planning period of this length is needed, as critical wildlife resources may take that long to develop".

Shields and Kavanagh (1985) state "enlightened wildlife management will rely on assessments of the impact of continued operational cycles of forest management on forest fauna."(p.26).

Tyndale-Biscoe and Calaby (1975) conclude "Reliable and worthwhile information cannot be collected in a short time and the deplorable thing is that changes to the forests are going on at such a rate that society may not be able to exercise its rightful choice between eucalypt forests as a timber resource and eucalypt forests as a refuge for wildlife."

1.3.1 FAUNA SURVEYS

Davey and Norton (1990) state "Clearly, forest surveys remain a fundamental component of any viable strategy for wildlife management but, at the same time, they need to be made cost effective. This can be achieved by moving, whenever possible, from one-off inventories towards surveys which record, at least, parameters readily adapted to Geographic Information Systems (GIS) and process models."

Davey (1990) states "Efficient planning for environment and wildlife management in our native forests now requires adequate ecological data bases collected by standardised methods to enable comparison between habitats, regions and years... A standard survey system should provide estimates, in a standardised unit, of relative abundance of the population detected. Techniques should be usable by individuals (an increasing requirement for forest wildlife surveys), should minimise variability between individuals, be both time and cost effective and be compatible with an integrated faunal survey. To be effective, the influence environmental factors have upon detectability and abundance must be known."

Recher. Rohan-Jones and Smith (1980) found that "Abundance, species number and the composition of the avian community differs between years for all plots on which we have two or more years data. The differences are often substantial with species number varying by as much as thirty per cent... and the number of individuals by fifty per cent." and "As the pattern of flowering varies from year to year, nectivorous birds show considerable yearly and seasonal variation in distribution."

Shields and Kavanagh (1985) state "to investigate or conserve animals, it must first be determined whether or not they are present in the areas under consideration."(p.10)

2.0 HABITAT RETENTION

Norton and Lindenmayer (1990) consider "that a reserve network stratified, in part, on regional environmental gradients might help capture the greatest range of forest wildlife... and be a useful basis for managing wildlife in light of climate change... Therefore, a practical approach to maintaining the present diversity of wildlife in native forests needs to aim at ensuring the linking or networking of areas managed primarily for nature conservation across major latitudinal and elevational gradients. This approach would attempt to maximise the long term options available for managing forest wildlife and maintaining ecosystem integrity... and be amenable to modification as new scientific data became available."

Davey and Norton (1990) state "Planning for the conservation of forest wildlife presently centres around the principles of island biogeography, minimum viable population and optimal habitat. ... In general, present design involves the linking of reserves, drainage lines (filter strips) and areas unable to be logged for logistic or economic reasons (refuge areas) with unlogged forest through which wildlife can disperse (wildlife corridors). All these features within the design area remain unlogged."

Bennett (1990) states "in forests used for timber harvesting, corridors must form part of a linked system of retained habitat that will sustain, throughout the forest landscape, populations of species that are sensitive to harvesting. The system of retained habitats will include nature reserves and other existing reserves...; areas exempted from harvesting because of steep slopes, or because they are uneconomic for production; filter strips and buffer strips retained to protect water quality; designated sites of floral or faunal significance; rainforests and their associated buffer strips; and, a hierarchy of wildlife corridors. Initial planning and location of corridors may be most appropriately carried out on a forest block basis, but it is important that the system of retained habitat be co-ordinated and developed from a broader regional perspective."

2.1 RESERVING SUITABLE AREAS

2.1.1 Will existing reserves and steep unloggable country do?

Recher, Rohan-Jones and Smith (1980) state "We do not consider the National Parks and Nature Reserves in the Eden District adequate by themselves for the long term conservation of the region's wildlife.", "Alone each [National Park and Nature Reserve] is probably inadequate in area for the long term survival of the region's full complement of wildlife and their isolation means the prospect of recolonization between parks is remote for all except the most mobile animals.", "The parks west of the Pacific Highway have been located mainly on rough terrain and therefore sample higher elevation and ridge vegetation in greater proportion than the moist gully forest types known to be richest in wildlife.", and "With the exception of Nadgee Nature Reserve, none of the parks was established following a survey of their flora and fauna nor was the scientific community ... consulted."

Recher (1986) states "Generally, the forests reserved for nature conservation have been those in the wildest and most remote places or those on poor soils with limited commercial potential.

Preservation has seldom been preceded by any form of inventory or biological assessment and has been largely a political exercise in response to pressure from the conservation lobby."

Neave and Norton (1990) note "reserves have often been established only where other land use-options have not been considered economically-viable... As a consequence, representative samples of the remaining range of Australia's forest biodiversity are yet to be adequately protected... The size of existing reserves is also of concern as many may not be viable in the long-term without active management... Most reserves in forests are less than 15,000 hectares in size and few are larger than 50,000 hectares".

Kavanagh (1985b) considers that areas reserved because they are steep unloggable country "are likely to contain poor habitat for animals and may therefore be a poor source for the recolonisation of adjacent more favourable, but unlogged areas."

2.1.1.1 WHAT IS GOOD WILDLIFE HABITAT.

Recher, Rohan-Jones and Smith (1980) found that; (i) small ground mammals are most abundant in tall moist forest and low open forest, noting "Few individuals occur in dry open-forest... and, in our experience, forest along ridges is particularly poor for small ground mammals. These habitats are characterised by sparse cover with few shrubs.", (ii) arboreal mammals are uncommon throughout most of the dry forest types in the Eden sub-district and that they are "abundant in moist forest along gullies, creeks and swamp edges", and (iii) about half the bird species have broad preferences in forest-type, with 25 species characteristic of moist forests, 13 species characteristic of dry forests, 3 species most abundant in low forest with Banksia, 2 species most common in Spotted Gum forest and 3 species most common in tableland forest, noting "In terms of the mean number of species and individuals recorded per census, plots in dry ridge forest had poorer avifaunas than plots in the other four categories of eucalypt forest".

Binns (1981) reporting on Braithwaite's research in the Eden Region notes that arboreal mammals were concentrated in areas of favourable habitat rather than randomly or uniformly distributed (60% of animals were in about 5% of the forest area). More were found in tablelands wet sclerophyll types than drier coastal types, on more fertile soils and in areas from which severe fires had been excluded for at least 20-25 years.

Mackowski (1983) states that Braithwaite's findings that high concentrations of arboreal mammals occur only in high site quality forest is supported by preliminary analysis for north east NSW.

Shields and Kavanagh (1985 pp.81-82) state "the conservation of all possum - glider species depends not only on substantial areas

of uncut, unburnt forest but also on retention of tree species diversity."

Gilmore (1990) states "Important determinants of the carrying capacity of a particular stand of forest for vertebrate fauna are, firstly *forest type*, which reflects a limited range of climate, soil and other site variables, as well as the quantity and quality of herbage, nectar and even insect populations available to consumers... Secondly, the *history of the stand* with respect to fire, silvicultural treatments, harvesting etc. The *size and context of the stand*, with respect to adjacent stands and potential sources of plant and animal propagules or colonists, microclimate and edge to area ratio can all influence fauna populations, such that a particular population is prevented from reaching the carrying capacity defined by summing the innate, resource based carrying capacity of a series of stands."

Recher *et al.* (1991) note "The structural and biological diversity of these forests is an indication of the greater availability of water and richer soils (i.e. nutrient status) along creeks and gullies than on ridges. Overall biological productivity is probably greater under these circumstances and greater population densities and richer faunas can be sustained.", and "The lowest population densities occurred in dry open-forests on ridges... These forests were characterized by low plant species diversity, a low, open canopy, poorly developed shrub and sub-canopy vegetation and often had skeletal soils."

Lunney, Cullis and Eby (1987) found that Bush Rat and Dusky Antechinus displayed a significant preference for south-east aspects over north-west aspects.

Neave and Norton (1990) consider the most favoured habitat of Greater Glider can be defined best by forest site productivity (fertile soils and a slope < 15 degrees) within its specific bioclimatic envelope.

Mackowski (1984) found "Blackbutt forest less than about 35 metres site height contains very low possum and glider populations".

Davey (1989) states "Habitat units encompassing optimum habitats for a number of 'target' species should where possible form the core areas as they will be viable sources of population from which a species can disperse."

2.1.1.2 WILDLIFE PRIORITY AREAS

Kavanagh and Webb (1989) state "Wildlife priority areas can be defined as those areas with particular significance to wildlife, either in terms of their richness of species or, in terms of their populations of sensitive and/or rare species."

Kavanagh and Webb (1989) considered that vegetation communities important for the most sensitive (to logging) species - Greater

Glider, Yellow-bellied Glider and Feathertail Glider - should be designated Wildlife Priority Areas, particularly where all three species are present. Kavanagh (1990) further notes that the Sooty Owl and Powerful Owl also need to be considered priority species.

Davey and Norton (1990) consider that significance of areas can be determined in a number of ways, including "(i) high value of optimal habitat reflecting high population density of a select species; (ii) high habitat-unit value (habitat-unit equates with a high diversity of habitats in a geographic area...); and/or (iii) high diversity or population density of select species. Select species are those that are rare, endangered or sensitive (detrimentally) to forest operations."

Davey (1989) considers the significance of an area for fauna can be determined in terms of either (i) habitat values approaching optimum, reflecting high population numbers of a target species, (ii) providing habitat for a lot of target species and/or (iii) high importance values of target species.

Recher *et al.* (1991) state "Those planning the conservation and management of the avifauna in southeastern [NSW] forests must recognise that species may have a restricted elevational range and/or specific habitat requirements. This includes species dependent upon mature forest, but others may have equally precise and particular requirements. Species with narrow habitat requirements (e.g. brown warbler, Lewin's honeyeater, glossy black cockatoo, spotted quail thrush, red-browed treecreeper) and those with special resource needs (e.g. hole-nesting birds such as cockatoos, treecreepers and owls, and bark-foraging species such as treecreepers and shrike-tits) justify the greatest concern from forest managers. Few of these species have shown the ability to adapt to the effects of logging".

Shields and Kavanagh (1985, p.15) state that "at present, conservation by reservation of the preferred forest types (eg. managing for habitat) is the safest option because it is not known what level of logging can be undertaken and still retain viable populations of animals, nor is the rate of recolonisation known for those areas which are rendered temporarily uninhabitable by logging."

2.1.1.3 MIGRATORY SPECIES

Birds and flying-foxes undertake significant seasonal migrations. Conservation of migratory species requires consideration of various species latitudinal migrations (mostly northwards winter movements), altitudinal migrations (mostly species that breed at higher elevations in summer and descend to lower elevations in winter) and nomadic wandering (mostly species following flowering sources).

Recher. Rohan-Jones and Smith (1980) note that in the Eden region 40% of birds "use different habitats during the breeding and non-breeding season and many range widely through the southeast and along the coast. The forest used when not breeding must be

considered as important to the bird as those in which it nests; for most birds the breeding season spans 3 months, the non-breeding season 9 months.", "Fifteen of the 94 forest bird species... are latitudinal migrants which are absent from southeastern N.S.W. during the winter... although small populations of four species... remain over winter. Migrants are most common amongst the cuckoos *(Cuculidae)*, cuckoo-shrikes *(Campephagidae)*, flycatchers *(Musicicapidae)* and honeyeaters *(Meliphagidae)*.", "Also present in the area during winter are birds belonging to the Tasmanian races of the Silvereye and Striated Pardalote.", and "Several species are altitudinal migrants, moving out of the Bondi State Forest during winter into lower altitudes on the coast or to other parts of the tablelands and western slopes.".

Recher. Rohan-Jones and Smith (1980) found that "Abundance, species number and the composition of the avian community differs between years for all plots on which we have two or more years data. The differences are often substantial with species number varying by as much as thirty per cent... and the number of individuals by fifty per cent. Changes are equally great in mature and regeneration plots, but plots do not necessarily change in unison.". They note "...we consider the changes reflect yearly variations in food resources with local and regional conditions affecting the numbers and kinds of birds occurring on any plot at any particular time of the year. The largest changes are almost certainly due to variations in the blossoming of eucalypts and other nectar producing plants.", and "Honeyeaters and lorikeets rely on nectar, however, and their movements are related to the availability of nectar-rich flowers. As the pattern of flowering varies from year to year, nectivorous birds show considerable yearly and seasonal variation in distribution."

2.1.2 The necessity for retaining old growth attributes.

Milledge, Palmer and Nelson (1991) state "Ecologically mature or old-growth forest is dominated by trees which have reached maximum vertical and horizontal expansion and provide fauna with a wide range of resources, including hollows suitable for hollow-dependent species. Mountain Ash is considered ecologically mature at approximately 150 years of age".

Mackowski (1987) interpreted the structure of natural unlogged (old growth) forest "as being an irregular unevenaged forest made up of an overlapping mosaic of even though different aged cohorts." He subjectively determined that two unlogged Blackbutt stands each contained 5 cohorts of trees in various size classes. The cohorts were assumed to have resulted from periodic regeneration events, notably fire induced.

Loyn (1985) considers that the species which need specific attention are those reliant upon old trees or old growth forest, particularly uncommon or rare species which are sensitive to harvesting.

Old trees provide a variety of resources which are either not provided, or provided in significantly lesser quantities, by young trees:

-hollows (e.g. Dunning and Smith 1986, Mackowski 1987, Milledge, Palmer and Nelson 1991, Smith and Lindenmayer 1988)
-large logs (e.g. Mackowski 1987)
-nectar (e.g. Loyn 1985, Kavanagh 1987b)
-some insects in the bark and foliage (e.g. Loyn 1985, Kavanagh 1987b)
-regular and abundant supply of insect food (e.g. Loyn 1985, Milledge, Palmer and Nelson 1991)
-nectar and fruit of mistletoe (Loyn 1985)

Loyn (1985) considers species most reliant upon old growth to be those utilising old trees for feeding, such as some honeyeaters and mistletoebirds which feed on mistletoe nectar or fruit, some insectivorous birds which feed from old eucalypt bark or among canopy foliage and some arboreal mammals which feed on sap and invertebrates from large eucalypt trunks and branches or on canopy foliage in tall eucalypts.

Richards and Tidemann (1988) note that most of the 20 or so species of bats that inhabit Australia's southern forests use tree hollows as refuges in which to roost during the day, and to rear their young, and as 'safe houses' during several months of inactivity or hibernation each winter.

Mackowski (1984) states "Hollows in eucalypt trees are an essential resource for most possums and gliders. Five of the ten possums and gliders occurring in central eastern Australia require tree hollows for denning - arguably nine species require tree hollows for nesting."

Milledge, Palmer and Nelson (1991) found "both the Yellow-bellied Glider and Greater Glider showed a significant association with old-growth forest, and the Sooty Owl and Yellow-bellied Glider were strongly associated with large areas of old-growth forest."

Bennett (1990) states "Species that have been identified as being sensitive to forest changes resulting from timber harvesting are primarily those that are dependent upon some aspect of a mature, or old-growth, forest environment... Animals that use tree hollows, such as forest owls, parrots, cockatoos, gliders, possums and bats, are prominent examples. Of particular importance are those forest-dependent species that naturally occur in low densities; predators (e.g. Masked Owls, Powerful Owl), species with large body size (e.g. Yellow-tailed Black Cockatoo), and those that are social, or have specialised foraging or habitat requirements (e.g. Leadbeater's Possum, Yellow-bellied Glider). For these species, the effect of broad-scale habitat changes are compounded by the need for larger areas to sustain viable populations."

Recher *et al.* (1991) cite research that suggests "the importance of both forest maturity (approximated by total biomass) and

productivity in determining the number of bird species which can co-exist at a site".

Davey (1989) considers sensitive species of fauna dependent upon mature forest need consideration as the lengths of time involved make it difficult to appreciate the long-term effects of forestry practice on these species.

Bennett (1990) notes "it is not uncommon for canopy trees to pre-date European settlement, particularly those trees in small remnants or scattered through farmland. However, there is often an obvious lack of successful regeneration, due to grazing by stock, to replace these ageing individuals. As remnant stands age and senesce we can expect even further depletion of forests and woodlands in the rural landscape, unless active measures are taken to promote regeneration."

2.1.3 Rainforest conservation

Conservation, Forests and Lands (1989) for Victoria define rainforest "ecologically as closed broadleaved forest vegetation with a more or less continuous rainforest tree canopy of variable height, and with a characteristic composition of species and life forms. Rainforest canopy species are defined as shade tolerant tree species which are able to regenerate below an undisturbed canopy, or in small canopy gaps resulting from recurring minor disturbances, such as isolated windthrow or lighting strike, which are part of the rainforest ecosystem. Such species are not dependent on fire for their regeneration."

Cameron (1991) proposed a new ecological definition for rainforest in Victoria:
"Rainforest is defined by a combination of ecological, floristic and structural attributes. In the event of ambiguity, ecological criteria are to be given precedence over floristic and structural criteria and floristic criteria are to be given precedence over structural criteria.

"Rainforest is defined ecologically as fire-sensitive forest composed of or dominated by primary or secondary rainforest species. Fire-sensitive forest is defined as a forest which exhibits a combination of fireproof site characteristics with fire-resistant or fire-retardant vegetation characteristics which minimise the risk of destruction of the rainforest canopy by running crown fire. (The ecological definition includes transitional (ecotonal) and seral (secondary or mixed) communities once they have developed a recognizable understorey canopy of rainforest species below an overstorey of sclerophyll emergents.) Primary rainforest species are defined as shade-tolerant species which are able to establish or perpetuate themselves (either vegetatively or from seed), in the absence of fire, below an undisturbed rainforest canopy, or in minor canopy gaps resulting from endogenous processes of renewal within the rainforest ecosystem, such as isolated windthrow or endemic forest pathology. Such species are not dependent on fire for their regeneration.

"Rainforest is defined floristically as vegetation with a characteristic composition which is consistent with that of rainforest communities or sub-communities described on the basis of a complete regional or statewide floristic analysis of reliable quadrat data. Rainforest may be recognised in the field using floristic field keys based on differential species.

"Rainforest is defined structually as forest vegetation with a rainforest canopy which provides the habitat for a characteristic diversity of dependent life forms. The rainforest canopy is defined as a more or less continuous closed canopy composed of primary and/or secondary species. Most primary rainforest species are broad-leaved and evergreen."

Cameron (1991) notes "A well developed rainforest buffer can shield rainforest from the direct impact of fire by creating turbulence in, and dispersing, oncoming air currents, by absorbing radiant heat and by reducing fire intensity (either by maintaining a moisture differential between the rainforest stand and adjacent sclerophyll vegetation or by having inherent fire retardant properties such as succulent foliage, for example *Myoporum insulare*, or non-flammable foliage with a low oil content, for example some acacias). Post-fire development of a rainforest buffer of secondary rainforest species can be instrumental in providing a nurse crop to nurture primary rainforest species toward maturity. Other biotic factors such as vertebrate and invertebrate grazing pressure, pest pressure, pathogen outbreak and weed invasion may have a significant impact on post-fire succession in particular circumstances."

Cameron (1991) considers "Land use practices such as clearfell harvesting and prescribed burning should be excluded completely from all ecological rainforest buffers because they damage the buffers directly and reduce the effectiveness of homoeostatic mechanisms... which maintain the structural integrity of rainforest. These same land use practices should also be excluded from all catchment based sites of significance for rainforest because they modify fire regimes by increasing flammability, removing old growth eucalypt forest and sharpening moisture gradients."

Roberts (1991) found "The Black and White aerial photographs flown in 1946, over the wet sclerophyll forests in the Otways, just seven years after the 1939 fires, showed clearly the path of the fire through eucalypt forest and rainforest. Although no delineations of rainforest were made on these photographs, it was obvious that clearing for agriculture and heavily logged areas adjacent to rainforest had intensive fire on them which rendered the rainforest extinct or severely damaged, i.e. most rainforest sites on the northern and eastern fall of the Otways. Similarly rainforest areas burnt in the 1919 wildfire were more severely damaged in areas that had been intensively logged or cleared.", and in relation to the 1983 fires in East Gippsland he observed "that many rainforest sites which had intensive selective logging or clearfelling onto the margins or into the rainforest, had severe crown scorch compared to rainforest with no logging around them, which suffered less crown damage and sometimes only a ground fire. Wildfires appear to be severe in dense young eucalyptus regrowth stands..."

Roberts (1991) notes "The intensity of a fire burning into the margins of a rainforest will be far greater through a younger regenerating eucalypt forest than through an old eucalypt rainforest.", and "It is of concern that most patches of rainforest in the state are suffering from clearfelling during the 1970's and 80's around their margins, and that this fact places the rainforest estate at a far greater risk from wild fire, than it has been for millenia. We are possibly twenty years too late fot a large percentage of our rainforest sites. It could only take two dry summers!"

Conservation, Forests and Lands (1989) state "Rainforest must be excluded from timber harvesting, and must be protected by appropriately managed buffers. Timber harvesting operations must be excluded from a buffer area surrounding rainforest. Where the rainforest is generally linear in shape, such as along gullies and streams, the minimum width of the buffer is to be 20 m. Elsewhere the minimum width is to be 40 m. Care must be taken to ensure that no tree is felled into the buffer. Trees which are likely to disturb the buffer must not be felled."

Roberts (1991) considers that clearfelling operations should not take place within a buffer equivalent to two or three mature tree heights from the margins of all old rainforest to "reduce the risk of fire entering rainforest and keep wind turbulence patterns in a more natural state." Cameron (1990) recommends a minimum prescribed buffer width around rainforest of 100 metres.

2.1.4 **Habitat fragmentation**

Bennett (1990) considers habitat fragmentation "one of the major issues confronting wildlife conservation on a global scale. In Australia, clearing and fragmentation of natural vegetation is also of major importance, and it is having a profound effect on our native fauna." He notes that documented examples of species' extinctions have frequently shown an initial pattern of major range reduction and fragmentation followed by successive extinctions of local populations.

Neave and Norton (1990) state "The major threat to forest fauna arises through the fragmentation and loss of their habitat... The species at greatest risk of extinction are those which appear least resilient to habitat modification... The long-term viability of now disjunct populations of fauna may be compromised further by many factors including predation by introduced carnivores such as foxes... and episodic extreme events like fire, drought and outbreaks of disease..."

Possingham (1990) notes "Integrated harvesting fragments populations. Fragmentation can result in a species occurring as small isolated populations, each of which is unlikely to persist. Migration between these small populations is essential to the long-term survival of the species."

Bennett (1990) states "Fragmentation of wildlife habitats can also occur in large, seemingly intact, tracts of vegetation. Timber harvesting, for example, leaves isolated or loosley-connected patches of mature forest (old-growth forest) amid stands of regenerating forest. With the increasing intensity and scope of forestry activities in south-eastern Australia, areas of mature forest outside reserves are becoming fewer in number, smaller in size, and more and more isolated. For the fauna that is dependent upon mature forests, the degree of isolation of populations in these patches is related to their ability to pass through or utilise forests of earlier successional stage. Fires, both natural and of human origin, can also create patches of differing successional stages within extensive natural areas, and so isolate faunal populations that may depend upon a particular seral stage."

Bennett (1990) considers there are three main consequences of habitat loss and fragmentation:

(i) changes in the number of species in fragments - there is a highly significant relationship between the area of a fragment and the number of species that are present, with larger fragments likely to have sampled a greater diversity of fauna habitats and fauna, and larger more viable populations;

(ii) changes in the composition of faunal assemblages - smaller patches support the most widespread and 'edge' species and larger fragments the more uncommon and 'forest-interior' species; and

(iii)changes in the ecological processes - the loss of native species and invasion by exotic species disrupts or modifies ecological processes such as food chains, predator-prey interactions, plant-animal pollination and dispersal associations, and nutrient cycling pathways.

Saunders (1990) in his study of Carnaby's Cockatoo (in remnants in Western Australia) found that nesting attempts at one fragmented site declined from 23 in 1970 to none in 1977, and they have not been recorded in the area since. He observed that at least one nestling was killed by a cat and at least seven nest hollows were invaded and taken over by Galahs. He notes that the galah was not found in the south-west of Western Australia prior to European settlement but has quickly expanded into agricultural areas with clearing of native vegetation, this, coupled with the cockatoo's need to forage widely and consequent inability to adequately defend its nest, has left the cockatoo vulnerable to competition with galahs.

Milledge, Palmer and Nelson (1991) found that in the Mountain Ash forests they studied most records of Sooty Owl and Yellow-bellied Glider were clustered in and about old-growth stands with a core area greater than 1 km^2. They state "The fragmentation of large

areas of old-growth forest will also have a severe impact on the numbers of Sooty Owls and Yellow-bellied Gliders."

Jarman (1986) believes "Remnant communities of wildlife will become more vulnerable to foxes as suitable habitat becomes fragmented."

Gilmore (1990) notes that "many small remnant populations will continue to disappear, as time since isolation is one of the independent variables influencing extinctions in remnants."

2.1.5 Edge effects

Andrews (1990) states "The edge is a human artefact where two contrasting habitats suddenly converge without the natural graduations. The human made edge is usually inimical to most wildlife, and species from the natural interior do not inhabit edges. Species with excellent dispersal abilities, capable of invading and colonizing disturbed habitats, are attracted to edges, and move into the core of natural habitats if a road or utility corridor carries the edge into a previously undisturbed area. The edge experiences a different wind and radiation effect, leading to a different microclimate. If habitats are fragmented too much, and the ratio of edge to interior favours edges, the habitat will no longer be suitable for the interior species we most need to conserve. The core of areas important for conservation should ideally not be dissected with roads and utility corridors which create edge effects."

Bennett (1990) outlines some of the effects of edges:

(i) micro-climate changes - including changes in solar radiation, incident light, humidity, temperature, and windspeed.

(ii) changes in the composition and structure of plant communities - species from adjacent habitats, including weeds, can invade and compete with forest plants,

(iii)wildlife species that are edge specialists and those typical of adjacent developed habitats can invade the edge and become predators, competitors, or parasites of interior species,

(iv) edges are prone to a range of disturbances - including the drift of fertilizers and chemicals from farmland, trampling and grazing by farm animals, fires escaping into forest edges or riparian buffer zones, the placement of access tracks and control burns along edges, and recreational disturbance and littering.

Gilmore (1990) cites research that suggested "that forest-edge and farmland bird species exclude certain forest dependent bird species from smaller forest fragments more than area-dependent changes in habitat or degree of isolation." He notes that a variety of researchers "have all differentiated bird species by the degree to which their populations increase or decline with different degrees of habitat fragmentation."

Bennett (1990) cites various overseas research that found; (i) in terms of vegetation structure the width of the edge was less than 13 m. but based upon the distribution of birds nests the functional width of the edge ranged from 9-64 m., (ii) elevated levels of predation on birds nests at the forest-farmland edge declined with increasing distance into the forest, and were still higher at 100 m than 200-500 m. into the forest, and (iii) changes in the microclimate of forest patches adjacent to farmland extended from 30 m to more than 100 m. depending on aspect.

Gilmore (1990) notes "The creation of a large ratio of edge per unit area between stands of different age will benefit non forest-dependent species. Recent studies overseas indicate that edges and roads are utilized to a greater degree by predators and nest parasites."

2.1.6 Global warming and increasing ultra-violet radiation.

Arnold (1988) notes "that in a relatively short time span man has wrought massive changes on Australia's natural environment. Many species are still adapting their range and abundance to the changes, or are moving slowly towards extinction. The rapidity of the climate changes mean that we will never know what the equilibrium status of different species exposed to the changes imposed by land clearance for agriculture and urban development, and to pastoral activities would have been. Thus it is difficult to assess what additional effects further major changes in the environment will cause."

Main (1988) considers "The critical aspect for understanding the impact of climate change is the appreciation that patchiness is characteristic of natural environments and that this patchiness is maintained by disturbing factors, many of which are related to climate. Consequently, following climatic change the abundance of both animal and plant species will change, and in some cases rarity and commonness may alter. These changes will pose serious problems for management which will have to be within a dynamic context in which not only the impact of climatic change will operate, but also the effects of predators, competitors, and diseases of the indigenous biota may also change dramatically."

Main (1988) notes "The one certainty is that following climatic change the perturbation regime will lead to alterations in the floral composition, species dominance and ecosystem structure, and in the distribution and abundance of species. ...widespread responses of the fauna and flora such as occurred in the past cannot take place now because the natural environment is only represented by remnants of its former distribution. ...Much of the land between remnant areas is unsuited to the passage of many animals or native plants which consequently will be unable to

change their ranges in response to the alteration of climate. The consequences of this will be that some species will be restricted to environments at the limits of their physiological or ecological tolerances and hence be at risk of extinction."

Busby (1988) used a proposed climatic change scenario for the year 2030 to model the impact of global warming on the Long-footed Potoroo and Antilopine Wallaroo and concluded "The future of species which are currently rare and endangered, such as [Long-footed Potoroo], must be urgently considered. The climates of their present habitats are predicted to change, and potentially 'suitable' climates may or may not appear at some other location. In most cases suitable migration corridors will not be available, largely because of major habitat changes around their present locations."

Page (1989) discusses the impact of rising sea levels and shifting climatic zones on ecosystems. He notes that the life zones that circle mountains in tiers would move up vertically and that the higher a life zone moves the smaller it becomes. He states "As an ecosystem becomes smaller, it supports fewer individuals. At some point, an increasingly small population becomes inbred - usually with lethal effects."

Arnold (1988) considers "In previous times when climate changed, those species that were adversely affected became restricted to the most favourable habitat sites. These 'refugia' then acted as sources of conservation from which the species recolonised areas when environmental conditions improved. For many species this state exists now as a consequence of man's impact, and unfavourable climate changes will result in extinctions. For other species, 'refugia' may exist but be isolated by land clearance, and species preservation will depend on man translocating the species to them. Barriers created by man mean that for many species, natural recolonisation can never again occur."

Busby (1988) considers "The climate-change scenario makes it even more imperative that every effort be made now to secure a wide range of present vegetation and landscape types in nature conservation reserves. Emphasis might, perhaps, be placed on areas containing significant altitudinal (Hence temperature and precipitation) variation. This is essential not only for the continued management of currently rare and endangered species, but also for species such as [Antilopine Wallaroo], a presently widely-distributed species of minimal conservation concern, which may become rare and endangered as a consequence of climate change."

2.1.7 Designing adequate reserves

Davey (1989) outlines the five principles that have been applied to the survival of populations on marine islands:

i) as the size of a reserve increases, the probability of any one species becoming extinct diminishes;

ii) a single composite area is preferable to several smaller reserves of equal total size;

iii) if fragmented, reserves should be connected by corridor systems;

iv) if fragmented, reserves are better where equidistant; and

v) if fragmented, reserves are better where close together.

Davey (1989) considers that the forest analogy to 'islands' results from the planting of exotics, clearing for agriculture and intensive logging of native forests on short rotations, which break up the continuity of mature forests.

2.1.7.1 MINIMUM VIABLE POPULATIONS

Tyndale-Biscoe and Calaby (1975) note that an "Effective population number is the population size that will retain the original genetic diversity of the species, or a large fraction of it, in perpetuity and provide the genetic means for continued evolution. It must take account of natural fluctuations and be large enough to withstand the vicissitudes of fire, disease and drought; it is the lowest number that the population can fall to under these circumstances."

Possingham (1990) states "The themes of chance, luck and uncertainty are central to the study of population viability." and "To make a prediction... we first need to understand the processes that may contribute to extinction. These are: demographic uncertainty; inbreeding; loss of genetic diversity; environmental uncertainty; catastrophes. Besides these processes we need to bear in mind several characteristics of a species that influence the probability it will become extinct." He also notes "Australia's environment fluctuates enormously from year to year. These fluctuations add yet another degree of uncertainty to the survival of species. Catastrophes such as fire, flood, drought or epidemic may reduce population sizes to a small fraction of their normal level. When these two additional elements of uncertainty are taken into account the population size necessary to be confident of persistence for a few hundred years increases to several thousand." and "Some scientists present an even more pessimistic picture of species extinction. Studies on mammals that only occur on isolated mountain tops in the south-western United States suggest that a potoroo-sized organism requires a population size of tens of thousands to have a 95 per cent chance of persisting for 1000 years."

Possingham (1990) notes "On the one hand small isolated populations are more likely to become extinct than large populations, however species restricted to a single locality can be extinguished by a single catastrophe." and "Without genetic

variability a species lacks the capacity to evolve and cannot adapt to changes in its environment. The ability of a species to adapt to a changing environment, new predators and new diseases, is essential in this time of increasing environmental change."

Tyndale-Biscoe and Calaby (1975) adopt an effective population of 1,000 individuals as near to the minimum to ensure the continuance of genetic variability and took 5,000 as an effective population size above the minimum for dependent residents of Tall Open forest. Using this they calculated that the area required to support an effective population of Greater Gliders in the area (near Tumut) they studied to be 6,656 - 10,870 hectares.

Tyndale-Biscoe and Calaby (1975) note the futility of setting aside small blocks of land of a few hundred hectares or less as wildlife refuges because (i) species with high attachment to their homesites do not move to other areas because these are already occupied, and (ii) the number of animals that the small reserve can support in isolation is quite inadequate for the species long term survival.

Davey (1989) considers that emphasis in forest planning and management needs to be placed upon maintaining a minimum viable population that will safeguard against genetic degradation and determining the habitat units that will support this population.

Davey (1989) notes that to derive the theoretical breeding population size required to ensure that the population, genetically, does not deteriorate the effective minimum population level (50+) must be adjusted for (i) variance in progeny of females, (ii) sex ratio, (iii) over-lapping generations and (iv) population fluctuations. A multiplication factor of 10 is then applied to allow for long term evolutionary fitness.

Using this formula Davey (1989) calculates that the theoretical long-term breeding population size of Greater Gliders would be 2375 animals, but notes that as the estimate was derived from a poor data base the long-term viable population size of 5 000 suggested by Tyndale-Biscoe and Calaby may well be realistic.

Dunning and Smith (1986) adopt "the minimum population size of 500 proposed by Franklin (1980)", and state "This value increases to an effective population number of 521 for P. volans [Greater Glider] ...when the uneven sex ratios are taken into account.... Examination of the spatial distribution of logged and unlogged moist hardwood ... indicates that this total population [of Greater Gliders] is split into 3 major groups separated by rainforest. An effort should be made to maintain 521 individuals within each of these isolated areas. At present these isolated patches contain approximately 721 P. volans in the west patch, 285 in the central patch and 764 in the east patch. This central patch is the most vulnerable to the effects of inbreeding and loss of genetic variability."

Mackowski (1986) adopted a minimum population size of 500 individuals as "sufficient to maintain heterozygosity for continued evolution depending on even sex ratios". He noted that Yellow-bellied Glider "occurs in foraging groups of two to six individuals... Two hundred and fifty home ranges should represent an effective population size of 500 individuals. The upper limit of reported home ranges for *P. australis* is about 60 ha... Using 250 home ranges of 60 ha each, an unfragmented area of 15,000 ha of suitable habitat should support a minimum effective population of *P. australis*."

Mackowski (1987) states "The planning process should consider the absolute size of wildlife populations to ensure the genetic viability of contiguous wildlife populations in refuge zones and temporally contiguous populations in logged zones."

Possingham (1990) cites Dr. Michael Soule as stating "...it is necessary to stress that MVPs (minimal viable populations) will likely span a range of two or three orders of magnitude (several hundred to several hundred thousand), and that citing the 'few thousand' estimate to a given species... deserves all the contempt that will be heaped on him or her. A variability analysis must be performed for each case, because each case is different. 'Few thousand' is not a rule-of-thumb. Rather, it is a possible, order of magnitude lower boundary... Estimates below this range should be an automatic signal for scrutiny."

Clark, Backhouse and Lacy (1991) report on Population Viability Analysis using the computer program VORTEX for six species, including Long-footed Potoroo and Mountain Pygmy-Possum. They note that most species and populations were highly susceptible to local extinction, stating "Any further habitat loss or fragmentation or reduction in population size or density would result in rapid extinction. ...Options included strict habitat protection, enhancement of existing habitat or restoration of lost habitat, captive breeding, and reintroduction of animals to existing habitat patches in which the species has become extinct in recent decades or to newly created habitat. ...the stimulations demonstrated that if proactive conservation management had been undertaken even five or ten years ago when populations and habitats were considerably larger, the task of present day managers would be much more tractable."

Davey and Norton (1990) note "The crux of the problem for wildlife management is that the habitat needs to be made available to support viable populations of taxa. Currently, there are only a very few species of Australian vertebrates for which there is adequate information to enable an estimate of a minimum viable population. Few studies have attempted estimates for other taxa."

Milledge, Palmer and Nelson (1991) state "To achieve conservation of viable populations of all species with confidence requires knowledge of their individual distributions, abundances, ecological requirements and population dynamics. This task, given current time and financial constraints, is beyond researchers at

present. However, an approach which could offer a partial solution to this dilemma is the adoption of management indicator species."

Possingham (1990) considers "Managing the forest for viable population sizes of a small number of *key species*, may be the most economic way of minimising the loss of biodiversity. The key species should be relatively easy to study and represent the entire range of organisms present in the forests. Some potential candidates include the powerful owl, the yellow-bellied glider and the platypus. Several invertebrates, such as the evolutionarily significant *peripatus*, should be included in the list of key species."

Recher, Rohan-Jones and Smith (1980) note "None of the birds and mammals found at Eden are confined to the district and in a continental context may not be threatened. However, any contraction of a species range increases its vulnerability to other disturbances (e.g. fire, disease) and risks the extinction of the species. With the rapid changes in forest management throughout Australia, it is best to be cautious and ensure that populations of all species are retained in each forestry district.".

2.2 FAUNA CORRIDORS

Bennett (1990) states "Essentially, corridors are linear habitats that differ from a more extensive, surrounding matrix. Frequently, they link one or more patches of habitat in the landscape and may be a pathway for animal movement, but they may occur as isolated lines of habitat."

Bennett (1990) notes that there are a variety of fauna corridors; riparian habitats, hedges, shelterbelts and plantations, fencerows, roadsides, tunnels and underpasses

Bennett (1990) notes that streamside riparian habitats are natural corridors comprised of a band of vegetation that usually is structurally and floristically distinct from adjacent habitats, with which it intergrades. Frequently they support species that do not occur in adjacent habitats or provide necessary habitat components for more widespread species.

Bennett (1990) considers that the structural connectivity of corridors is influenced by the (i) distance they extend, (ii) number and length of gaps, (iii) number of junctions with other corridors, and (iv) presence of 'nodes' of habitat along the corridor.

Bennett (1990) considers that the functional conectivity of corridors depends on (i) the behaviour of the species utilising the corridor, (ii) the scale of the species movements, and (iii) the species response to the width and quality of habitat in the corridor.

2.2.1 The need for Fauna Corridors.

Bennett (1990) considers "Habitat corridors have the potential to make a major contribution to regional conservation strategies by ameliorating the detrimental effects that habitat fragmentation and isolation have on wildlife populations."

Bennett (1990) notes that the island biogeographic theory predicts that corridors will increase the conservation status of habitat isolates by maintaining a higher level of species richness at equilibrium. This is achieved by (i) increasing the rate of colonisation of species to the isolate, and (ii) supplementing declining populations, and reducing the rate of species' extinctions.

Bennett (1990) considers that animals living in remnants can be viewed as 'metapopulations' when there is some level of interchange between them, so as to enable recolonization of populations that have become locally extinct and supplementation of declining local populations. The fragmented populations can thus be considered as one larger population.

Bennett (1990) considers that corridors can fulfil three main beneficial functions in the landscape, (i) habitat for certain species, (ii) facilitate the movement of plants and animals between fragments, and (iii) provide habitat components for species utilizing surrounding habitat.

Bennett (1990) cites various research that has conclusively established the benefits (and often necessity) of streamside habitats, hedges, shelterbelts, plantations, fencerows and roadsides for fauna utilizing them for refuge, foraging, dispersal, migration or as a resident habitat.

In the south east of NSW Kavanagh (1985a) undertook a series of logging trials at Waratah Creek, in which 100 metre buffer strips were left along streams, giving a total width of 200 metres of unlogged forest. He noted that before logging most animals were clustered in or around the 100 metre wildlife corridors and that after logging these corridors appeared to contain most animals within them. Kavanagh (1985b) states "most animals which were found well away from creek reserves before logging were not found in these areas after logging". Kavanagh (1985a) states that "the provision of wildlife corridors appeared to play a major role in retaining populations of arboreal marsupials throughout the areas which were logged." Kavanagh and Webb (1989) note that approximately 50% of the original populations of arboreal marsupials remained after logging, partly because they were most abundant in creek reserves prior to logging.

Saunders (1990) considers the lack of connecting corridors of native vegetation hampered Carnaby's Cockatoo's ability to locate patches of remnant vegetation suitable for feeding, stating "When patches are visually isolated, finding a suitable patch may be a chance event." He cites a previous paper where he "pointed out that avian species will continue to be lost in some locations because very small populations of many species have been isolated on remnants and because many Australian bird species have poor colonizing abilities ...There is a need to provide corridors of native vegetation to link isolated remnants and allow movement between them."

Mansergh (1984) states "as no comprehensive system of corridors between reserves has been incorporated into the reserve system there is a possibility that the Victorian populations of [Tiger Quoll] will be further fragmented."

Moon (1990) notes "Koalas disappear from their usual feeding area from time to time, leading to the conclusion that both corridors and alternate feeding areas are essential to the conservation of a koala population."

Page (1989) notes that there is a need to consider migration of species at higher latitudes and higher altitudes of their range in response to global warming. He notes the vital necessity of corridors as pathways that creatures might take to remain in a familiar climate.

2.2.2. Adequacy of Fauna Corridors.

Bennett (1990) notes that gaps in a corridor can severely disrupt animal movements along the corridor, or the continuity of a resident population within the corridor. He states "For a forest animal, a gap in a forested corridor could be a stream, a road, a strip of grassy vegetation, a burned patch of forest, a break in the canopy, or even a different forest community."

Bennett (1990) considers the length of a corridor can influence its effectiveness in several ways; (i) with increasing length there is a reduced likelihood of single animals (particularly small terrestrial animals) traversing the length of the corridor, and an increased reliance on self-sustaining populations in the corridor to provide habitat continuity, (ii) greater cumulative impact of edge effects (e.g. risk of predation) from adjacent habitats, and (iii) greater vulnerability to sudden disturbance or catastrophe that can cut the corridor (e.g. fire, grazing by stock).

Bennett (1990) notes that the linear shape of corridors means that the ratio of edge to area is very high, which makes them very vulnerable to edge effects. He considers that narrow corridors within farmland may effectively be entirely edge habitat while in contrast, a mature forest corridor surrounded by earlier successional stages of the same forest type is more likely to have an interior habitat and support interior species.

Gilmore (1990) notes "If remnant habitat is long and narrow, such as many retained wildlife corridors and filter strips along gullies, the mean distance between the centre and a series of random points within that home range increases as the home range deviates from circular. Thus species with large home ranges may be excluded theoretically from occurring not by absolute area, but by the shape of the remnant habitat... Obviously the width of wildlife corridors should be adequate to accommodate the diameter of the home range of the vertebrates inhabiting the area, rather than arbitrarily determined values." and because of the edge effect "many wildlife corridors and other linear reserves are probably a suboptimal habitat and inhabitants have lower reproductive success compared to those in continuous habitat."

Kavanagh and Webb (1989) note some deficiencies with the corridor system applied by the Forestry Commission: uncertainty that the creek reserve system contains habitat suitable for the conservation of all sensitive species; uncertainty regarding the minimum number of individuals needed to comprise a "viable" population when the animals are confined to a reserve; low probability of success in maintaining populations of some species in narrow (<100m) linear corridors of mature forest; and, lack of knowledge about the rate of recolonisation of forest regenerating after logging by species initially confined to adjacent corridors and reserves, and whether this can be accomplished within the duration of the logging cycle.

Milledge, Palmer and Nelson (1991) consider that the impact of logging upon Greater Gliders, Yellow-bellied Gliders and Sooty Owls "is unlikely to be mitigated by environmental prescriptions such as those applied to the clearfelling system... where stands of old-growth forest are only maintained as linear stream-side reserves and corridors."

Kavanagh (1985b) notes that Yellow-bellied Gliders "are not easily managed in creek reserves" and populations "apparently can not be maintained unless creek reserves are very large." That is well in excess of the 100 metre each side of streams prescription.

Shields and Kavanagh (1985) note that "the preferred habitats of many species do not include narrow riparian strips or steep unloggable country. Consequently, it is often necessary to take other measures to reserve suitable areas of preferred habitats to ensure conservation of some species."

Recher *et al.* (1991) in their study of birds in the Eden woodchip area conclude "Attention has therefore focused on moist forests along creeks or in gullies where narrow strips (20 m to either side of the drainage) of undisturbed vegetation are normally retained as filtration strips to control erosion and protect water quality. These recommendations, which have been substantially implemented, offer a measure of protection to species at lower elevations that have been shown to have the most restricted habitat requirements. These areas also reserve habitat for a large number of more widely distributed and abundant birds. Reserves along creeks and gullies in tableland forests, although effective, are likely to conserve a smaller proportion of the local avifauna because of the greater area of wet sclerophyll forest in escarpment areas. A problem with implementing these

recommendations in forests affected by integrated logging can also occur where catchments for gullies are small and filtration strips are not required". and, "Birds restricted to dry sclerophyll forests or woodlands are not necessarily protected by reserves or corridors along creeks and gullies. A conservative interpretation of the requirements of the forest avifauna in southeastern New South Wales suggests that it is also necessary to retain areas of mature forest along ridges and on slopes."

Recher *et al.* (1991) note that where narrow creekside reserves (< 80 m. total width, and > 100 m. total width) were retained in areas being converted to pines, they suffered a drop in forest-dependent species and an influx of open-country or non-forest birds within a few years.

Mackowski (1984) notes that "Corridor retention strategy in gullies on a regional basis at Eden (southeastern N.S.W.) is teleologically evident because, at Eden, possums and gliders concentrate in gully areas... However, there are many situations in north coastal N.S.W. where large scale corridor retention in gullies will not preserve the type of habitat that is utilised by the possum and glider community of adjacent logged areas.", and "A drawback of the corridor strategy is that the recruit regeneration event (fire or other disturbance) may have to be specifically allocated to retention corridors as it may be excluded from adjacent forest management."

Shields and Kavanagh (1985) note that "the effect of the Bombala fire on the avifauna of retention strips was drastic - in effect, complete removal of birds."

Andrews (1990) cites a survey of 7 fauna tunnels constructed under a 35 km length of new railway line by the New South Wales Rail Authority which raised the problem that feral predatory mammals could focus their activities on the tunnels which acted as funnels for prey. A comparison with the use of existing culverts showed small mammals used these more, as vegetation cover was well established, and they were too small to allow entrance of some predators.

2.2.3 Design of Fauna Corridors.

Bennett (1990) states "Much of the evidence for the use of corridors by wildlife is observational and concerns remnant corridors that have survived by default rather than by good management (e.g. roadsides, fencerows). There are few planned systems of corridors, and there is little empirical data that addresses practical questions to which wildlife managers and planners require answers in order for ecologically sound corridors to be established. ...Clearly there is an urgent need for quantative, process-orientated research to provide a more satisfactory basis for such planning." He outlines in some detail recommendations for research and management.

Bennett (1990) states "Identification of the species or species assemblage for which a corridor is required, and a basic knowledge of their ecology is a first requirement for corridor design. Knowledge of the spatial scale of a species movements is of particular value. ...Information concerning the habitat requirements, diet and other necessary resources, will assist in optimizing the habitat within the corridor. Other behavioural and ecological attributes, such as the ability to cross gaps, the role of dispersal in the life history, the age of dispersing individuals, social organisation, and behavioural spacing mechanisms within the population, will also influence the ability of species to effectively utilise corridors. ...Design of corridors to provide habitat and effective population continuity for those species with the largest movement patterns and more-specialized habitat and foraging requirements should also encompass the requirements of many other species."

Bennett (1990) considers population continuity between patches of habitat can be achieved by three types of movement along corridors; (i) direct movement by single individuals, (ii) movement by a single individual, punctuated by pauses of hours or even months in the corridor, or (iii) most effectively by genetic flow through resident populations of target species within the corridor.

Bennett (1990) states "Corridor length is obviously determined by distance between habitat isolates, but several measures that may reduce the risks associated with corridor length include: duplication of the corridor; creating a network of corridors; and increasing the width of the corridor to reduce edge effects."

Bennett (1990) states "Incorporation of nodes of habitat along the corridor can increase its effectiveness by providing additional habitat in which animals can pause during lengthy movements, or maintain a larger breeding population, thus introducing more dispersers into the system."

Recher *et al.* (1991) cite previous researchers who "recommended modifications to the creek reserve and corridor system to include the reservation of larger areas (e.g. entire coupes) of forest at periodic intervals along drainages on which creek reserves were established." They note that intent of proposals to add such nodes and retain mature forest along ridges and on slopes "was to include within the corridor system a complete sample of the fauna and their resource requirements along a topographical gradient from gully to ridge as well as providing larger areas of old growth forest for species requiring large, non-linear habitats."

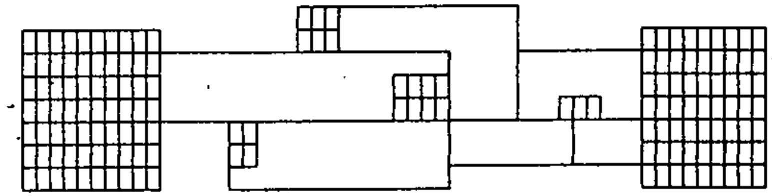

Fig. 1.
A corridor system that provides continuity, multiple pathways and nodes of habitats along the way is likely to be the most effective way of linking animal populations in remnant habitats (adapted from Bennett, 1990)

Bennett (1990) states "The width of a corridor is a particularly important consideration in corridor design as it influences most aspects of corridor function. Maximising the width of corridors is one of the most effective options that wildlife managers can exercise to increase the effectiveness of corridors for wildlife conservation." He notes that increasing width increases species richness and can make corridors more suitable for sensitive species with greater spatial requirements or specialized feeding and habitat requirements.

Bennett (1990) states "The retention of existing natural vegetation to create a corridor is more effective than attempting to reconstruct or revegetate a corridor. A high quality habitat for wildlife requires the full diversity of natural vegetation, and it is maintained by the functioning of natural ecological processes. Resources such as litter, tree hollows, dead trees, hypogeal fungi, and diverse invertebrate communities cannot be created simply by planting trees and shrubs in rows. They require the operation of natural ecosystem processes. There is an urgency, therefore, to retain and protect corridors and natural links that are still present in the landscape before they are lost."

Bennett (1990) states "When corridors link large tracts that include several contrasting habitats (e.g. ridges and gullies in mountainous forest, dunes and swales in arid environments), the corridor must be suitable for species that occur in all habitats. This can be achieved by a broad corridor that encompasses the range of habitats, by duplication of corridors, or by placement of the corridor in a habitat that all species can utilise."

Bennett (1990) envisages a hierarchy of corridors;

(i) Regional corridors to restore natural links between formerly continuous large blocks that are isolated by developed land - because they are generally surrounded by farmland or other developed land, they are likely to experience greater levels of disturbance and consequently a broad swathe of forest will be required to maintain the integrity of the corridor habitat,

(ii) Major wildlife corridors within production forests to provide links between important reserved areas - they could follow the larger river systems,

(iii)Wildlife corridors forming common linkages in the system of retained habitat in a co-ordinated network throughout the forests - research is needed to determine optimum width but in the interim a minimum width of 100 m., with no logging, should be adopted.

Recher, Rohan-Jones and Smith (1980) recommend that:

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

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

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

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

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

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

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

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

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

A.H.C. and C.A.L.M.'s (1992, vol.5) proposed management practices to protect National Estate values in Western Australia include: "CALM has developed a new system of undisturbed strips and patches of vegetation (including mature forest) to provide for wildlife, hydrological and aesthetic values. This system will also be an important source of protection for some national estate values. In particular these patches will help protect some endemic invertebrate fauna and some gondwanic fauna species.

"It is recommended that:

1. all streams, permanent and ephemeral, including valley headwaters and seepage areas will be protected by riparian zones. Timber harvesting will be excluded from these zones;

2. riparian zone width will be variable according to a range of criteria (soil type, slope, type of harvesting, rainfall zone and stream order);

3. ecological boundaries will be used to guide the selection of riparian zone boundaries;

4. the following guideline will be used for selection of riparian zone width:

Stream Order	Width either side (approx)	Total width (approx)	Minimum width either side
First	30	60	20
Second	30	60	20
Third	30	60	20
Fourth	75	150	50
Fifth	200	400	100
Sixth	200	400	100

5. diverse vegetation communities will be protected. These include rock outcrops (>0.2 ha in size), lakes, swamps and other wetland, heathlands, sedgelands, herblands, and

woodlands. Ecological factors will also be used to determine the selection of boundaries of these areas. Transitional vegetation (ecotones) should be kept undisturbed for at least 50 m from the edge of the feature;

6. aesthetic zones along roads and other travel routes will be selected and managed according to Visual Resource Management classification and management guide-lines. The width of these zones will be variable in accordance with VRM criteria. A minimum width of 200 m will be kept free of disturbance on level 1 travel routes and 100 m undisturbed on level 2 travel routes;

7. movement corridors or links between aethetic, riparian and diverse ecotype zones will be provided. These links will be chosen to optimise the mosaic pattern of undisturbed forest. Sites with high moisture and high nutrient status will be favoured in the selection of links. The boundaries of upland linkage corridors should be chosen using VRM criteria as well as ecological criteria;

8. no timber harvesting or vehicle movement will occur within designated riparian zones and diverse ecotype zones. Vehicle movement across riparian zones should be restricted to properly engineered and sensitively constructed stream crossings; and

9. road construction activities will avoid transitional vegetation (ecotone) sites and preferred alignments will be located in high open forest communities."

Conservation, Forests and Lands (1989) in Victoria consider that wildlife habitat must be retained by "linking areas excluded from harvesting and reserves of various seral stages by the retention of forest strips along specified watercourses, mid-slopes and/or ridge-tops, to act as wildlife movement corridors. Wildlife movement corridors are strips of forest at least 40 m wide which are reserved from harvesting to provide for the movement of wildlife and for sufficient diverse habitat to maintain resident wildlife populations. In certain situations it may be desirable to retain much wider corridors. Where such corridors are at least 80 m wide, selective logging is permissible on the outer 50% of the extra width (i.e. 25% on each side)".

Kavanagh (1989b) recommends the retention of 100m wide wildlife corridors for a radius of 2.5km around known localities of the Powerful Owl and Masked Owl. For Sooty Owls he recommends 200m wide wildlife corridors for a distance of 1km.

Saunders (1990) states "The optimum width of the connecting strip is not known and would be expected to vary for different species, but several general principles must be borne in mind by planners. Roads and railway lines should be placed to one side of the corridor, not in the middle as is presently standard practice in Western Australia. A road or railway line may act as a barrier to movement from one side to the other (in some species), doubles

the amount of edge of the remnant vegetation and increases the chances of highway fatalities. In addition, linear reserves should be wide enough to retain their integrity and to resist the degrading physical and biotic influences of edge effects. ... In the agricultural areas of Western Australia these connecting corridors should be at least 200 m wide and any road or railway line should be located on one side. Such reserves should not be restricted to road and railway reserves, as these pose dangers to animals through collision with transport. Linkages are, where possible, better placed along paddock boundaries and drainage lines."

Dunning and Smith (1986) state "Results of this study suggest that two corridor systems are necessary for the conservation of arboreal mammals. One continuous gully system should incorporate the unlogged rainforest gullies throughout the study region. This corridor system would preserve rainforest inhabiting species, principally [Rufous Ringtail Possum, Mountain Brushtail Possum and Fawn-footed Melomys]. A second interconnected ridgetop corridor system of unlogged or lightly logged moist hardwood forest will be necessary for conservation of mature hardwood dependent species such as [Greater Glider]. [Greater Glider] cannot be conserved within a rainforest gully corridor system ... The ridgetop corridors may only need to be relatively narrow (approximately 100 m) if they are sited adjacent to or continuous with ...low intensity logging and tree hollow retention zones".

Dunning and Smith (1986) consider "The unlogged ridgetop moist hardwood corridor system should have side branches that link up with the rainforest corridors to provide an avenue for movement of species that utilise both habitat types, and to increase the area of contact between logged forest and unlogged source areas for species that can recolonise after logging.", and "The proposed corridor system may possibly prevent the isolation of [Greater Glider] populations and allow genetic exchange through juvenile dispersal."

Mackowski (1984) states "Strip/corridor management needs the managerial control input of knowing what possum and glider communities occur in all forest types. This is so that a particular community is not missed in the strip retention system without justification."

Davey (1989) recommends that corridors may be improved by maximising diversity of stream side reserves through not stipulating constant width and enabling boundaries to maximise the structural and species diversity, and designing movement corridors through forest where it can be shown movement actually occurs.

3.0 MANAGEMENT FOR WILDLIFE AND OTHER PURPOSES

Tyndale-Biscoe and Calaby (1975) state "it is by no means easy to determine how much alteration the wildlife can tolerate when the forests are used as a resource for other commodities. This is due to our great ignorance about the majority of forest species."

McIlroy (1978) stated "There is general public support in Australia for policies of multiple use management of forests including, in particular, the conservation of wildlife. The problem is that in any single forest area it is impossible to satisfy the requirements of every animal species. A choice must be made between various management plans."

Mackowski (1987) states "The strategy of multiple use can be criticised because management is incapable of rigourously valuing options... Therefore multiple usage tends to default to the single use that is most conveniently valued".

Mackowski (1987) notes "Wildlife and other environmental objectives are often considered as constraints when discussing commercial forest management."

3.1 TIMBER

3.1.1 Does Multiple Purpose management work?

Dunning and Smith (1986) state "Under the Forestry Act, the Forestry Commission of New South Wales is obligated to conserve native wildlife in State Forests, but when this objective conflicts with that of timber production, as it clearly does in many regions, timber production has generally achieved management priority over wildlife conservation. Wildlife conservation has largely been achieved inadvertently in unlogged, erosion control streamside corridors, areas of inaccessible or excessively steep terrain, or low site quality forests with a high proportion of 'defective' trees."

Mackowski (1987) states "Historically, the general approach to Australian wildlife management has been exterminate then deify - or, don't bother at all.", "Incidental management of wildlife is the management (of wildlife populations) that occurs due to natural resource management that does not consider wildlife and has non-wildlife objectives. The management of arboreal wildlife in Australia has been subject to a long tradition of incidental management.", "Natural resource managers often cannot rely on continued consensus following compromise advice from disciplines with opposed goals..., and may consider co-operation between such disciplines as unnatural acts... As well as immiscibly compromised advice, management organisations have to deal with inertia of established personnel to the acceptance of novel management goals... This inertia has occurred in north American commercial forests, where there has been a lack of implementation of hollow tree management policies... The potential for similar

lack of implementation in Australia's commercial eucalypt forest should not be overlooked."

Davey and Norton (1990) state "Despite the creation of seemingly appropriate legislation and formal structures relatively early in the development of the forestry industry to oversee the wise management of resources , it is clear that wise management has not been achieved. Several commentators have concluded that, in practice, forestry in Australia has been conducted within a philosophical framework, albeit unwritten, of wood primacy... That is, its practitioners believed that the principle function of forestry was wood production. Multiple-use management was considered to be wood production plus other uses." and, "...this history of resource management has had a significant impact on, at least, the past and current status of forest wildlife. Most State Forests have been cut over and few old-growth stands remain. Wildlife habitats have been removed, modified, fragmented and created."

Dunning and Smith (1986) describe the "normal logging" of "moist hardwood" forest in northern N.S.W.; "This generally involves 75%-95% of canopy removal, depending on the timber quality in the stand, followed by a post logging burn and minimal stand improvement. Large defective trees may be removed by ringbarking or felling and regeneration may be aided by planting with seedlings during logging operations in what is referred to as 'timber stand improvement" (TSI) operations. Current practice in the study region now favours defective tree retention and regeneration by natural means, a policy of 'minimal stand improvement'."

Kavanagh and Webb (1989) describe "normal logging" in southern N.S.W.; "Integrated logging as normally practised in the region results in the retention of about 10% of the original tall canopy cover in the forest, although this may vary depending upon the nature of the terrain and the proportion of commercially acceptable tree species. This cover is comprised mainly by the 4-5 evenly spaced mature trees retained per ha to act as a source of eucalypt seed, the 5 'overmature' hollow-bearing trees per 15 ha left specifically to enhance the requirements of wildlife for habitat, and other trees which may provide good sawlogs in the future". Their normally logged coupe retained 28% of the original canopy cover, 21% of the original basal area (m2/ha), and 6 trees > 80 cm. dbhob.

Recher, Rohan-Jones and Smith (1980) expected the following effects of logging in the Eden District to become manifest:

"1. There will be a decline in the abundance of animals which require mature forest. The impact will probably be greatest on species which require large trees or tree hollows. A number of birds and mammals may be threatened with extinction on a regional level.
2. Open-country, shrub and heath species of birds will increase in abundance. Some ground mammals may also become more abundant.
3. Changes in the pattern of flowering and the abundance of nectar will affect the movements and numbers of nectivorous

birds. There will be fewer opportunities for reproduction of these species and there may be a decrease in the abundance of nectar feeders north and south of Eden.
4. There may also be other changes in abundance, patterns of movement or nesting cycles which will not become apparent until a significant part of the existing mature forest is logged and replaced by regeneration."

3.1.1.1 MAMMALS

Recher, Rohan-Jones and Smith (1980) compared plots in unlogged and logged (2-3 years after clearfelling) dry open forest and low open forest and found that Brown Antechinus, Bush Rat, Swamp Rat and House Mouse were most abundant on the logged plots, Dusky Antechinus more abundant on unlogged low open forest and logged dry open forest plots, and White-footed Dunnart only found on one unlogged dry open forest plot. They state "Clearfelling eliminates arboreal mammals from the logged area. ...small numbers of arboreal mammals (e.g. Greater Glider, Mountain Possum) persist in patches of mature forest... or in the strips of forest retained along watercourses."

Recher, Rohan-Jones and Smith (1980) state "At this stage of our research, we consider that all gliders (*Schoinobates, Petaurus,* and *Acrobates*), the Koala (*Phascolarctos*), and several forest bats (e.g. *Myotis, Miniopterus, Nyctophilus,* and *Tadarida*) ... among the native mammals are probably sensitive to the effects of integrated logging ...Populations of Pygmy Possum (*Cercartetus*), Short-eared Possum (*Trichosurus*) and Dunnart (*Sminthopsis*) may also be reduced."

Dunning and Smith (1986) state "In general, the effects of logging on arboreal mammals were consistent with each species food and general habitat requirements. Clearfelling (5% canopy retention) caused a significant decline in populations of [Greater Glider, Rufous Ringtail Possum and Brown Antechinus] and an apparent decline in numbers of [Mountain Brushtail Possum]. This result presumably reflects loss of food and foraging substrate for all these species and is consistent with the results of previous studies."

Dunning and Smith (1986) state "The conservation of arboreal mammals in logged forests is a function of individual species preference for particular seral stages after logging, dispersal ability and proximity to recolonisation source populations and the availability of nest sites."

Dunning and Smith (1986) found that the abundance of Ringtail Possum, Greater Glider and Brown Antechinus declined significantly following normal logging, with no Ringtail Possums found 2 months after logging and no Mountain Brushtail Possums 5 months after logging (they note that numbers of these later two species increased in unlogged areas and areas logged to a lesser intensity - suggesting movement out of 'normally' logged areas). They state that the Greater Gliders observed following normal

logging "were on the borders with the 66% retention and the control II zones and it is assumed that their territories may have overlapped this area prior to logging. No animals were observed away from boundaries."

Milledge, Palmer and Nelson (1991) found that Yellow-bellied Gliders had a strong relationship with old-growth forest and made "little use of young forest even where stags or scattered old trees apparently suitable for nest and den sites were available.", with "Most records were clustered in and about old-growth stands with a core area greater than 1 km^2". They found that the Greater Glider was more abundant in old-growth forest and considered its distribution was more closely linked with hollow availability. They concluded that conversion of old-growth Mountain Ash forest to a series of stands younger than 80 years of age will cause substantial reductions in densities of the Greater Glider and the likely loss of the Yellow-bellied Glider.

Tyndale-Biscoe and Calaby (1975) "predict that about ten species of mammal resident in Eucalyptus forests will probably disappear altogether from areas clear-felled. For these species, reserves of indigenous forests are the only means for their long term survival."

Kavanagh (1985a) stated that "the 10% and 25% canopy retention treatments clearly form no part of the management strategy designed to maintain populations of arboreal marsupials where these animals are to be given priority. The value to arboreal marsupials of the 50% canopy retention is also doubtful."

Kavanagh and Webb (1989) found "Species which remained more abundant in unlogged forest compared with all logging treatments were the Greater Glider, Yellow-bellied Glider, Feathertail Glider, and the lizards *H.maccoyi, S.tympanum* and *L.coventryi*."

3.1.1.2 BIRDS

Shields and Kavanagh (1985 p.78) cite research that found the greatest effects of logging on birds fell among the hollow nesters, eucalypt canopy feeders, the moist ground litter feeders and the non-passerines in general. They also note that regenerating forests lose some 20% of the bird species found in mature forest (pp. 18,43,67).

Recher, Rohan-Jones and Smith (1980) found "The early stages of regeneration in the Eden District support bird species found also in the ground and shrub layers of mature forest. ...In addition regeneration supports bird species typical of heath, scrub and open-country habitats and which are not normally found in mature forest. A number of open country and shrub birds appear to be increasing in abundance as a result of integrated logging... Birds which feed in the canopy of mature forest (e.g. Spotted Pardalote) or on the trunks and branches of trees (e.g. White-throated Treecreeper) are absent or scarce in young regeneration.", and "In effect, logging regeneration up to ten years of age supports fewer than half the breeding bird species expected in mature forest on a comparable site... In particular, species which nest in hollows or in the canopy and those which forage on tree trunks or in the canopy are absent from young logging regeneration. ...A young forest with some older trees which provide nest and foraging sites will have more birds than a forest of the same age where older trees are absent."

Recher, Rohan-Jones and Smith (1980) state "Among the birds, 10 to 15 per cent or more of the terrestrial avifauna is sensitive to the effects of clearfelling ...The most sensitive birds in our estimation, are the cockatoos (*Calyptorphynchus* and *Callocephalon*), lorikeets (*Trichoglossus* and *Glossopsitta*), owls (*Ninox* and *Tyto*), parrots (*Aprosmictus* and *Platycercus*), Owlet-nightjar (*Aegotheles*), Sacred Kingfisher (*Halycon*), and tree-creepers (*Climacteris*). These constitute 10 per cent of the terrestrial avifauna. Each of these birds and mammals requires tree hollows as nest or den sites. Species which need tree hollows are the species *most likely* to be affected by integrated logging."

Milledge, Palmer and Nelson (1991) found that the relative frequency of records of the Sooty Owl in different age classes suggests that its optimum habitat is large patches of old-growth forest. They note "The Sooty Owl was most abundant in old-growth forest, but often occurred in young stands... The proximity of some records in young stands to old-growth stands... suggested that some pairs of Sooty Owls include areas of both young and old-growth forest in their extensive home ranges... However, some findings in young forest removed from old-growth forest ...indicated that other pairs were able to occupy stands lacking high densities of old live trees.", and "Most records were clustered in and about old-growth stands with a core area greater than 1 km^2". They concluded that conversion of old-growth Mountain Ash forest to a series of stands younger than 80 years of age will cause substantial reductions in densities of the Sooty Owl.

Mackowski (1987) notes the importance of downed timber to wildlife, stating "The harvest of timber from cohorts in a rotation < 40 y.o. would leave a minimal volume of down timber behind in the forest. This down timber would be of smaller piece size, and contain proportionately more sapwood, than that left following similar logging of older forest cohorts. This timber would be less in volume than what falls to the forest floor in natural forest and would also be less resistant to decomposition by decay and fire. This may have significant effects on carbon flow through the forest ecosystem to soil organic matter, and on energy flow to decomposer organisms and organisms at higher trophic levels that provide food for ground dwelling vertebrate wildlife and for tree nesting but ground foraging carnivores..."

Gilmore (1990) states "Lowered soil moisture in dry seasons and reduced stream flows consequent on the establishment of densely stocked plantations, beyond the stage of crown closure, has the potential to influence the suitability of gully habitats and

streams for amphibians, and possibly other vertebrates. Clearly these effects will depend on the temporal and spatial mosaic of plantation types and age and treatment of stands and of other land cover within the catchment. Effects are likely to be greater for species dependent on gullies and low order streams within smaller catchments, but the extent of the impacts on fauna has not been investigated so far."

Recher, Rohan-Jones and Smith (1980) note "If we are dealing with a single avian community and not a series of discrete populations along the coast, then changes in resource abundance (i.e. nectar) in the Eden District will affect the numbers of nectivorous birds outside the region."

Recher, Rohan-Jones and Smith (1980) state "We are in a similar dilemma when it comes to predicting the escalating impact on fauna as the area of mature forest is progressively reduced in area. It is possible that some populations of dependent fauna which we presently record in buffer strips, on reserves and in regenerating forest are derived from animals bred in the large area of mature forest which remains (i.e. in 1979) in the Eden District. There may come a time in the logging cycle when the area of mature forest is reduced to a level where the numbers of animals produced are insufficient to maintain these populations. If this critical point is reached, there would be a precipitous decline in species number and abundance, leaving little scope for remedial action."

3.1.2 Habitat tree retention prescriptions

Mackowski (1984) notes "Management for adequate, uniformly distributed hollow trees and recruits does reduce problems of fragmentation and adequacy of reserve size suggested by biogeographic island theory".

Mackowski (1987) states "The occurrence of arboreal wildlife in eucalypt forest is dependant on a suite of critical resources that differ for different species... Tree hollows are resources that are measurably separate to other resources, and are critical to a large number of arboreal wildlife in eucalypt forest".

Smith and Lindenmayer (1988) note that "Approximately 75% of arboreal marsupials use tree hollows as daytime refuges for shelter or reproduction".

Mackowski (1987) considers "The tree hollow resource in eucalypt forest may vary as to: (i) number of trees with hollows, (ii) number of hollows in each tree, (iii) size and disposition of hollows, and (iv) suitability of hollows for various species of wildlife."

McIlroy (1978) emphasises that to define how many trees and logs containing appropriate hollows should be retained, and at what stage the remaining or regenerating trees and logs will become useful to certain animals, further research is needed on (i) the types or characteristics of hollows required by different species, (ii) the specific number and distribution of hollow-containing trees and logs and the density of the surrounding canopy and understorey that each species requires, (iii) the relationship between the number of such nesting, roosting or homesites and population levels, and (iv) the competition between different species for their use.

Loyn (1985) states "The number of trees that need to be retained to provide breeding habitat for individual species of forest animal is not known." He considers that the highest densities of old trees are needed by species which use them for feeding, whether or not they also need them for nesting.

Smith and Lindenmayer (1988) state "Under conditions of resource limitation, the density of tree hollow dependent arboreal mammals should increase approximately linearly with tree hollow density and then plateau once tree hollows are present in excess and other resources such as food become limiting."

Mackowski (1983) states "Presently the Forestry Commission logs its eucalypt forests without measuring impact on, and with minimal regard for, arboreal wildlife populations, although in clearfelling/clearing situations occasional possum trees are left behind, these have no more prescription than 'it looks good to the eye'. This is incidental wildlife management..."

Kavanagh (1985b) states "The results of this study should be taken as an early warning of the probable inadequacy of current 'habitat tree' retention specifications for wildlife (arboreal marsupials) in forests subject to integrated logging. Management for wood production will inevitably take precedence over management for wildlife in most areas. However, it should be recognized that in other areas a strong commitment must be given to managing wildlife and that normal tree retention specifications (and creek reserves) are likely to be inadequate. The appropriate specifications for such areas are still unclear."

Kavanagh and Webb (1989) note that the present approach is deficient because of lack of knowledge about the number of mature and hollow-bearing trees that should be retained in logged areas to provide for the present or future requirements of mature forest-dependant wildlife.

Davey (1989) outlines a number of requirements for the management of fauna requiring hollows: knowledge of the rate at which hollows develop in a suite of species over a range of site qualities; identification of characteristics of hollows for all species utilising them; and determination of seasonal use of hollows. He advocates the development of models predicting development of hollows in tree species in relation to size class of trees.

Loyn (1985) notes "The problem with the retention of large numbers of scattered old trees is that regrowth is suppressed by these trees ...and wood production is accordingly reduced. This

increases the pressure to extend harvesting operations into mature forest which might be better reserved as habitat for the most sensitive plant and animal communities that could be damaged even by intermediate levels of selective logging."

Mackowski (1987) notes that where forests abut non-forest habitats (e.g. estuarine, mangrove, billabong, swamp, heath, pasture) the hollow trees in the forest "are significant resources for the hollow tree dependant wildlife that forage in adjacent non-forest habitats."

3.1.2.1 OCCURRENCE OF HOLLOWS

Mackowski (1987) considers "Hollows used by arboreal wildlife occur in trees that have attained a dbhob greater than the dbhob at which crown size increment declines reflecting a culmination of growth and the shedding of major branches."

Dunning and Smith (1986) found "The number of hollow bearing trees (>96 cm d.b.h.), in the Mt. Boss study, varied from 0.5 per hectare on some logged sites to on average 16 (8-30) per hectare in mature unlogged forest sites. Factors other than hollows would appear to limit arboreal mammal populations in mature moist hardwood, while in heavily logged forest the lack of hollows almost certainly limits population density."

Mackowski (1984) found that two stands of unlogged blackbutt forest had stockings of 6.7 and 13.4 hollow bearing trees per hectare. Kavanagh and Webb (1989) found their unlogged areas had averages of 26.9-40.8 trees > 80 cm. per hectare.

Mackowski (1987) found that in 40 m site height forest "although hollows occurred in blackbutt older than about 40 y.o. these hollows were not suitable for wildlife unless the blackbutt was > 144 y.o. [> 100 cm dbhob] and also, these hollows were not suitable for large hollow dependant wildlife unless the blackbutt was > 224 y.o. [> 140 cm dbhob]." and "Blackbutt longevity is about 300 years old, when blackbutt is about 180 cm dbhob in 40 m site height forest."

Smith and Lindenmayer (1988) found that Leadbeater's Possums: were not found in trees less than 1 m dbh; strongly avoided living trees less 2.1 m dbh and preferred those greater than 2.5 m dbh, and; exhibited a significant preference for dead trees of 1.1-2.5 m dbh. They cite work that predicted that Mountain Ash trees of 2.1 m dbh were about 190 years old, and that Shining Gum have an approximately 20% slower growth rate.

Mackowski (1987) notes "there is a mortality of about 1 tree/ha every 8 years during the 80 years the cohort takes to grow from 100 to 140 cm average dbhob, and about 1 tree/ha every 18 years during the 80 years the cohort grows from 140 - 180 cm average dbhob."

Mackowski (1987) notes "The average age of blackbutt with wildlife hollows is 185 years... Thus they have an average life of about 120 years left... Trees with large hollows have an average life of only about 50 years left... If primary logging in blackbutt forest leaves existing hollow blackbutt as wildlife habitat, and relies on regeneration to provide tree hollows when existing hollow trees die, then it is probable that there will be a temporal gap in the availability of hollow trees for arboreal wildlife. It is almost certain that there will be a period without trees with large hollows in forest managed in this manner."

Mackowski (1983) notes that previously logged areas often have low stockings of hollow trees and states that "salvage logging in these areas will remove more hollow habitat, and continued management for timber will remove recruits to the hollow tree class."

Milledge, Palmer and Nelson (1991) state "There are practical difficulties in maintaining the prescribed densities of hollow-bearing trees and stags on logged coupes when these are often incinerated during post-harvesting burning or collapse when exposed to wind... In any case, the survey results for the Yellow-bellied Glider indicate that the problem of conserving hollow-dependent vertebrates in Mountain Ash forests is unlikely to be resolved simply by maintaining an arbitrarily determined density of hollow bearing trees and stags throughout the forests."

Recher, Rohan-Jones and Smith (1980) state "The sudden exposure of large trees to new wind stresses after clearing the adjacent forest commonly leads to these trees dying or being thrown by the wind." Mackowski (1987) notes that habitat trees are lost or damaged by fires, lightning or windstorms.

Smith and Lindenmayer (1988) note "The number of large hollow-bearing overstorey trees in regrowth timber production forests is declining however, through a combination of natural decay, deliberate culling of dead trees, harvesting of large living trees, and incidental loss during post-logging, slash-burning operations."

3.1.2.2 UTILISATION OF HOLLOWS

Mackowski (1987) lists 13 species of marsupial, 13 species of bat, and 49 species of bird that use tree hollows and occur in northeastern NSW. He also found 3 species of lizards in tree hollows he dissected.

Smith and Lindenmayer (1988) found "A strong linear, almost 1:1, relationship occurred between the total number of all species of possums and gliders recorded emerging from tree hollows and the density of PNT [Potential Nest Trees] on each site." They predicted that when less than 1.5 PNT per 3 ha. remained that the density of possums and gliders would average zero and that

minimum number of PNT necessary to sustain animal density at the average maximum (11.3 per 3 ha) was 12 PNT per 3 ha.

Smith and Lindenmayer (1988) found that "the total numbers of possums and gliders per site, were significantly related to the number of 0.25 ha blocks on each site supporting PNT [Potential Nest Trees]. ...The total number of possums and gliders increased linearly from a predicted value of zero when the number of 0.25 ha blocks with PNT was 0.6, to an estimated maximum of >12.8 animals per 3 ha when the number of 0.25 ha blocks with PNT exceeded 10. ...it is possible that maximum possum and glider density will only be reached on 3 ha sites in which all [12] 0.25 ha blocks support PNT."

Mackowski (1987) states "The characteristics of tree hollows that may influence their use by wildlife include: hollow orientation (vertical, horizontal, aspect); the type of entry (smooth, jagged); the type of surrounding wood (green, wet, dry, cracked); entry size; hollow volume; drainage; ventilation; availability of water; biotic agents (predators, competition, parasites); hollow numbers; and availability of non hollow resources".

Mackowski (1987) states "Only trees > 100 cm dbhob were utilised by wildlife... Larger trees (> 140 cm dbhob) were utilised by more wildlife than were trees 100 -140 cm dbhob. Larger hollow utilising birds such as ducks, cockatoos and owls... are probably restricted to nesting in blackbutt >140 cm dbhob as larger hollows mainly occurred in these trees".

Mackowski (1987) notes "Arboreal marsupials the size of yellow-bellied glider and larger appear to require hollows > 100 cm^2 entrance size, these hollows only occur in blackbutt > 100 cm dbhob and are most abundant in blackbutt > 140 cm dbhob".

Lindenmayer *et al.* (1991) found that of the 823 trees they stagwatched only seven (0.9%) were occupied by more than one species, noting "Where co-occupancy did occur, nest trees were typically inhabited by a large and small species".

Mackowski (1987) identified three forms of wildlife hollows: branch, main stem and top. He found that 83% of hollows were branch hollows, and "Most of the wildlife occurrence in hollows... was in branch hollows." He also found that about half of the branch hollows were not seen by ground level observers.

Mackowski (1987) found that the two thirds of hollows which had jagged wood entries were utilised by Feathertail Gliders and lizards, while "All the non feathertail glider/reptile arboreal wildlife in blackbutt forest is restricted to choosing suitable hollows from the one third of blackbutt hollows that are smooth overgrown hollows."

Mackowski (1987) considers "that parrots (and large cockatoos?) may require deep vertical hollows to reduce egg and chick predation". He found evidence of use by parrots in three large hollows, all greater than 3 m deep.

Lindenmayer *et al.* (1991) state "Our results indicate that small species... prefer nest sites with a small entrance cavity, particularly holes. The dens of larger species... had a large entrance, such as a hollow-branch or spout. Medium-sized species... showed no particular preference for any type of nest entrance although holes were the most commonly used."

Lindenmayer *et al.* (1991) found that the dens of gliding marsupials were usually higher than those of non-volant species. They noted "Differences in the type and height of the entrance to the nest, together with the time of emergence from the den, indicate partitioning of the nest tree resource between the various species..."

Mackowski (1984) notes that "low numbers of hollow trees means more interspecific competition for hollows'

Smith and Lindenmayer (1988) found that Leadbeater's Possum on average occupied only one in three Potential Nest Trees, they considered that available evidence suggested three factors may operate to some extent, if: "Approximately only one in every three PNT contain suitable hollows for the species; Leadbeater's possum is excluded from potentially suitable hollows by other species of possums and gliders; or if each Leadbeater's Possum colony requires access to more than one PNT." They note that when PNT occur at low density "The species most likely to be disadvantaged are those of poor competitive ability (e.g. small size) with specialised hollow requirements."

Recher, Rohan-Jones and Smith (1980) note "Dead trees appear to be unsuitable to many (although not all) species of birds and mammals which require tree hollows".

3.1.2.3 DETERMINING HABITAT TREE RETENTION PRESCRIPTIONS

Recher, Rohan-Jones and Smith (1980) recommend that:

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

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

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

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

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

Mackowski (1984) found "that low possum and glider populations occur in blackbutt forest of 40 metres site height with less than 3 hollow bearing trees per hectare." He presents results from 10 spotlighting transect estimates of Greater Glider and Brushtail Possum densities in blackbutt forest of 35 - 45 m site height which show that on the seven sites with some 3 or less hollow trees per hectare there were less than 0.09 animals per hectare, while on the 3 transects with more than 3 hollow trees per hectare the densities were greater than 0.27 per hectare.

Smith and Lindenmayer (1988) from their study in Mountain Ash forest concluded "a minimum of 10-12 PNT [Potential Nest Trees] need to be retained in each 3 ha patch of ash forest to ensure maximum hollow availability for tree-hollow dependent species of possums and gliders. In logged forests at least an equivalent number of younger trees will also be required to provide replacements for existing PNT in the event of natural or logging-induced PNT losses. Furthermore, replacement trees will need to be maintained in spatial isolation from existing living PNT to prevent their suppression and slowed hollow development. In other words, the retention of trees in small clusters does not allow for tree hollow replacement." It is worth noting that the arboreal mammal density they were considering was about 4 per ha.

Smith and Lindenmayer (1988) recommended "Rather than attempt to integrate and compromise wood production and wildlife conservation" that all remaining areas of mature and multiage structured forest (with >12 living PNT per 3 ha) be reserved or subjected to only low intensity selective logging and that no living PNT be felled in other areas.

Dunning and Smith (1986) used the results of studies in Victorian Mountain Ash forests and Mackowski's findings to recommend "The number of hollow bearing trees to be retained in the zones managed primarily for timber would be a minimum of 3 evenly spaced or 5 randomly spaced self sustaining potential nest tree clusters in each hectare of logged forest."

Loyn (1985) found that at Boola Boola retention of about 14 mature trees per hectare apparently failed to provide habitat for a significant small group of arboreal birds and mammals, even up to 70 years after harvesting.

Kavanagh (1990) suggests minimum numbers of habitat trees for four groups of forest types: from one per hectare on the poorest sites, through three and five to 10 on the richer sites.

Kavanagh and Webb (1989) in their study found that populations of Greater Glider, Yellow-bellied Glider and Feathertail Glider "were markedly reduced when less than 10 large (> 100 cm dbh) trees were retained per hectare."

Mackowski (1984) states "The retention of scattered hollow bearing veterans in heavily logged forest, when first logged, serves to ameliorate the impact of logging on hollow dependent fauna - but this is only of short term benefit.", "The retained veteran in first logged, heavily logged blackbutt forest will average 250 years of age at the time of logging. With a longevity of 300 years this means an average length of service as possum and glider habitat of only fifty years (30 years with adequate foraging substrate). The regeneration cohort will be 200 years old before it can provide hollows - there will be a period of 150 years during which there will be no hollows. Obviously larger sized trees need to be retained as recruits to the hollow tree class.", and "When managing a forest for possums, gliders, and timber, it is not a question of how many hollow trees to leave when logging - rather how many hollow trees to manage for. To maintain hollow trees in perpetuity requires the management of the forest so that new hollow trees are recruited as old hollow trees die."

Mackowski (1987) states "If the provision of wildlife hollows is to be continuous then there is a need, both in natural forest and in managed forest, for an unevenaged forest structure with regeneration events less than about 120 years apart for small hollow dwellers, and probably a 50 year periodicity of regeneration events for large hollow dependant wildlife."

Mackowski (1987) states "A continuous flow of 3 hollow trees/ha can be achieved, on a broadacre basis in 40 m site height blackbutt forest, by retaining 4 sound trees/ha as recruits of variable size between 60 and 100 cm dbhob, plus 2 hollow trees/ha of variable size between 100 and 140 cm dbhob, plus one hollow tree/ha >140 cm dbhob, at the primary logging and by managing the forest so as to maintain this distribution of tree sizes into the future. In a commercial forest where multiple use is the current management system, but where adequate hollow trees have not been retained in the past, a greater proportion of larger recruits should be selected (rather than evenly distributed between 60 & 100 cm dbhob) to facilitate the early return of hollow trees and the immigration of hollow dependant wildlife if it occurs nearby."

Mackowski (1984) states "Management for hollows on a small area basis requires a uniform distribution of hollow trees and their recruits. It requires the managerial control input of knowing hollow and food removal responses of possum and glider communities in different forest types."

Mackowski (1987) notes "The retention of trees across species is meant to be on a pro-rata basis so that the existing tree species mix is maintained in the hollow bearing tree community. However some species appear to have different hollow bearing characteristics to blackbutt and should not be relied on to produce wildlife hollows similar to blackbutt."

Mackowski (1987) suggests a "rapid method of predicting hollows, in forest of unknown producing character, is to determine dbhob/crown width curves and assume wildlife hollows occur in trees of dbhob greater than at which crown width levels off."

Mackowski (1987) states "The planning stage needs to look at hollow tree values of adjacent land use and land tenure. Adjacent retained/refuge areas may contain plenty of hollow trees but may be of a forest type that does not carry the same wildlife species as blackbutt forest (eg: low site quality forest of poor nutrient status, or riparian rainforest, both contain different suites of hollow dependant wildlife than occurs in blackbutt forest - unpub. data)."

Mackowski (1987) recommends permanent marking of all habitat trees and identified potential replacements with stainless steel ribbon.

3.1.3 Logging on long rotations

Recher, Rohan-Jones and Smith (1980) state "Existing management proposals suggest that a cutting cycle of 40 to 45 years will be followed in the Eden Woodchip Concession. This means that by AD 2015 all forest in the district except that reserved in buffer strips, unlogged reserves or National Parks and Nature Reserves will be regeneration between 0 and 45 years. Forest of this age is unsuited for birds and mammals which require older trees. To ensure the survival of these species in the Eden district, the length of the logging cycle should be staggered through space and time. The following are recommendations:

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

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

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

A.H.C. and C.A.L.M. (1992, vol.5) in their recommended practices to protect National Estate values in Western Australia state

"Forest values will also be protected by extending the rotation length (up to 250 years) in some patches. This rotation length more closely approximates the average physiological rotation age of Jarrah and Karri. Retention of these additional patches of undisturbed forest beyond the first harvest cycle will ensure that mature and senescent characteristics are perpetuated in the stand until maturation of younger regrowth."

Davey and Norton (1990) state "Equally important is to realize the length of time... for habitat to become optimal for most arboreal marsupials after major disturbance (clearfell, intense wildfire). Such a length of time has to be considered in the determination of the rotation length of a particular forest stand."

Loyn (1985) notes "The age which evenaged regrowth begins to support those species most sensitive to harvesting is not yet known." He considers that a rotation of 100 years or less would eventually exclude a small group of species from cutover areas, and a rotation of 150 years would be needed to maintain about a third of the forest in a condition suitable for these species.

Dunning and Smith (1986) consider that appropriate rotation and spatial organisation of logging coupes is useful for arboreal mammals with good dispersal capability dependent on particular successional stages after disturbance.

3.1.4 Logging at lower intensities

Dunning and Smith (1986) consider that conservation within logged compartments by modification of logging practice and reduction of logging intensity to maintain species and their essential resources at a lower but stable density is useful for disturbance tolerant species dependent on mature forest.

3.1.4.1 25% CANOPY RETENTION

Kavanagh and Webb (1989) note that their 25% canopy retention plot retained 57% of its canopy, 52% of its original basal area and 54% of trees > 80 cm. dbh. It can thus be considered to more accurately represent 50% canopy retention. There was no post logging burn.

Kavanagh (1985b) found that it was clearly apparent that few or no arboreal mammals were retained in logging areas outside of creekside reserves in the area logged to this prescription, with neither the Greater Glider or Yellow-bellied Glider persisting in logged areas.

3:1.4.2 33% CANOPY RETENTION

Dunning and Smith (1986) found that the numbers of Greater Gliders decreased by a half, Fawn-footed Melomys and Rufous Ringtail Possum declined by two thirds and Mountain Brushtail Possum and Brown Antechinus increased (the later apparently due

to juveniles and the former immigrations from more intensively logged areas). They also note that Challengers Skink declined significantly in numbers (even without a post logging burn).

3.1.4.3 50% CANOPY RETENTION

Kavanagh and Webb (1989) note that their 50% canopy retention plot retained 57% of its original canopy cover, 51% of its original basal area and 54% of trees > 80 cm dbh. The method utilized was a 'chessboard' method where alternate patches were clearfelled. There was no post logging burn.

Kavanagh (1985b) states "Surprisingly, Greater Gliders were not observed in the small (0.5 ha) retained patches in the 50% treatment." Prior to logging he recorded 19 Greater Gliders in the area subsequently subject to logging, after logging he recorded 7 in the same area (6 of which were in unlogged patches adjoining unlogged corridors). Kavanagh (1985a) notes that Yellow-bellied Gliders were observed on occasions feeding just inside the logged areas (< 30 m from logging boundary) "but these wide ranging animals were normally encountered only in creek reserves or on the unlogged plots."

Kavanagh and Webb (1989) note that "This pattern of logging approaches the 'Australian group-selection' logging system ... which, silviculturally and ecologically, is the more traditional and widely accepted form of logging elsewhere in Australia."

3.1.4.4 66% CANOPY RETENTION

Dunning and Smith (1986) found that the numbers of Rufous Ringtail Possum decreased by one half, Greater Gliders and Brown Antechinus by one third, and Fawn-footed Melomys by four fifths.

3.2 FIRE MANAGEMENT

McIlroy (1978) notes "As yet there has been little research on the effects of fire on wildlife, especially fires of different frequencies, intensities and seasons of Occurrence.", and "Studies of the effects of fire on wildlife in Australian forests have been limited to the first four years after the fires. ...Hence any conclusions made from the Australian studies to date must be regarded tentatively."

Recher, Allen and Gowing (1985) state "there is remarkably little information about the effects of fire on fauna or the long-term consequences of burning on forest ecosystems."

McIlroy (1978) states "Frequent low intensity fires (prescribed burning) also tend to produce a uniform habitat by gradually eliminating the shrub layer and allowing the monocotyledons and ferns to dominate the forest floor. As a consequence there is a gradual disappearance of animals dependent on the shrubs, litter or old logs for food and shelter."

Leigh and Holgate (1979) consider that "Possibly the current procedure of dropping aerial incendiaries on a grid basis as part of the burning programme in various areas especially for forestry and national park use may lead progressively to a substantial change in understorey structure and composition because of the localized selective grazing [by native species] of those small areas which have been burnt. ...it would lead most likely to a progressive increase in unpalatable plant species. This would alter, probably irreversibly the suitability of those areas for conservation of all parts of the flora and as a suitable habitat for the endemic fauna, both as shelter and feed."

Dunning and Smith (1986) found that post logging burning of moist hardwood forest was significantly deleterious for a variety of species and so advocated tractor clearing, rather than burning, to create disturbance for regeneration.

Mackowski (1987) found that "butt hollows" in the blackbutt forest he studied were lined with charcoal and "were probably 'excavated' by fire. He found that there was an average of 0.33 "butt hollows" in each tree 80 - 99.9 cm dbhob, 0.14 in trees 100 - 119.9 cm dbhob, 0.33 in trees 120 - 139.9 cm dbhob, 0.0 in trees 140 - 159.9 cm dbhob, and 1.17 in trees > 160 cm dbhob.

Mackowski (1987) notes "Interconnected hollows act as chimneys and, if connected through to the basal fire box, the result of even a moderately intense fire means either the burning down of the tree, the death of the standing tree, or, if it survives, the virtual sterilisation of the wildlife hollow complex of the tree mainstem and branches."

Mackowski (1987) notes that the frequent Occurrence of fire in 40 m site height blackbutt forest precludes a 100% chance of survival for habitat trees, as a proportion will be damaged, or weakened, or burnt down by each fire.

Bennett (1990) states "Fires, both natural and of human origin, can also create patches of differing successional stages within extensive natural areas, and so isolate faunal populations that may depend upon a particular seral stage."

3.2.1 BIRDS

Cowley (1971) notes "The birds most affected by fire are those which feed and nest close to the ground... Many other species which spend much of their time feeding at or near ground level but which nest in the higher levels of the forest would be affected to a lesser extent."

Cowley (1971) notes that the frequency with which fire burns an area can have a marked effect on the habitat by changing the plant species composition of the understorey and that this will in turn effect the bird species composition.

Rohan-Jones (1981) notes "the effects on birds of logging will be compounded by slash burning and the broad area hazard reduction

programme. These together will serve to maintain more of the forest in a relatively simplified structural condition and overall there will be more 'effectively dry' habitat conditions. As well as resulting in a much more open understorey condition with few hollow and over mature trees, soil moisture will also be significantly reduced. The resultant loss of invertebrate faunal prey and decreased humidity will make unsuitable conditions for a number of bird species that would otherwise be present."

Recher, Allen and Gowing (1985) found that "There was a significant effect of fire and logging on the number of birds. Burnt and logged plots had lower numbers and fewer species of birds than unburnt or unlogged plots. The combined effect of logging and fire was greater than either treatment alone."

Recher, Allen and Gowing (1985) note that "The species of bird affected by any given burn varies according to the intensity of the fire and amount and layers of vegetation burnt. It is probable that changes in the abundance of birds after a fire occur in response to changes in the structure of the vegetation. In most instances the impact will be greatest on birds which forage or nest in ground and shrub vegetation while those favouring more open vegetation may benefit. ...recolonization and an increase in the abundance of birds probably proceeds in parallel with the rate of post-fire revegetation."

3.2.2 MAMMALS

Shields and Kavanagh (1985 p.21) note that fire regimes "have been shown to have a greater effect on small mammal populations than logging, and current policy in some regions prescribe fuel reduction burning at very short intervals."

Fox and McKay (1981) found a replacement sequence in time for species of small ground mammals to reach their maximum abundance following a fire: New Holland Mouse and/or House Mouse -> Common Dunnart -> Brown Antechinus -> Bush Rat. They interpreted this as species occupying stages in the succession when their optimal habitat requirements were fulfilled, with New Holland Mouse and House Mouse populations peaking around one year post fire, Common Dunnart peaking at 4yr, Brown Antechinus reappearing after 2yr and peaking at 5yr and Bush Rat establishing populations after 3yr and plateauing at 8yr.

Wilson *et al.* (1990) studied small mammal succession following a wildfire, the impact of which few animals apparently survived. They found that "Populations of native small mammals at our burnt sites remained at extremely low levels for three years after the fire. They survived and recovered at a greater rate at partially burnt sites." They found that House Mouse populations peaked in the second to third years post fire on both the burnt and partially burnt sites. New Holland Mouse disappeared from one site after the fire and its population peaked 3 years after the fire at another site. Brown Antechinus populations peaked in burnt sites five years after the fire and continued to recolonise new sites up to the sixth year. Bush Rat achieved maximum abundance and colonization of sites in the fifth year. Swamp Rat was absent from a site it previously occupied for 3.5 years and was still increasing both in abundance and number of sites occupied in the sixth year. Southern Brown Bandicoot was present in low numbers until years 4 to 6 and was slow to colonise new sites.

Wilson *et al.* (1990) consider that Swamp Antechinus, Dusky Antechinus and Long-nosed Potoroo "may now have disappeared from the study area as they have not been captured for two to three years." They note that these species and New Holland Mouse "are vulnerable to the combined effects of disturbance factors due to their low population numbers and restricted distributions."

Fox and McKay (1981) cite reported greatly increased numbers of Yellow-footed Antechinus in forest unburnt for 40 years as opposed to stands unburnt for 30 years.

Dunning and Smith (1986) state that declines in numbers of Mountain Brushtail Possum and Fawn-footed Melomys "in the control plot accidently subject to burning suggests that the post logging burn commonly used in regenerating moist hardwood may be as disadvantageous as canopy removal to species that utilise the ground stratum."

Lunney, Cullis and Eby (1987) found that populations of Bush Rat, Brown Antechinus and Dusky Antechinus were drastically reduced following wildfire, with no Dusky Antechinus trapped for the three years sampled after the fire.

Moon (1990) states "For koalas, the effect of fires is to suppress eucalypt regeneration resulting in a simplified forest age structure, and to promote a dense ground stratum which inhibits koala movements." He recommends the formulation of alternative strategies to regular hazard reduction burning, to permit regeneration of koala food trees.

Wilson *et al.* (1990) state "Fuel reduction burning practices should be well planned and take into account ecological factors such as the frequency, area burnt, timing and intensity. It is recommended that 1) burning should not be at frequencies of less than four years, 2) patch burning be undertaken to produce a mosaic of successional ages within vegetation types, 3) burning not be carried out in spring when small mammals are breeding." For New Holland Mouse habitat they consider "It is essential that burning within these communities is not carried out on a large scale. It is recommended that burning be done in small patches (1-3 ha) within the preferred communities to maintain a variety of successional ages from 2-8 years."

3.2.3 REPTILES

Dunning and Smith (1986) found that post logging burning, "unlike logging, destroys litter and logs and increases the area of bare soil and rock. Since all three species of common reptiles were found to require logs and two were found to require litter, post

logging burning probably has a more detrimental long term effect than logging on reptile numbers." and "Normal logging had an immediate effect on population numbers resulting in a shift from dominance by [Murray's Skink and Challenger's Skink] to dominance by [Delicate Skink]." They conclude "results suggest that elimination of slash burning after logging may be sufficient to sustain the fallen log microhabitat requirements of [Murray's Skink and Challenger's Skink] in logged forests."

3.3 ROADING AND DISTURBANCE CORRIDORS

Bennett (1990) notes that streams and naturally burnt areas can act as natural barriers but is most concerned that disturbance corridors of human origin (highways, canals, pipelines, railway lines, transmission clearings) are imposing an ever-growing network of partial or complete barriers to animal movement throughout the landscape.

Andrews (1990) undertook a literature review which revealed a variety of harmful effects of roads; (i) habitat loss and modification with accompanying effect on populations, (ii) intrusion of the edge effect into the core of natural areas, (iii) subdivision and isolation of populations by acting as a barrier, (iv) a source of disturbance to wildlife, (v) increased roadkills, and (vi) increased human access with undesirable impacts on disturbed areas.

Richards and Tidemann (1988) in relation to tropical rainforests state "The process of selective logging requires the construction of access roads for large trucks and machinery, smaller tracks for bulldozers to extract logs, and large open areas for loading logs onto semi-trailers. When a tree is felled it leaves a large gap in the normally closed canopy. All this activity results in a network of connected clearings. Other disturbance or modification practices such as rainforest real estate developments produce the same result. These disturbed areas are unsuitable for most of the rainforest (specialist) bats to forage in, but are ideal for the open forest (opportunist) bats that invade within just a few weeks of their creation. There are, however, a few rainforest species (generalists) that seem to be unaffected."

Andrews (1990) cites a variety of overseas studies which have identified numbers of species which avoid roads, with specific species keeping particular distances away, some as far as 1.8-2.1 km away. In some instances breeding areas have been rendered unsuitable for a variety species by the construction of nearby roads. In others fragmentation by roads has significantly reduced suitable breeding areas.

Andrews (1990) notes that some species can be disturbed by roads so that they have less feeding and lying time, and expend more energy in flight. She also cites a study that established hearing loss in some species for weeks after less than 10 minutes exposure to a tape of a dune buggy, this caused inability to respond to recordings of predator sounds.

Andrews (1990) cites a variety of overseas studies that have found that roads (as narrow as 3 metres), powerline corridors, fences and even 10-15 metre wide mown grass strips, can act as total or partial barriers to the dispersal of a variety of vertebrates and invertebrates. She states "A barrier to dispersal of species can disrupt social organization. It can lead to local extinctions if an area is affected by fire or drought, can reduce the immigration of species to areas which may need replenishment, and also limit gene-flow, with subsequent 'bottle-neck' effects."

Barnett, How and Humphreys (1978) found "Road crossing by small mammals was inversely related to road width; roads severely restricted or stopped the movement of small mammals even when the road consisted of a long-unused and partly overgrown track."

Barnett, How and Humphreys (1978) cite overseas research that found that roads have impeded bird dispersal and small mammal dispersal, the most striking example being a population of *Rattus rattus diardi* (in Singapore) infested with the vector mites for scrub typhus which was contained within an area of 40ha. surrounded by roads; the adjacent populations across roads in all directions never carried the vector.

Andrews (1990) notes the most obvious effect of roads is the mortality caused by collisions with vehicles. She cites animals crossing roads, insects being attracted to shiny surfaces, birds alighting to feed on insects or collect grit, scavengers attracted to other road kills and animals attracted by grassy road verges as being contributing factors. She cites one estimation that one bird is lost every 13 km. and one mammal every 30km. In Australia in 1976 there were 866 000 km of roads.

Moon (1990) found vehicles to be the most significant cause of koala mortality (aside from habitat loss), in a single year at least six koalas were killed by vehicles in the Iluka area, leaving a population of some 20-25 animals.

Bennett (1990) notes that road systems "are a source of chemical and physical pollutants and they may introduce invasive plants and animals into environments that the road corridor passes through."

Bennett (1990) states "Lightly trafficked roads are commonly used by predatory mammals as a clear pathway for movement and hunting, unimpeded by vegetation and other obstructions... In south-western Tasmania, the marsupial predators Tiger Quoll, Eastern Quoll and Tasmanian Devil were recorded only along forest tracks despite a greater survey effort away from tracks... The introduced predators, Fox and Cat, also use roads extensively as movement pathways through forests. The proliferation of roads and tracks in forests facilitate their spread."

Andrews (1990) notes "Plants and feral animals are easily introduced into the core of an area along a road, partly because the edge effect favours species with generalized requirements.

Roads provide easy travelling conditions for animals, and are used by hunters such as foxes."

Gilmore (1990) notes "Many Australian predators exhibit a distinct bias to using tracks and roads through densely forested vegetation, suggesting that these areas may be subject to increased mortality of prey species."

Anon (1988) note that "Foxes tend to utilize established tracks and paths whenever possible while moving through bush areas".

Dunning and Smith (1986) state that Delicate Skink, "which is a widespread less habitat specific species, could survive along roadsides from where it could invade newly logged areas."

Andrews (1990) notes "Pollutants are emitted by vehicles, including oil residues and heavy metals such as lead, zinc, copper, nickel and chromium... Alongside heavily used roads the pollutants have potential biological significance if plants in which they concentrate form a large part of the diet of fauna, or if fauna living there breathe airborne pollutants. Pesticides and herbicides may be sprayed along roadsides and other utility corridors.".

Andrews (1990) considers roads allow easy access to humans, which has been noted to lead to deliberate lighting of illegal fires, and illegal hunting.

Andrews (1990) notes that "No Australian study documents the horrific injuries and mass mortalities documented in the USA" from powerlines, and cites American analyses which reveal that poor visibility, bad weather, mass migrations, dispersal by juveniles and the fragmentation by powerlines of the area flown between resting and feeding create the situations in which the greatest numbers of deaths occur.

Andrews (1990) notes that increases in traffic flow and/or speed lead to increases in road deaths of fauna. She notes that the speed of vehicles is not decreased by animal warning signs.

3.4 GRAZING

Bennett (1990) states "Grazing by domestic stock in remnant vegetation has marked effects on the composition and structure of wildlife habitats through selective browsing of plants, an overall decline in understorey biomass, trampling and soil compaction, and altered soil nutrient levels."

Andrews (1990) cites the detrimental effects of fences on wildlife including entanglement, the cutting off of important natural factors such as water supplies, prevention of movement into suitable habitat areas, disruption of seasonal movement, over-population through limitations on dispersal and increased human access through use of fence maintenance roads.

Yellow-bellied Gliders, Greater Gliders (pers. obs.) and Queensland Blossum-Bat (D. Milledge pers. comm.) have been noted to become inextricably entangled on barbed-wire fences.

3.5 CHEMICAL USAGE

3.5.1 PESTICIDES

Cowley (1971) considers "every species of land bird in Australia is a potential victim of chemical pesticides. Most of these species are at least partly insectivorous and could therefore be seriously affected by insecticides, birds which eat fruit or seed can fall victim to poisoned baits intended for mammal pests, and owls and hawks can receive toxic amounts of pesticides indirectly by preying on animals which have come into direct contact with pesticides."

Cowley (1971) cites an American example of the progressive concentration of chemical pesticides in a food chain which resulted in an overall 80,000 fold increase in concentration and widespread mortality of predaceous fish and birds; (i) apparently safe application of T.D.E. (trichloro-dichlorophenzlethane) applied to lake, (ii) 0.02ppm T.D.E. recorded in water, (iii) 5.3ppm in plankton, (iv) 10.0ppm in small fish, (v) 1700ppm in the predaceous fish, and (vi) 1600ppm in the predaceous birds.

Cowley (1971) considers that T.D.E. and other organo-chlorines act on the central-nervous system and sub-lethal amounts may affect an animal's behaviour in such a way that it becomes more susceptible to predation. He notes that in Australia there is circumstantial evidence that the application of pesticides is causing the unintentional death of many birds and lowering the reproductive capacity of other birds receiving sub-lethal doses. He also notes that significant quantities of dieldren and DDT have been found in birds eggs and the bodies of honeyeaters, kestrels, falcons and kookaburras.

Richards and Tidemann (1988) consider that the accumulation of insecticide toxins via the food chain is adversely impacting bats, stating "As insect pests become more and more tolerant to agricultural chemicals, and higher strengths are required for their demise, bats and other animals that eat sprayed insects are at an ever increasing risk. The annual cycle of most insectivorous bats ...is to store fat when prey is abundant which they can draw upon later. In areas where ground crops are grown and sprayed from the air, insect-eating bats that forage on crop pests gradually accumulate these poisons (microgram by microgram) into their fat reserves. At this stage the input dose of the chemicals isn't toxic, but is much higher when accumulated in their fat reserves and metabolised during winter hibernation."

3.5.2 1080 (SODIUM MONOFLUOROACETATE)

Allen *et al.* (1989) undertook trial baitings in southern Queensland (in areas where foxes were either absent or in very

low numbers) with unpoisoned fresh meat baits and factory baits. Of the 412 (61% of total) fresh meat baits eaten 24% were eaten by 'dogs', 31% by birds, 2% by cats, 11% by reptiles, and the balance by ants, a fox and unknown (29%) species. Of the 123 (18% of total) factory baits eaten 44% were eaten by 'dogs', 17% by birds, 6% by reptiles, 4% by cattle, and the balance by a possum, a fox and unknown (28%) species. They note "Numerically, the two significant non-target consumers of both bait types were birds (28% of all baits consumed), dominated by crows (*Corvus* spp.), and reptiles (10% of all baits consumed), which, with only a few exceptions, were goannas (*Varanus* spp.). In the trials conducted in November and February reptiles removed more baits than did birds, but in the cooler March and May trials reptiles were poorly represented."

McIlroy *et al.* (1986) undertook two successive trail-baiting campaigns with fresh meat baits injected with 1080 in Kosiosko National Park. They found "During the first poisoning campaign foxes removed the greatest proportion of baits, followed by birds, dogs and pigs... The birds seen interfering with baits were pied currawongs *Strepera graculina*, Australian ravens *Corvus coronoides*, Australian magpies *Gymnorhina tibicen*, and wedge-tailed eagles *Aquila audax*." and, "During the second poisoning campaign birds removed most of the baits, followed by dogs, foxes, pigs and cats." During the first campaign 92% of baits were removed within 4 days and 99% within 21 days, though only 7% were removed by dogs. During the second campaign 99% of baits had disappeared after 18 days with only 10% being taken by dogs.

Allen *et al.* (1989) note "Generally, birds and reptiles are many times more tolerant of 1080 on a per kilogram body weight basis than are canines. Birds range from 1.3-18.51 mg 1080 kg^{-1} body weight... ; goannas, 43.6-119 mg 1080 kg^{-1} body weight... ; and dingoes/wild dogs, 0.1 mg 1080 kg^{-1} body weight, and cats, 0.2 mg 1080 kg^{-1} body weight".

McIlroy (1982) assessed the risk mammalian carnivores face from 1080 poisoning and found "Amongst the species studied, the Dingo faces the greatest risk followed in descending order by the smaller dasyurids, the feral Cat and the larger dasyurids and Long-nosed Bandicoot." In a field trial in southern NSW he compared areas baited with poisoned and unpoisoned baits and found "During the two months before the baiting there were no significant differences between the numbers of Brown Antechinus trapped in each area... Area A, the area to be poisoned, though, did contain 24-31% *more* antechinus than Area B. Two weeks later, however, after the poisoning, Area A contained 73% *less* antechinus than Area B, a significant difference." He considered that, in theory, Brown Antechinus and Dusky Antechinus could "eat sufficient bait containing 0.015 mg/g of commercial 1080 (a relatively low concentration advocated for some campaigns) during a poisoning campaign for them to face a 73-100% chance of being killed".

Calver *et al.* (1989) undertook labratory experiments on 20 native Western Australian mammals to determine the potential hazard of

1080 baiting by comparing their consumption of non-toxic baits with the appropriate lethal dose for each species. Twelve species were assessed to be potentially at risk from crackle (factory) baits and six species from fresh meat baits. The Northern Quoll "often ate all the food offered to them ... endangering their health through overeating.", had "high projected doses with meat baits... reflected the large amounts of meat baits eaten", and was "the species found to be at greatest potential risk". The two species tested which occur in NSW escarpment country, Common Planigale and Pale Field Rat, were both considered to be susceptible to crackle baits and the former to meat baits.

McIlroy (1982) notes that for mammals "Symptoms did not normally appear in poisoned individuals until 0.1-23 hours after ingestion of 1080. Typical symptoms, in approximate order of appearance, included depression or increasing sensitivity to stimuli, restlessness, rapid respiration, bouts of trembling, vomiting and convulsions. Most deaths occurred between 1.5-147 hours after ingestion of the poison while all survivors showed signs of recovery after 2-60 hours."

Calver *et al.* (1989) concluded that "more individuals of many species ate crackle bait compared with meat bait... The crackle baits also hold a much higher concentration of 1080 per gram of bait. Crackle baits are therefore potentially far more hazardous to non-target fauna than are meat baits, especially during periods of food shortage." They also recommended sun drying of meat baits prior to distribution to reduce their palatability to non-target species. Allen *et al.* (1989) found "Fresh meat baits laid on the surface were significantly more palatable to a broad range of non-target wildlife species than were factory baits. An important finding in this study was that factory baits, while less palatable to dogs, were significantly more target-specific than fresh meat laid on the surface."

Allen *et al.* (1989) undertook an assessment of the effectiveness of surface verses buried (2-5 cm) meat baits. Of the 114 (57% of total) surface-laid baits eaten 32% were eaten by 'dogs', 48% by birds, 5% by reptiles, 2% by cats, and the balance by ants and unknown (6%) species. Of the 38 (19% of total) buried baits eaten 89% were eaten by 'dogs' and the balance by ants, a bird and a cat. They concluded "Analysis of the data... shows no significant difference in palatability or attractiveness of meat to wild dogs between the two presentation techniques; 18.5% of surface-laid meat baits were removed by dogs compared with 17% of buried meat baits. However there was a significant difference in the non-target bait take between the two techniques."

McIlroy *et al.* (1986) undertook an assessment of the relative attractiveness of green dyed verses undyed fresh meat baits and found "During the first two campaigns birds pecked at 28 undyed baits compared with 4 dyed baits, and dragged 55 undyed baits, compared with 10 dyed baits, away from raked sites, giving the impression that they found undyed baits more attractive. However, although in the trial with unpoisoned baits they initially took more undyed than green-dyed baits..., analysis by means of 2 by 2

contingency tables revealed there was no significant difference between the numbers of either type removed by them or other animals".

McIlroy *et al.* (1986) concluded "Trapping, compared with poisoning, proved to be a more effective method of control during the present study. Fifteen (56%) of the 27 individual dogs known to be in the area during the study were trapped either initially for attachment of transmitters or later during efforts to recover the transmitters. In comparison, only three (11%) were known to have been poisoned and, in the unlikely event that all the individual dogs not seen after the baiting were killed, only 44% were poisoned. However, trapping requires a considerable amount of effort (e.g. 60 trap-nights per dog) and some expertise, and it can be an inhumane practice, especially if traps are not visited each day."

Jarman (1986) cites a number of examples where "Active suppression of dingoes in sheep-raising regions may have helped establishment of foxes." He notes "Although no Australian foxes live entirely within closed-canopy forest, if dingoes are absent foxes can penetrate dry forest..., wet eucalypt forest..., and even isolated patches of rainforest..."

Eason and Frampton (1991) found that at doses of 0.4 and 0.6 mg of 1080 per bait only one of six cats died, at a dose of 0.8 mg seven of 13 died, at 1.2 mg 6 of 8 died and at 1.4 and 1.6 mg all 10 cats died. They recommended a dose of 2 mg of 1080 per bait to kill all cats eating it within 24 hours.

Anon (1988) note when using 1080 Fox baits that the baits should be buried 10 cm deep along identified fox trails with the uneaten bait and dead foxes picked up and burnt or buried (at least 50 cm deep) after four nights.

Cowley (1971) states "Losses of birds and mammals have been recorded following the use of '1080' for rabbit control. In one incident over 75 brush-tail possums were killed and examination revealed large amounts of bait material in their stomachs. Possums form part of the diet of the powerful owl."

3.5.3 FERTILIZERS

Gilmore (1990) notes "Changes to water quality, associated with leaching of fertilizer from some soils has the potential to influence aquatic-dependent fauna downstream of a plantation. This has obvious implications for species such as the 'acid frogs' which are restricted to breeding in low pH waters, in the sandy coastal lowlands of subtropical Australia".

3.6 MINING

Wilson *et al.* (1990) found that the House Mouse was the only small mammal resident on revegetated mine areas up to five years after the revegetation. They note the adjacent unmined area supported populations of White-footed Dunnart, Swamp Rat and New Holland Mouse, stating "The study indicates that the vegetation on the regenerating mined areas had not developed to a suitable successional stage for permanent occupation by these native small mammals." They concluded that "The major factors contributing to this were sub-optimal rehabilitation procedures and the absence of suitable corridors for animal movements."

Wilson *et al.* (1990) for post-mining rehabilitation recommend techniques including "burning before clearing, reducing soil stockpiling and seed burial to optimize seed germination rates, using organic mulch and indigenous species. Mapping and maintenance of corridors for small mammals around the mine area should also be carried out."

Richards and Tidemann (1988) note that some old derelict mine tunnels have become vitally important sites for bats to raise young. They note that many of these old sites are now being reworked by open cut methods, particularly for gold, "consequently, several important bat colonies inhabiting abandoned mine tunnels are now under threat, and presumably others will follow."

3.7 FERAL ANIMALS

Main (1988) notes "Competitors and predators such as rabbits, foxes, cats, pigs, goats, cattle, donkeys, horses, camels and many invertebrates, of which the Portuguese millipede (*Ommatoiulus moreletti*) is notable, are among the many introductions made since European settlement. All have had an impact on the floral composition and structure of ecosystems. In the context of the theory of diversity advanced earlier, they all have acted as persisting perturbations beyond that to which ecosystems can respond with resilience. The predicted climatic changes are likely to favour all the introductions as an increase in rainfall is likely to lead to higher survival rates as drought-induced mortality is reduced."

3.7.1 Foxes

Jarman (1986) notes that "Foxes in Australia respond flexibly to availability of foods: large carcases are scavenged when they occur; the most abundant or easily caught mammals up to 3 kg in weight are most commonly hunted; and easily harvested invertebrates, fruits, and nest-contents of birds and reptiles are eaten seasonally. Yet some species are preferred, or are particularly vulnerable to hunting."

Jarman (1986) considers "where rabbits support numerous foxes, more vulnerable species such as rat-kangaroos or bandicoots may be subjected to insupportable predation. In north-eastern New South Wales rufous rat-kangaroos *Aepyprymnus rufescens* persist only where foxes and rabbits are scarce..." He cites similar situations with Woylies *Bettongia penicillata* and rabbits in

Western Australia, and Broad-toothed Rats *Mastacomys fuscus* and the common Bush Rat in alpine areas.

Jarman (1986) cites a number of examples where "Active suppression of dingoes in sheep-raising regions may have helped establishment of foxes." He notes "Although no Australian foxes live entirely within closed-canopy forest, if dingoes are absent foxes can penetrate dry forest..., wet eucalypt forest..., and even isolated patches of rainforest..."

Bennett (1990) notes "Foxes, efficient introduced predators in Australia, have been associated with the declining status of medium-sized marsupials (e.g. Brush-tailed Bettong, Parma Wallaby, rock wallabies)."

Kinnear (1987) studied the population dynamics of five remnant Black-footed Rock-wallaby populations in the central wheatbelt region of Western Australia. From 1979-82 the populations remained relatively stable or declined. Beginning in 1982 a Fox control programme using 1080 baiting was implemented on two sites and maintained for 4 years. He found that during a 31 month period 183 foxes were knowingly destroyed, which showed that poisoned foxes were rapidly being replaced by immigrant foxes. Despite this he concluded that the control programme was effective as on the two baited sites Black-footed Rock-wallaby populations increased by 138% and 223% while the unbaited sites recorded an increase of 29% and decreases of 14% and 86%.

Anon (1988) note that "Foxes tend to utilize established tracks and paths whenever possible while moving through bush areas".

Jarman (1986) notes "Foxes could also penetrate forests where they do not occur now if dingoes were eliminated, intensive logging, clear-felling or plantations introduced, or stock-grazing in the forests increased." and "Remnant communities of wildlife will become more vulnerable to foxes as suitable habitat becomes fragmented."

3.7.2 Cats

Eason and Frampton (1991) note that feral cats have altered ecosystems and depleted populations of indigenous lizards and birds on the mainland of both Australia and New Zealand and on numerous island habitats throughout the world.

Potter (1991) edited the proceedings of the Australian National Parks and Wildlife Service's workshop on the impact of cats on native wildlife which concluded:

> ".The unanimous conclusion of workshop participants is that cats represent a significant threat to wildlife in Australia.
>
> .Cats occupy most ecological habitats across mainland Australia and many offshore islands.

.Cats are known to kill and eat more than 100 native Australian species of birds, 50 reptiles, three frogs and numerous invertebrate animals. The list is growing rapidly as more knowledge comes to light through research.

.Cats kill prey up to their own body size; most of Australia's endangered and vulnerable mammals, birds and reptiles are in this size category.

.Cats prey significantly on endangered and vulnerable mammals including the Greater Bilby, Numbat, Rufous Hare Wallaby and Eastern Barred Bandicoot.

The impact of cats is threatening the success of recovery programs for these species. Cats killed all of the Rufous Hare-wallabies released in a recent recovery program. They are a major cause of death in the only remaining population of the Eastern Barred Bandicoot on the Australian mainland.

.There is evidence of cats causing the decline and extinction of native animals on islands.

.One in three Australian households keep domestic cats. These bring home five to ten birds on average each per year, with millions of birds being killed annually in large cities like Melbourne. This predation accounts for most of the young birds bred in suburban areas each year. Thousands of native mammals, such as Ring-tailed Possums, are also killed in suburban areas by domestic cats each year.

.Domestic cats provide a high density reservoir of breeding animals for feral populations.

.Cats are responsible for the carriage and transmission of infective diseased such as toxoplasmosis and sarcosporidiosis which can debilitate and kill native animals as well as affect livestock and humans.

.There has been little study of the broader biological impact of cats (eg competition with marsupial carnivores, interactions with other introduced species, impact of diseases) on the Australian environment.

Reduction of population size of otherwise common species by cats may have important ecosystem effects (eg reduction in numbers of honeyeaters reduces pollination rates and subsequent seed set of plants)."

3.7.3 Others

Anon (1988) consider the effects of competition of Brush-tailed Rock-wallabies "with Goats and European Rabbits for food are unknown but are likely to be detrimental and may be exacerbated in years where food is scarce. Unlike competition for food, where the effects are often subtle and difficult to detect, competition

for shelter has been directly observed... and may be an important factor in limiting the size and extent of Brush-tailed Rock-wallaby populations."

Recher, Rohan-Jones and Smith (1980) note that the introduced House Mouse and Black Rat "are known to respond to disturbance... and the intensive disturbance of large areas of forest through clearfelling could result in the development of permanent large populations of either species in the Eden District. The intrusion of these animals from logged forest could then have an adverse effect on native small mammals which survive in unlogged reserves."

Saunders (1990) notes that in his eight years observing the nests of Carnaby's Cockatoo nest hollows were taken over by swarming honey bees on three occasions while there were eggs or nestlings in them.

Moon (1990) notes that feral pigs "cause widespread ground disturbance, which may inhibit regeneration of vegetation, and they may inhibit koala movements."

3.8 Disease

Wilson *et al.* (1990) found that the presence of *Phytophthora cinnamomi* was "a major factor affecting small mammal abundance." They consider consequences of infection such as the reduction of plant species diversity, elimination of specific species, reduction in cover and a decrease in plant productivity would be expected to ultimately affect small mammals. They cite a study that found that the soil and litter fauna in infected areas is markedly reduced.

4.0 TARGET SPECIES

NOTE: * - denotes a species listed as threatened or rare and endangered on Schedule 12 of NPW Act as of March 1992.
H - denotes a species which utilises tree hollows.
L - denotes a species which utilises large logs.
P - denotes a species particularly vulnerable to predation by foxes and/or cats.
F - denotes a species particularly vulnerable to fire.
G - denotes a species particularly vulnerable to impacts of global warming.
R - denotes a species which utilizes rainforest, including where it is overtopped by eucalypts or Brush Box.

4.1 MAMMALS

***Spotted-tailed (Tiger) Quoll *Dasyurus maculatus* H**
Mansergh (1984) notes that the Tiger Quoll is considered to have a patchy distribution and be common to uncommon in Tasmania, very rare or extinct in South Australia, to occupy about half its pre-European range and considered rare in Victoria, to have a limited disjunct range and be uncommon in Queensland and to be generally

uncommon (but more common in the north) in New South Wales. He cites the obtaining of only one locality record in a five year study of the Eden woodchipping region, where it was previously described as possibly endangered.

Mansergh (1984) notes infestations by the parasitic larvae of the native flea *Uropsylla tasmanica* may have a debilitative affect on Tiger Quolls and that feral cats and foxes may compete with them for food resources, but considers a combination of habitat destruction and the widespread trapping and poisoning in and around forest areas were probably responsible for the extinction of Tiger Quolls in many areas. He notes there is considerable concern over the impact of clearfelling practices, and while there has been no study of these impacts he cites concerns about adverse effects on potential food sources and reduced availability of breeding hollows.

***Eastern Quoll** *Dasyurus viverrinus*
While generally considered extinct in NSW there have been visual sightings in recent years by reputable wildlife researchers on the Petroi Plateau and Carrai Plateau in the head of the Macleay valley.

***Brush-tailed Phascogale** *Phascogale tapoatafa* H

Yellow-footed Antechinus *Antechinus flavipes* F
Fox and McKay (1981) cite reported greatly increased numbers of Yellow-footed Antechinus in forest unburnt for 40 years as opposed to stands unburnt for 30 years.

Dusky Antechinus *Antechinus swainsonii* F
Lunney, Cullis and Eby (1987) found that this species showed a negative relationship to canopy cover, significant preference for regenerating forest, dependence on a high percentage of ground cover and was absent from three successive post-fire censuses.

Common Planigale *Planigale maculata*

Narrow-nosed Planigale *Planigale tenuirostris*

***White-footed Dunnart** *Sminthopsis leucopus*

***Southern Brown Bandicoot** *Isoodon obesulus* F P
Wilson *et al.* (1990) found that following a wildfire Southern Brown Bandicoot was present in low numbers until years 4-6 and was slow to colonise new sites.

***Koala** *Phascolarctos cinereus* P
Kavanagh (1987a) notes that "no studies have been reported on the effects of logging, prescribed burning or other forest management practices on Koalas. Being an arboreal species and one dependent on eucalypt leaves for food, it could be predicted that below a certain threshold the intensity of logging would seriously affect Koala populations. This threshold level is unknown."

Kavanagh (1989a) reiterates these concerns following a Koala Summit (7-8 November 1988) by stating "the lack of information which is of any use to forest managers on Koala habitats and their ecology in forests was one aspect highlighted by this summit. <u>The Commission should redress this situation by initiating a research programme</u> to address the questions: 1) What is good Koala habitat? 2) What are the movements and home ranges of Koalas in forest?" He considered that such research would help decide further questions: Are Koalas conserved by gully corridor reservation?; Do they require mature forest on ridges? and, To what extent do Koalas use regenerating forest?

Watts (1989) also advocates ongoing surveys and a specific research project on the Koala. He emphasises that in the short-term, in each area where Koalas are known to occur the preferred forest types/species should be noted and provision made for retention of undisturbed areas.

Moon (1990) notes that "the north coast has been identified as the remaining stronghold of koalas in NSW, these populations are known to be declining." In his study area he estimated that the koala population had been reduced to 20-25 animals and were still declining - "due mainly to an increased mortality caused by (in order of impact) habitat loss, road deaths, stress-related disease, dogs and fire." He considers "In the absence of action to redress the problems this population will cease to function as a breeding unit within a decade."

Fanning (1990) recommended adoption of an interim protocol to be applied when a Koala is found: immediate cessation of logging; record all relevant details and search area for other animals, and; initiate a research programme.

Greater Glider *Petaurus volans* H
Mackowski (1987) cites findings that the Greater Glider favours the use of two primary dens in each territory and use other hollows less frequently, and that their home ranges are 1.5 to 2.5 ha. Kavanagh (1985b) found the home range of Greater Gliders varied between about 0.75 and 2.0 ha (typically about 1.0 to 1.25 ha). Recher, Rohan-Jones and Smith (1980) found that Greater Gliders were recorded most often in large trees (91% of sightings being in trees over 60 cm dbh) and sightings were clumped with the greatest numbers associated with the large *E. obliqua*, high tree species diversity, and better quality soils.

Lindenmayer *et al.*(1991) found that in their study area Greater Gliders predominantly utilized branch hollows at a height of 40 m +/- 3 m.

Dunning and Smith (1986) found that the abundance of Greater Gliders "was positively associated with the number of trees >96 cm d.b.h., which is consistent with its apparent height preference of 30-36 m". They state that the Greater Gliders observed following normal logging "were on the borders with the 66% retention and the control II zones and it is assumed that their territories may have overlapped this area prior to logging. No animals were observed away from boundaries."

Kavanagh (1985a) found that all Greater Gliders were observed in unlogged patches of forest and nearly always in unlogged creek reserves in his study area.

Milledge, Palmer and Nelson (1991) found that the Greater Glider was more abundant in old-growth forest, which they considered "probably reflects the higher densities and more even distribution of the large, tall trees and stags it prefers for nest and den sites".

***Yellow-bellied Glider *Petaurus australis* H**

Mackowski (1984) found one of his study areas (logged 1920) had 57 Yellow-bellied Glider den trees/km^2 in Blackbutt forest (which averaged out to 12/km^2 when adjacent forest types were included). Kavanagh (1985b) considered that the Yellow-bellied Glider has an elongated range amounting to about 60 ha.

Loyn (1985) notes that Yellow-bellied Gliders regularly feed in the mid-slope region and move between ridges and gullies in a single night.

Recher, Rohan-Jones and Smith (1980) found the colony of Yellow-bellied Gliders they studied varied between 5 and 11 animals in an area of about 60 hectares. They note that Yellow-bellied Gliders mostly forage in tall mature canopy trees, den hollows are located in large live trees and up to three animals shared the one hollow.

Goldingay and Kavanagh (1990) in their study of Yellow-bellied Gliders in southern NSW found that they: had a social group structure consisting of an adult male, an adult female and subadult offspring; home ranges of glider groups were exclusive; mean group size was 2.6 +/- 0.3, though up to 6 were recorded; births occurred June-December; females apparently breed, and produce one offspring, in successive years with breeding failures in some years; subadults disperse from their natal home-range when 18-24 months old; females probably don't breed till they are two years old, and; individuals were still present when 6 years old.

Mackowski (1987) notes "Arboreal marsupials the size of yellow-bellied glider and larger appear to require hollows > 100 cm^2 entrance size, these hollows only occur in blackbutt > 100 cm dbhob and are most abundant in blackbutt > 140 cm dbhob".

Kavanagh (1987b) found "The foraging behaviour of the [Yellow-bellied] gliders also followed an annual pattern. Searching under loose bark for arthropods and honeydew, and licking the phloem sap from incisions made in the bark of eucalypts, were observed in all seasons of the year. Other foraging behaviours such as licking flowers to obtain nectar, licking foliage and small branches to obtain honeydew, chewing manna from small branchlets, and shredding fibrous bark to obtain beetle larvae, were confined

to particular seasons." 50.7% of observations were of Yellow-bellied Gliders searching under loose bark for arthropods and honeydew, 24.5% of incising bark and licking sap, 12.1% of licking flowers for nectar and pollen, 12.1% biting and licking branches and foliage for manna and honeydew and 0.5% shredding fibrous bark for beetle larvae.

Kavanagh (1987b) found that Yellow-bellied Gliders primarily selected trees of certain species and secondarily trees of larger size for foraging, with 92% of trees used over 60 cm dbh and 58% over 80 cm dbh. He notes "The gliders in my study area selected the trees with the greatest number of flowers in which to forage for nectar; these would have been the older trees, because mature trees (c.200 years old) produce 2.2-15.5 times as many flowers as pole stage trees (c.25 years old)".

Mackowski (1988) located 248 trees of 22 species tapped for sap by Yellow-bellied Gliders in northern NSW. Northern Grey Gum (*Eucalyptus punctata didyma*) was most commonly utilised (110 records), followed by Scribbly Gum (*E. signata*)(24), Small-fruited Grey Gum (*E. propinqua*)(20), Spotted Gum (*E. maculata*) (19), Large-leaved Spotted Gum (*E. henryi*)(14) and Forest Red Gum (*E. tereticornis*)(12). The average dbhob was 65.6 cm and "Apart from a minimum dbhob of about 30 cm there was no consistent selection of a particular diameter class of tree for sap-tapping by *P. australis*." He also found that they prefer vigorous trees for sap-tapping.

Mackowski (1986) sent out questionnaires to all Forestry Commission and National Parks and Wildlife Service offices in north east N.S.W. to obtain records of trees tapped for sap by Yellow-bellied Gliders. Only 7 of the reported 131 sites were from south of the Bellinger River Valley, though he considered this to be an artefact of survey methodology it was also "interpreted as reflecting a greater than normal abundance of *P. australis* in the Clarence and Richmond River catchments."

Binns (1981) notes that the Yellow-bellied Glider is though to be very sensitive to disturbance, often apparently vacating a coupe when logging first begins. Kavanagh (1985a) found that Yellow-bellied Gliders were occasionally seen foraging just inside logged areas but were normally only encountered in creek reserves or unlogged areas. Kavanagh and Webb (1989) found that following logging they continued to use their den trees in the unlogged wildlife corridor but moved up to 1 km away to forage in unlogged forest. Recher, Rohan-Jones and Smith (1980) found that they moved into adjoining logged areas where taller trees had been left and that they could move through logged areas with scattered tall trees.

Kavanagh (1987b) concludes "These results suggest that mature forests which provide sufficient diversity of the favoured eucalypt species will be the habitats with the highest concentration of yellow-bellied gliders."

Milledge, Palmer and Nelson (1991) in their comparison of 50-80 year old regrowth (from wildfire) and 160-250+ year old-growth found that Yellow-bellied Gliders had a strong relationship with old-growth forest and made "little use of young forest even where stags or scattered old trees apparently suitable for nest and den sites were available.", with most records "clustered in and about old-growth stands with a core area greater than 1 km^2". They considered that Yellow-bellied Gliders are usually found in forests containing a high diversity of eucalypts which provide food sources at different times of the year, whereas as their study area sampled largely monotypic Mountain Ash stands the Yellow-bellied Glider's specialized foraging requirements may only be met only in old growth forest where the seasonal availability of resources such as anthropods sheltering in decorticating bark, as well as nectar and pollen and plant and animal exudates, are most abundant.

Mackowski (1986) notes "Using 250 home ranges of 60 ha each, an unfragmented area of 15,000 ha of suitable habitat should support a minimum effective population of *P. australis*."

***Squirrel Glider** *Petaurus norfolcensis* H

Eastern Pygmy-possum *Cercartetus nanus* H
Ward (1990) studied the Eastern Pygmy-possum at two sites in Victoria and found: diet includes nectar, pollen, insects and seeds; nest sites include knot-holes in trees, burrows, vacated birds' nests and accumulations of leaves and twigs caught between branches; individuals changed nests frequently; breeding can occur throughout the year depending on the availability of food resources, particularly banksia flowers; some females produce three litters a year with a mean of approximately 2.5 per year; the modal litter size is four, indicating females will produce about 10 young per year; young can mature from 4.5-10 months old, depending on season of birth; females are probably behaviourally dominant and may exclude males from areas of prime habitat, and; individuals can survive at least 4 years in the field and 8 years in captivity.

Rohan-Jones (1981) considers that from known habitat preferences Eastern Pygmy Possums will decline as the result of logging, primarily due to the reduction of suitable dense shrub patches by the practice of slash burning. Kavanagh and Webb (1989) note that the four Eastern Pygmy Possums they caught were all in unlogged forest. Dunning and Smith (1986) note that the Eastern Pygmy Possums they found "were only trapped in mature unlogged moist hardwood forest."

Feathertail Glider *Acrobates pygmaeus* H
Mackowski (1987) notes that Feathertail Glider nests, within hollows, contained 3 - 5 gliders when occupied.

Mackowski (1987) notes "Feathertail gliders were the most abundant arboreal wildlife found in blackbutt hollows... but they were not sensed by spotlight or aural means... This suggests that they are also common in other forests where they are not sensed."

He found that Feathertail Gliders occupied an average of 0.86 hollows in each tree 100 - 119.9 cm dbhob, 0.17 hollows in trees 120 - 139.9 cm dbhob, 1.00 hollows in trees 140 - 159.9 cm dbhob, and 1.17 hollows in trees > 160 cm dbhob.

Kavanagh (1985a) notes that no Feathertail Gliders were seen on plots after they were logged. Dunning and Smith (1986) note that most captures of Feathertail Gliders were in mature moist hardwood, though two were found two years after heavy logging.

***Long-footed Potoroo** *Potorous longipes* P R F
Claridge (1990) notes that prime Long-footed Potoroo habitat is warm-temperate rainforest and bordering wet sclerophyll eucalypt forest and that hypogeal fungi fruiting bodies comprise between 80-95% of their diet. He considers that logging and prescribed burning may be detrimental to the fungi and thus the potoroo.

Clark, Backhouse and Lacy (1991) note that only 32 individuals of this species have been trapped and it has been detected in 63 canid scats, with 23 scattered colonies detected. They note the main perceived threats to its survival are predation from introduced predators, and habitat disturbance from logging and unsuitable fire regimes.

***Long-nosed Potoroo** *Potorous tridactylus* P R F
Kavanagh (1982) notes that controlling the use of fire and reducing the number of foxes (and dingoes) is recommended in areas where the potoroo is known to occur. Wilson *et al* (1990) found Long-nosed Potoroo "may have disappeared" from their study area within a couple of years post fire, and considered it one of those species "vulnerable to the combined effects of disturbance factors due to their low population numbers and restricted distribution."

***Rufous Bettong** *Aepyprymnus rufescens* P
Kavanagh (1982) notes that management to favour Rufous Bettongs could best be achieved by controlling competitors (mainly rabbits), predators (foxes and dingoes) and beef cattle stocking rates,

***Red-legged Pademelon** *Thylogale stigmatica* P R F

***Brush-tailed Rock-wallaby** *Petrogale penicillata* P
Anon (1988) consider "Predation by Foxes is likely to have been an important factor in the disappearance of the Brush-tailed Rock-wallaby from the The Grampians, and the current low population levels [in Victoria] are possibly limited by Fox predation..." Kinnear (1987) found that populations of Black-footed Rock Wallaby increased by 138% and 223% over four years when a fox control programme was implemented.

Anon (1988) consider the effects of competition of Brush-tailed Rock-wallabies "with Goats and European Rabbits for food are unknown but are likely to be detrimental and may be exacerbated in years where food is scarce. Unlike competition for food, where the effects are often subtle and difficult to detect, competition for shelter has been directly observed... and may be an important factor in limiting the size and extent of Brush-tailed Rock-wallaby populations."

***Parma Wallaby** *Macropus parma* P R F
Read and Fox (1991) note that due to its restricted range and continuing pressures on its forest habitat the Parma Wallaby is a species that is especially vulnerable to extinction. They note that since European settlement its range has declined, though consider with the paucity of information about population size, distribution and ecology its status must be treated with some reservation until more data is available.

Read and Fox (1991) consider that optimum habitat for the Parma Wallaby appears to be wet sclerophyll forest (often with Sydney Blue Gum and Tallowwood present) with a moist or rainforest understorey. They found Parma Wallabies in areas subject to past logging disturbance and noted that Parma Wallaby occurred in 4.6% of Dingo scats collected in the Petroi-Five Day Creek area.

***Black-striped Wallaby** *Macropus dorsalis* P R F

***Black Flying-fox** *Pteropus alecto*

***Queensland Tube-nosed Bat** *Nyctimine robinsoni*

***Queensland Blossum Bat** *Syconycteris australis*

***Yellow-bellied Sheathtail-bat** *Saccolaimus flaviventris* H

***White-striped Mastiff-bat** *Nyctinomus australis* H

***Eastern Little Mastiff-bat** *Mormopterus norfolkensis* H

***Beccari's Mastiff-bat** *Mormopterus beccarii* H

***Queensland Long-eared Bat** *Nyctophilus bifax* H

***Common Bent-wing Bat** *Miniopterus schreibersii*

***Little Bent-wing Bat** *Miniopterus australis*

***Large Pied Bat** *Chalinolobus dwyeri*

***Hoary Bat** *Chalinolobus nigrogriseus* H

***Large-footed Mouse-eared Bat** *Myotis adversus*

***Golden-tipped (Dome-headed) Bat** *Phoniscus papuensis* H R

***Great Pipistrelle** *Falsistrellus tasmaniensis* H

**Eptesicus baverstocki*

**Eptesicus troughtoni*

Fawn-footed Melomys *Melomys cervinipes* R F
Dunning and Smith (1986) found "The abundance of [Fawn-footed Melomys] was positively correlated with the basal area of rainforest species in the overstorey and in the understorey and negatively associated with the basal area of overstorey eucalypts and Brush Box.", "The abundance of [Fawn-footed Melomys] on experimentally logged sites (33% and 66% canopy retention) declined in greater proportion than the amount of forest biomass removed (66% and 80% respectively)." and "this species appeared the most sensitive to logging disturbance." They found that Fawn-footed Melomys also declined on unlogged control sites, one area was attributed to the affect of an escaped post logging burn though in another area for no apparent reason "unless it was caused by the general disturbance created by logging of adjacent areas as [Fawn-footed Melomys] population numbers declined more than those of any other species in response to logging."

***Smoky Mouse** *Pseudomys fumeus*

***Hastings River Mouse** *Pseudomys oralis* F

New Holland Mouse *Pseudomys novaehollandiae* F
Wilson *et al.* (1990) found that New Holland Mouse disappeared from one site after a fire and its population peaked three years after a fire at another site. They considered it one of those species "vulnerable to the combined effects of disturbance factors due to their low population numbers and restricted distribution."

***Pilliga Mouse** *Pseudomys pilligaensis*

***Eastern Chestnut Mouse** *Pseudomys gracilicaudatus*

Broad-toothed Rat *Mastacomys fuscus* F

Pale Field Rat *Rattus tunneyi*

4.2 BIRDS

Pacific Baza (Crested Hawk) *Aviceda subcristata*

***Square-tailed Kite** *Lophoictinia isura*

***Red Goshawk** *Erythrotriorchis radiatus*

***Black-breasted Button-quail** *Turnix melanogaster* R

***Bush Hen** *Gallinula ventralis* R

***Bush (Stone Curlew) Thick-knee** *Burhinus magnirostris*

***Superb (Purple-crowned) Fruit-dove** *Ptilinopus superbus* R

Wompoo Fruit-dove *Ptilinopus magnificus* R

Yellow-tailed Black Cockatoo *Calyptorhynchus funereus* H

***Red-tailed Black Cockatoo** *Calyptorhynchus magnificus* H

***Glossy Black Cockatoo** *Calyptorhynchus lathami* H
Turner and Kavanagh (1990) consider that of the large cockatoos the Glossy Black Cockatoo is potentially the most threatened by logging. They note that this species "feeds exclusively on *Casuarina* fruits which although not scarce, appear to be selected from only certain trees. The effect of logging and prescribed burning on the availability of these preferred trees is unknown." They also note that the Glossy Black Cockatoo "appears to prefer the lower slopes of dry sclerophyll ridges, a habitat that is not usually protected by wildlife corridors."

***Coxen's Fig Parrot** *Psittaculirostris diophthalma coxenii* H R

***Superb Parrot** *Polytelis swainsonii* H

***Swift Parrot** *Lathamus discolor* H

Powerful Owl *Ninox strenua* H
Kavanagh (1989b) notes that "our knowledge of the ecology and habitat requirements of large owls, including the use, if any, of regenerating forest is largely unknown." He recommends that there is a need to determine the requirements and the reliance of the large owls for old growth forest as habitat.

Kavanagh and Webb (1989) note that intense predation by Powerful Owls significantly reduced arboreal mammals within unlogged forest in the vicinity of logged forest and that they were more frequently detected in the unlogged forest.

Kavanagh (1989b) recommends that for Powerful Owls the general locality (ie 2.5km radius or 2000ha) around each site where they were detected be well served by a network of reserved old growth forest along gullies as wildlife corridors (>100m width). He also recommends the employment of a specialist "nest finder".

Barking Owl *Ninox connivens*

***Sooty Owl** *Tyto tenebricosa* H R
Rohan-Jones (1981) notes that this owl is a predator of arboreal mammals together with which it forms a closely dependent subsystem, and recommends that where this combination is located should preferably be left unlogged.

Milledge, Palmer and Nelson (1991) found that the relative frequency of records of the Sooty Owl in different age classes suggests that its optimum habitat is large patches of old-growth forest. They note "The Sooty Owl was most abundant in old-growth forest, but often occurred in young stands... The proximity of some records in young stands to old-growth stands... suggested that some pairs of Sooty Owls include areas of both young and old-growth forest in their extensive home ranges... However, some findings in young forest removed from old-growth forest ...indicated that other pairs were able to occupy stands lacking high densities of old live trees.", and "Most records were clustered in and about old-growth stands with a core area greater than 1 km^2".

Kavanagh (1989b) recommends "that old growth forest be reserved in gullies in wide (>200m) corridors for distance of up to 1km in either direction at all locations where Sooty Owls were detected." He also notes the need for a specialist "nest finder".

Masked Owl *Tyto novaehollandiae* H
Kavanagh (1989b) recommends that for Masked Owls the general locality (ie 2.5km radius or 2000ha) around each site where they were detected be well served by a network of reserved old growth forest along gullies as wildlife corridors (>100m width). He also recommends the employment of a specialist "nest finder".

***Marbled Frogmouth** *Podargus ocellatus* R

***Albert's Lyrebird** *Menura alberti* R

***Rufous Scrub-bird** *Atrichornis rufescens* R

***Yellow-eyed Cuckoo-shrike** *Coracina lineata* R

***Northern Olive Whistler** *Pachycephala olivacea macphersoniana* R

White-eared Monarch *Monarcha leucotis* R

***Eastern Bristlebird** *Dasyornis brachypterus*

***Regent Honeyeater** *Xanthomyza phrygia*

***Painted Honeyeater** *Grantiella picta*

4.3 REPTILES

**Eulamprus leuraensis*

**Delma impar*

**Coeranoscincus reticulatus* L R

**Pseudemoia lichenigera*

Beech Skink *Cautula zia* L R

Hemiergis maccoyi L
Hemiergis maccoyi is a burrowing skink found under rocks and fallen timber in southern NSW. Kavanagh and Webb (1989) found that there was a significant reduction in populations of *H. maccoyi* on three logged compartments compared with the unlogged control, with effects still significant three years after logging.

Lampropholis caligula

Challengers Skink *Lampropholis challengeri* L R
Dunning and Smith (1986) found that the highest densities of Challenger's Skink were associated with a closed forest canopy and abundant litter and logs in the ground cover. They found that numbers of Challenger's Skink declined significantly following logging in moist hardwood, even where there was 33% canopy retention and no post logging burn.

Leiolopisma coventryi L
McIlroy (1978) cites research that found that prescribed burning during winter destroyed the hibernation sites (logs and litter) of this species.

Murray's Skink *Sphenomorphus murrayi* L R
Dunning and Smith (1986) found that the highest densities of Murray's Skink were associated with a ground cover of abundant logs and litter. They found that its numbers decreased significantly following logging and burning.

***Southern Angle-headed (Rainforest) Dragon** *Hypsilurus spinipes* R

***Carpet and Diamond Python** *Morelia spilota*

Pale-headed Snake *Hoplocephalus bitorquatus*

***Broad-headed Snake** *Hoplocephalus bungaroides*

Stephen's Banded Snake *Hoplocephalus stephensi* R

4.4 AMPHIBIANS

***Green and Golden Bell Frog** *Litoria aurea*

***Green Thighed Frog** *Litoria brevipalmata*

**Litoria piperata*

**Litoria raniformis*

**Litoria spenceri*

**Litoria subglandulosa*

***Pouched Frog** *Assa darlingtoni* R

**Mixophyes fleayi*

***Giant Barred Frog** *Mixophes iteratus*

Philoria kundagungan W R G

***Loveridge's Frog** *Philoria loveridgei* W R G

***Sphagnum Frog** *Philoria sphagnicolus* W G

5.0 STATUTORY RESPONSIBILITY

The Forestry Act 1916 obliges the Forestry Commission to conserve native wildlife in State Forests, stating:

"8A (1) The objects of the commission shall be -
...
(e) consistent with the use of State Forests for the purposes of forestry and of flora reserves for the preservation of native flora thereon -
(i) to promote and encourage their use as recreation; and
(ii) to conserve the birds and animals thereon.

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

In practice timber production has achieved primacy over wildlife conservation (Dunning and Smith 1986, Mackowski 1987, Davey and Norton 1990). The Forestry Commission has consistently ignored research undertaken by their own personnel and other institutions on the impact of their operations on wildlife and failed to adopt adequate mitigation measures.

The Environmental Planning and Assessment Act 1979 gives the Department of Planning responsibility to protect and enhance the environment. They too have consistently failed their responsibility to ensure that developments or activities likely to have a significant impact on wildlife are controlled or adequate mitigation measures adopted, as evidenced by the large number of successful court challenges to E.I.S.'s which the Department has allowed. They also have responsibility for administration of the Heritage Act which contains mechanisms for the temporary and permanent protection of items of the State's natural and cultural heritage. There has been a political directive not to apply this Act to natural areas in recent years.

The Crown Lands Act requires that Crown land be managed so that the natural resources of the land, including flora and fauna, are conserved whenever possible. The Soil Conservation Act provides for the mapping and conservation of protected lands which can include land containing rare or endangered fauna. These acts are now administered by the Department of Conservation and Land Management, which is an amalgamation of the government departments who have historically had responsibility for these acts and similarly utterly failed their statutory duties to conserve fauna.

The National Parks and Wildlife Act 1974 gave the National Parks and Wildlife Service a clear statutory responsibility for the protection of protected and endangered fauna. This responsibility has only been partially applied for individual animals where direct methods of capture or killing were utilised, habitat destruction or indirect killing (e.g by felling of a tree) of protected fauna has been ignored.

The amendments to the National Parks and Wildlife Act 1974 and Environmental Planning and Assessment Act 1979 resulting from the Endangered Fauna (Interim Protection) Act 1991 specified in greater detail the National Parks and Wildlife Service's and Department of Planning's responsibilities to ensure the survival of protected fauna in N.S.W. These ammendments were further amended by the Timber Industry (Interim Protection) Act which substituted the word endangered for protected wherever it appeared in the E.P.A. Act. Most importantly the National Parks and Wildlife Service still has over-riding responsibility to ensure the protection of endangered fauna.

The other significant ammendments made by the Timber Industry (Interim Protection) Act are that for nominated management areas (which encompasses most of those on the north coast) the Forestry Commission can continue logging without complying with the requirements of the E.P.A. Act until they prepare E.I.S.'s in accordance with a schedule specified in the Act (though they are still required to comply with the N.P.W. Act), and that for those Management Areas the Minister for Planning is the determining authority.

Endangered fauna are protected fauna of a species named in Schedule 12 of the N.P.W. Act 1974 as threatened, as vulnerable and rare, or as a marine mammal.

The director of the N.P.W.S has the responsibility for licensing any activity which will take or kill endangered fauna. On the receipt of such a licence application the director must advertise the application in a statewide newspaper and invite public submissions for at least 28 days. In considering the application the director must take into account any fauna impact statement or environmental impact statement, submissions, the status of the species and proposed mitigation measures. The director must then notify the applicant and people who made submissions of the director's decision and reasons for it, and make all information concerning fauna supplied to the director in support of the application freely available to the public.

The applicant or people who made submissions may, within 28 days of notification of the director's decision, appeal to the Land and Environment Court if dissatisfied with the director's decision.

The amended Environmental Planning and Assessment Act 1979 requires that a Fauna Impact Statement is prepared if a proposed development (under part 4) or activity (under part 5) is likely to significantly affect the environment of endangered fauna:
"4A. ...in deciding whether there is likely to be a significant effect on the environment of endangered fauna the following factors shall be taken into account -

(a) the extent of modification or removal of habitat, in relation to the same habitat type in the locality and region;

(b) the sensitivity of the species of fauna to removal or modification of its habitat;

(c) the time required to regenerate critical habitat;

(d) the effect on the ability of the fauna population to recover including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development or activities;

(e) any proposal to ameliorate the impact;

(f) whether the land is currently being assessed for wilderness by the National Parks and Wildlife Service under the Wilderness Act 1987;

(g) any adverse effect on the survival of that species of endangered fauna or of populations of that fauna.

The amended National Parks and Wildlife Act 1974 states that a fauna impact statement is required to:

92D(1) "(c) include, to the fullest extent reasonably practical, the following:

(i) a full description of the fauna to be affected by the actions and the habitat used by the fauna;

(ii) an assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures upon them;

(iii) a description of the actions and how they will modify the environment and effect the essential behavioural patterns of the fauna in the short and long term where long term encompasses the time required to regenerate essential habitat components;

(iv) details of the measures to be taken to ameliorate the impacts;

(v) details of the qualifications and experience in biological science and fauna management of the person preparing the statement and of any other person who has conducted research or investigations relied upon."

The director is enabled to issue director's requirements for the preparation of Fauna Impact Statements which are legally binding.

The Minister for the Environment or the Director are able to issue stop work orders where they consider that an action is likely to significantly affect the environment of any protected fauna. Stop work orders last for 40 days and are able to be renewed.

6.0 GLOSSARY

dbh: diameter of a tree at breast height (1.3 m above ground), under bark - often used in general sense to include dbhob.

dbhob: diameter of a tree at breast height, measured over bark.

Cohort: a group of trees originating from the one regeneration event, often following a fire.

Endangered fauna: protected fauna of a species named in Schedule 12 of the N.P.W. Act 1974 as threatened, as vulnerable and rare, or as a marine mammal.

Habitat tree: trees containing hollows suitable for denning or nesting.

Indicator species: species that represents a particular use, ecosystem, or management concern.

Keystone species: a species, that if lost from a system, leads directly or indirectly to the disappearance of several other species.

Marginal habitat: habitat where a species can exist but not reproduce.

Minimum viable population: population size of a species that will ensure genetic viability over time.

Mobile link species: species which are important functional components of more than one food chain, plant-animal association, or ecosystem.

Optimum habitat: habitat that is of a quality that enables fecundity and/or population density of a species to be maximised.

Protected fauna: all fauna in N.S.W. not-named in Schedule 11 of the N.P.W. Act 1974.

Sensitive species: species affected detrimentally by forest operations - logging, fire management, silvicultural treatments, grazing, roading and 1080 baiting.

Sub-optimal habitat: habitat of a lower quality than optimal habitat, but where a species can still reproduce.

Target species: species that are rare, endangered or sensitive to the effects of proposed activities and/or global warming.

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MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

PRELIMINARY REPORT

Dailan Pugh
North East Forest Alliance
March 1992

MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

Preliminary report

"Apart from the hostile influence of man, the organic and the inorganic world are, as I have remarked, bound together by such mutual relations and adaptions as secure, if not the absolute permanence and equilibrium of both, a long continuance of the established conditions of each at any given time and place, or at least, a very slow and gradual succession of changes in those conditions. But man is everywhere a disturbing agent. Wherever he plants his foot, the harmonies of nature are turned to discords. The proportions and accommodations which insured the stability of existing arrangements are overthrown. Indigenous vegetable and animal species are extirpated, and supplanted by others of foreign origin, spontaneous production is forbidden or restricted, and the face of the earth is either laid bare or covered with a new and reluctant growth of vegetable forms, and with alien tribes of animal life."

G. P. Marsh, 1877.

INTRODUCTION

The Forestry Act 1916, National Parks and Wildlife Act 1974 and Environmental Planning and Assessment Act 1979 have all conferred a statutory duty upon the responsible government departments to ensure the conservation of fauna in N.S.W. In the main these departments have abrogated this duty and it has been up to concerned citizens to apply the law where possible. Because of the Forestry Commission's refusal to manage the fauna on the lands it controls in a responsible manner, and the Department of Planning's refusal to ensure the Forestry Commission complied with the Environmental Planning and Assessment Act's requirements to adequately assess the environment before commencement of an activity and prepare an Environmental Impact Statement if their proposed activities were likely to have a significant impact, the Forestry Commission has seriously degraded the faunal values of vast tracts of forests, fostered division in the community and been dragged before the Land and Environment Court on numerous occasions since 1980.

The Land and Environment Court ruling on Corkill vs. Forestry Commission (1991) over three compartments in Chaelundi State Forest, the subsequent ruling of the Court of Appeal and the Endangered Fauna (Interim Protection) Act have clearly established the National Parks and Wildlife Service's responsibility to ensure the conservation and survival of native vertebrate fauna throughout N.S.W. There is thus an unprecedented opportunity for the National Parks and Wildlife Service to develop a comprehensive strategy to protect fauna across all land tenures through both ensuring an adequate reserve system and designing mitigation measures to lessen the impact of developments and activities upon fauna.

It remains to be seen as to whether the National Parks and Wildlife Service will adequately implement their duty to ensure the conservation of fauna throughout the state or whether political interference, lack of resources, lack of resolve and inadequate knowledge of fauna will combine to allow the destruction of our unique fauna to continue unabated. It is hoped that it will not be again necessary for concerned citizens to drag a government department through the courts in order to get them to fulfil their legal responsibilities. Unfortunately history has a way of repeating itself.

It is evident that because of the abysmal lack of knowledge on Australian fauna and the impact of habitat modification upon apparently sensitive species, any conservation strategy can only be based on the best available information at this time and must be modified as more information becomes available. Given that habitat alteration is exponentially worsening and the fact that yet more species are undoubtedly doomed to extinction as changes already wrought upon their habitats become fully manifest it is imperative that a cautious and conservative approach be adopted.

While it is essential that fauna be conserved across the whole of N.S.W. throughout all habitats, this report focuses on forest dependent vertebrate fauna. Many of the principles and recommendations contained herein are applicable to other habitats.

This report is comprised of a summary and recommendations, a detailed background document which is comprised of a variety of extracts and summaries from the scientific literature, a still incomplete list of target species with some notes, and an outline of the legislation.

The report is basically a working document that will be expanded and improved as my limited time allows. Any comments or additional references will be gratefully received.

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March 1992

MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

PRELIMINARY REPORT

MEASURES THAT NEED TO BE TAKEN TO CONSERVE VERTEBRATE FAUNA IN FORESTS.

PRELIMINARY REPORT

D. Pugh March 1992

DISCUSSION AND RECOMMENDATIONS

Over the last two centuries Australians have led the world in eliminating species from the planet. Over this time New South Wales has suffered the loss of some 11 species of birds and 26 species of mammals. The genetic diversity within numerous species has similarly been dramatically reduced through the obliteration of populations of species. It is evident that the populations of a variety of other species have already been reduced below critical thresholds and that their extinction is inevitable.

To date the majority of extinctions have occurred in the more open habitats of western NSW where the impacts of humans and the animals they introduced was most rapid. The nature and integrity of forested areas has better enabled their inhabitants to withstand the onslaught, but as logging and roading extends into the remaining tall old growth forests many more species are being pushed to the brink of extinction.

Within ecosystems the innumerable components inter-relate in a myriad of ways to form the whole. Vertebrate fauna are key components of forest ecosystems. They pollinate plants, disperse plant and fungi propagules, control herbivorous invertebrates and perform other necessary functions which we are yet to comprehend. As we continue to eliminate vertebrates the repercussions spread throughout the forest and the ecosystem's functioning is further impaired.

The key factors affecting the ability of a range of native fauna to persist in New South Wales are habitat loss, habitat fragmentation and habitat degradation. Logging, prescribed burning, road construction, stock grazing, mining and chemical usage have all been found to significantly affect an array of native fauna. Overshadowing and compounding these impacts are global warming, increasing ultra-violet radiation, the buildup of toxic chemicals in foodchains, and displacement of native species by introduced species.

Habitat can be lost by clearing or by being rendered unsuitable by the loss of habitat components upon which a species relies. Habitat is degraded when components upon which a species depends are diminished but still sufficient to allow a species to persist (even if only temporarily). When considering the persistence of species in degraded habitats it is essential to consider whether the habitat has been rendered sub-optimal or marginal. If the later is the case then individuals encountered in that area may be non-breeding colonists from optimal habitat elsewhere.

As habitat suitable for a species becomes fragmented or degraded other species from more open habitats, or introduced from other countries, may invade to compete with or prey upon resident species (Jarman 1986, Saunders 1990, Andrews 1990, Neave and Norton 1990, Benett 1990, Gilmore 1990). These effects can penetrate well into intact habitat due to the edge effect (Andrews 1990, Bennett 1990, Gilmore 1990).

Fragmentation of populations of a species by unsuitable habitats can disrupt or stop gene flow between remnant populations (Andrews 1990, Barnett, How and Humphreys 1978, Bennett 1990). Entire populations of some species may have already been reduced to such an extent that their long-term viability can only be assured by active and costly management (Clark, Backhouse and Lacy 1991). Many isolated populations may also be suffering the same fate (e.g. Dunning and Smith 1986)

The full ramifications of changes already wrought upon the environment have yet to become fully manifest (e.g. declining numbers of habitat trees and large logs, global warming) and populations of many species can be expected to continue declining for many decades even after activities contributing to their demise cease (e.g. Gilmore 1990).

Disturbance to an ecosystem makes it more vulnerable to invasion by other species and susceptible to climatic changes. Population declines in, or loss of species from, an ecosystem can disrupt the ecosystem's functioning and cause imbalances which may take many years to become apparent (e.g. Bell Miners killing regrowth, Currawongs decimating small bird populations, Dingo control leading to increases in foxes and further declines in medium sized mammals).

The frequency at which disturbances recur is a major determinant of ecosystem potential and the ability of species to persist. If the frequency of disturbance is such that the structural components a species is dependent upon are unable to fully recover before the next disturbance then the impacts will compound the effects upon that species, with each disturbance lessening its ability to persist.

Conservation of natural ecosystems and processes is hampered by our ignorance of animal's requirements and failure to expend significant resources on gaining the required knowledge upon which to make informed decisions. Of the numerous forest vertebrates threatened by forestry activities only a few have been subjected to detailed studies, and for even those few it is evident that we still don't know enough to determine the consequences of what is being done to them.

In intentioned ignorance the Forestry Commission blunders on, returning to remove the old growth remnants from previously logged forests or flattening the alternate old growth coupes, while they rapidly polish off the few remaining tall old growth forests. Their vision of converting the readily accessible forests to tree-farms, while they plunder the less accessible forests for whatever they can get, has almost been fulfilled. The end is within sight.

While it is undoubtedly too late for some species it is time to stop this madness. We must ensure the establishment of an adequate reserve system, which will undoubtedly encompass most of the remaining tall old growth forests, and do everything possible to preserve the faunal values of the other forests.

A conservative approach to the conservation of forest vertebrates requires that for all species sensitive to forestry activities sufficient habitat is retained free of adverse disturbance to ensure their survival into our uncertain future. To maximise species chances to adapt to environmental changes it is essential to preserve genetic diversity within species by maintaining populations throughout a species range.

Those forests not required for an adequate reserve system still need to be managed to maintain fauna diversity and ecosystem functioning.

Given the abysmal ignorance of most species' demography and habitat requirements, it is necessary to select a number of key species that represent the entire range of organisms to use in determining reservations to conserve minimum viable populations (Possingham 1990), monitoring impacts of forestry practices (Norton and Lindemayer 1990, Milledge, Palmer and Nelson 1991), and modeling impacts of global warming (Busby 1988). A primary research requirement at this time is thus to identify key species, their demography and habitat requirements.

REGIONAL SYSTEM OF RETAINED HABITAT

The state needs to be separated into definable regions within which the aim should be to preserve the existing biodiversity. Given our ignorance of species requirements, ecosystem functioning and impacts of habitat modification it is essential that the highest priority be given to establishing a regional system of retained habitat which ensures the provision of adequate, and suitably linked, habitat to support viable populations of all target species.

A regional system of retained habitat should be comprised of adequate areas reserved from exploitation as legislated reserves, sites of significance and wildlife corridors. Such a system can be complemented by enhanced retention of habitat components and specific fauna prescriptions in unreserved areas.

Where feasible (ie State Forests) reserves should be buffered by habitat subject to a lesser degree of disturbance than normal (e.g. forest logged to a reduced intensity). This is particularly important for small reserves and wildlife corridors.

Legislated Reserves

One of the principle objectives in the establishment of an adequate reserve system should be to ensure the reservation of sufficient habitat to preserve minimum viable populations of all species significantly affected by human activities.

An effective population size needs to maintain genetic variability in perpetuity and provide the genetic means for continued ability to adapt to environmental changes and pressures (Tyndale-Biscoe and Calaby 1975, Mackowski 1986, Dunning and Smith 1986, Davey 1989, Davey and Norton 1990, Possingham 1990). Natural population fluctuations, catastrophes such as fire, drought and disease, along with global warming need to be accounted for in assessing the minimum population of a species needed for it to survive into our uncertain future (e.g. Tyndale-Biscoe and Calaby 1975, Davey 1989, Possingham 1990).

Assessments of minimum viable population sizes span a range from several hundred to tens of thousands, depending on the species (Tyndale-Biscoe and Calaby 1975, Davey 1990, Possingham 1990).

The emphasis should be upon reserving major source areas (e.g. areas with high population densities of target species), refuge areas (areas species are already restricted to, become periodically restricted to, or are predicted to become restricted to as the result of global warming or other factors) and areas with a high diversity of target species.

Faunal diversity and greater population densities of a variety of species have been found to be correlated with more fertile soils and moister sites (Recher, Rohan-Jones and Smith 1980, Binns 1981, Mackowski 1983, Neave and Norton 1990, Recher *et al.* 1991), and moderate slopes (Neave and Norton 1990).

Many wildlife researchers have noted the importance of reserving large areas of old growth forest free from logging activities (e.g. Shaw 1983, Shields and Kavanagh 1985, Loyn 1985, Dunning and Smith 1986, Lunney, Cullis and Eby 1987, Norton and Lindenmayer 1990, Bennett 1990, Milledge, Palmer and Nelson 1991).

The requirements of migratory and wide ranging species need to be considered in reserve design. It is essential that reserves incorporate significant altitudinal and latitudinal variation to account for the predicted future requirements of fauna resultant from global warming (Busby 1988, Arnold 1988, Main 1988, Page 1989, Norton and Lindemayer 1990)

Where possible reserves should be as large as feasible (Tyndale-Biscoe and Calaby 1975, Davey 1989, Bennett 1990) and have a minimum edge to area ratio (Bennett 1990, Gilmore 1990).

Sites of significance

Sites of particular botanical and zoological significance outside major legislated reserves need to be identified and given appropriate protection. Sites of zoological significance should be those with outstanding faunal values or containing populations of nominated threatened, vulnerable and rare fauna (Kavanagh and Webb 1989, Davey and Norton 1990). These sites should be identified in the Fauna Impact Statement process and managed as wildlife priority areas.

Sites of significance could be designated as Flora Reserves or protected under the Preferred Management Priority system if on State Forests. On private lands they could be designated as Environmentally Sensitive under the Protected Lands mapping system or a Conservation Agreement could be entered into with the landholder.

Wildlife Corridors

Corridors of forest need to be retained or established to provide multiple pathways for the dispersal of fauna throughout forests to allow: (i) genetic exchange between isolated populations (Dunning and Smith 1986, Bennett 1990, Saunders 1990), (ii) dispersal to required resources (Saunders 1990, Moon 1990), (iii) preservation of populations of some species in otherwise unsuitable habitat (Kavanagh 1985a, 1985b, Dunning and Smith 1986, Kavanagh and Webb 1989, Bennett 1990), (iv) for required resources for species utilizing adjacent habitats (Bennett 1990), and (v) for migration of species in response to predicted global warming (Busby 1988, Arnold 1988, Main 1988, Page 1989).

Wildlife corridors should be as wide as possible and where possible established in natural forest which has preferably not been subject to severe perturbation.

In general the Forestry Commission relies upon modified streamside retention strips (implemented for erosion mitigation purposes) for wildlife corridors. These may be strips of vegetation 20 metres each side of streams with catchments in excess of 30 or 100 hectares, which may or may not be subject to logging (but not entered by machinery), or "wildlife corridors" comprised of strips 40 metres wide with the outer 20 m subject to modified harvesting. In some instances (e.g. Eden region) 100 m + strips may be retained.

Narrow riparian strips do not provide habitat suitable or adequate for a variety of species (Mackowski 1984, Kavanagh 1985b, Shields and Kavanagh 1985, Dunning and Smith 1986, Bennett 1990, Gilmore 1990, Recher *et al.* 1991). Even where suitable habitat is encompassed corridors with a total width of 200 m have been found inadequate for some species (Kavanagh 1985b).

When designing wildlife corridors it is essential to consider: (i) the species being targeted, their ecology, habitat requirements, and dispersal ability (Bennett 1990), (ii) the edge effect and its impact on suitability of the corridor for target species (Bennett 1990, Saunders 1990, Recher *et al.* 1991), (iii) the pathways actually utilized by species for movement (Davey 1989), and (iv) the necessity of species to migrate in response to global warming (Busby 1988, Arnold 1988, Main 1988, Page 1989).

An adequate wildlife corridor system should encompass: (i) multiple pathways linking retained habitat (Bennett 1990), (ii) reservation of larger areas of suitable habitat at periodic intervals along corridors (Bennett 1990, Recher *et al.* 1991), (iii) linked riparian and ridge corridors sampling suitable habitat for a full range of target species (Recher, Rhonan-Jones and Smith 1980, Dunning and Smith 1986, Conservation, Forests and Lands 1989, Bennett 1990, Recher *et al.* 1991) and (iv) a hierarchy of corridors comprised of broad regional corridors established to restore links between isolated forests, major wildlife corridors within production forests to link important reserved areas and a network of smaller wildlife corridors forming common linkages in the system of retained habitat (Bennett 1990).

While it is essential that wildlife corridor design be based on the actual requirements of target species, as interim measures the minimum width of regional corridors should be at least 200-400 m wide (Saunders 1990, A.H.C. and C.A.L.M. 1992), major wildlife corridors at least 150 m wide (A.H.C. and C.A.L.M. 1992) and smaller wildlife corridors (incorporating all filter strips) at least 80-100 m wide (Recher, Rohan-Jones and Smith 1980, Dunning and Smith 1986, Kavanagh 1989b, Bennett 1990). Davey (1989) recommends not stipulating constant width and enabling boundaries to maximise the structural and species diversity. Recher, Rohan-Jones and Smith 1980 recommend that the riparian environment should be retained intact. Where rainforest occurs in riparian situations the incorporation of their buffer zones into the corridor system will greatly enhance the corridors value for non-rainforest species. Wildlife corridors should not be subject to logging (Recher, Rhonan-Jones and Smith 1980, Conservation, Forests and Lands 1989, Bennet 1990, A.H.C. and C.A.L.M. 1992).

In designing wildlife corridors it is essential to consider the effects of barriers to movement and strategies to facilitate movement across potential barriers (Andrews 1990, Bennett 1990, Saunders 1990). For example it is essential that movement of fauna be taken into account in highway and railway design by the provision of fauna underpasses (Andrews 1990). Forest roads should have fauna underpasses incorporated as well as ensuring that at strategic locations tree crowns can touch across roads to facilitate movement of arboreal species. Measures need to be identified to ensure that underpasses don't act as funnels to

concentrate prey for predators (Andrews 1990). Where possible corridors should not be situated along a road or railway, when they are they should be on one side to maximise effectiveness and minimise fatalities (Saunders 1990).

MULTIPLE USE MANAGEMENT

The Forestry Commission has managed its forests predominantly for wood production with wildlife considered a constraint and wildlife management at best incidental (Dunning and Smith 1986, Mackowski 1987, Davey and Norton 1990). Recommendations and research findings by research foresters have been regularly ignored by the Commission because they are considered to interfere with timber production. In attempts to justify their approach the Commission has resorted to propaganda which has been found to often contradict the results of their own research or have no scientific credibility.

Normal logging practices have been found to have a significant impact on wildlife, causing elimination or severe reductions of a variety of species in logged areas (Tyndale-Biscoe and Calaby 1975, Kavanagh 1985a, 1985b, Shields and Kavanagh 1985, Loyn 1985, Dunning and Smith 1986, Kavanagh and Webb 1989). Species most effected are considered to be those requiring tree-hollows for denning, roosting and/or nesting, eucalypt canopy feeders, nectivorous species, moist ground litter feeders, trunk and bark foraging species, species dependent upon large logs, species reliant upon reliable moisture regimes in gullies and low order streams, and species with narrow habitat requirements (variously Recher, Rhonan-Jones and Smith 1980, Loyn 1985, Shields and Kavanagh 1985, Dunning and Smith 1986, Mackowski 1987, Kavanagh and Webb 1989, Gilmore 1990, Recher *et al.* 1991). Logging has also been found to cause significant declines in some species in nearby unlogged areas (Dunning and Smith 1986, Kavanagh and Webb 1989) and affect fauna outside the region being logged (Recher, Rohan-Jones and Smith 1980).

The impact of logging has been found to be significantly compounded by the common practices of post-logging burning (McIlroy 1978, Rohan-Jones 1981, Recher, Allen and Gowing 1985, Dunning and Smith 1986) and other prescribed burning (Cowley 1971, Rohan-Jones 1981, Shields and Kavanagh 1985, Wilson *et al.* 1990, Moon 1990). Associated roading is also considered to be a major impact (Barnett, How and Humphreys 1978, Andrews 1990, Bennett 1990, Gilmore 1990). Other forestry practices such as application of herbicides and fertilizers, grazing, 1080 baiting and, conversion of native forest to plantations all contribute to the very significant impact of forestry operations on wildlife.

There is a dearth of research on the long term consequences of such disturbances upon fauna. Research to attempt to identify longer term consequences have often compared different sites where site variables can not be adequately accounted for and, as noted by Recher, Rohan-Jones and Smith (1980) "It is possible that some populations of dependent fauna we presently record in buffer strips, on reserves and in regenerating forest are derived from animals bred in the large area of mature forest that remains... There may come a time in the logging cycle when the area of mature forest is reduced to a level where the numbers of animals produced are insufficient to maintain these populations. If this critical point is reached, there would be a precipitous decline in species number and abundance, leaving little scope for remedial action."

Habitat tree retention prescriptions

Hollow-bearing trees, and with them hollow-dependent species, have already been decimated within vast tracts of forests. The problems such fauna are facing is expected to exponentially worsen as the few remaining tall old-growth forests continue to be felled and currently retained trees (in both forests and pastoral lands) die-out without potential replacement trees being available. The full ramifications of changes already wrought will take a century or more to become fully manifest.

To mitigate the impact of logging operations upon some hollow-dependent fauna it is necessary to manage for provision of habitat (hollow-bearing) trees in perpetuity (Recher, Rohan-Jones and Smith 1980, Mackowski 1984, 1987). While this requirement has been clearly identified to the Forestry Commission, Mackowski's (1987) concern that there would be a lack of implementation has been fully justified. Current blanket prescriptions in NSW vary from clumps of 5 habitat trees per 15 ha to 5 per 5 ha, though in individual cases foresters are being forced to retain higher numbers and distribute them more evenly through the logging area. It is reprehensible that there are still no provisions to retain potential replacement trees for the future.

Current prescriptions are a farce because (i) a clump of habitat trees may effectively only be equivalent to one tree for territorial species (Smith and Lindenmayer 1988), (ii) retained trees are more vulnerable to windthrow and post-logging burning (Recher, Rohan-Jones and Smith 1980, Mackowski 1987, Smith and Lindenmayer 1988, Milledge, Palmer and Nelson 1991), (iii) some retained trees have been observed to be already dead or burnt out at the base and unlikely to remain standing for long (pers. obs.), (iv) there is no provision for replacements as retained trees drop out of the system (Mackowski 1984, 1987), (v) there is no attempt to asses the usage of specific trees before delineation (Kavanagh 1989b), and (vi) there is generally no attempt to assess species densities and requirements prior to determining prescriptions for an area.

To determine habitat tree retention prescriptions for an area it is necessary to consider: (i) the habitat requirements and demography of the target species (including various species interactions), (ii) that only one large species may occupy a given tree (Lindenmayer *et al.* 1991), (iii) the type and position of hollows and their suitability for target species (Lindenmayer *et al.* 1991, Mackowski 1987, Davey 1989), (iv) the species of trees involved and their hollow-development characteristics (Davey 1989, Mackowski 1987), (v) the need for a uniform distribution of habitat trees (Dunning and Smith 1986, Mackowski 1987, Smith and Lindenmayer 1988), (vi) the area in a regional context (Mackowski 1984), (vii) the full range of species which utilise hollows in the area and their seasonal use (Davey 1989), (viii) the actual trees which are utilized by specified species (Recher, Rohan-Jones and Smith 1980, Kavanagh 1989b), (ix) the retention of sufficient potential replacement trees to maintain the prescribed number of habitat trees in perpetuity (Recher, Rohan-Jones and Smith 1980, Mackowski 1984, 1987).

It is feasible that management aimed at providing hollows in perpetuity should only need to focus on species requiring larger hollows and endangered species. Some such species would be Greater Glider, Yellow-bellied Glider, Squirrel Glider, Powerful Owl, Sooty Owl, Masked Owl, Yellow-tailed Black Cockatoo, Red-tailed Black Cockatoo, Gang-gang Cockatoo, Glossy Black Cockatoo and a variety of bats. Kavanagh (1989b) recommends the employment of a specialist nest finder for owls, such a concept could be expanded to identify habitat trees for most of these species before trees are felled.

In old-growth forests hollow-availability is not generally considered to be a limiting factor for most species of hollow dependent species but rather other resources that are limiting populations (Dunning and Smith 1986, Mackowski 1984, 1987). It is in logged forests that hollows do become a limiting factor. As well as managing for provision of hollow-bearing trees in perpetuity it is crucial to determine other limiting resources for target species, the recovery time of such resources and when population recovery can be expected.

Many forests have been denuded of habitat trees. To enhance such forests for nature conservation and maintenance of ecosystem functioning they need to be managed for the return of adequate stockings of habitat trees (Mackowski 1987). To determine adequate stockings for already disturbed areas it will be necessary to extrapolate from 'undisturbed' forests of similar type and productivity.

The concept of habitat tree needs to be expanded to include trees offering other critical resources for target species, for example trees tapped for sap or relied upon for abundant nectar at critical times by Yellow-bellied Gliders or the preferred individual food trees of Koalas or Glossy Black Cockatoos. Importantly the supply of large logs in perpetuity needs to be evaluated, target species dependent upon large logs for critical resources identified, their habitat requirements delineated, and the findings incorporated into habitat-tree retention prescriptions.

Habitat trees and their successors should be clearly marked in the field and monitored over time to determine their effectiveness (Recher, Rohan-Jones and Smith 1980, Mackowski 1987).

Suggested procedures to maintain habitat trees in perpetuity are:

1) Undertake surveys in representative old growth forests of each forest type to determine average densities of hollow-dependent and 'large log'- dependent fauna. Assess habitat tree/log requirements to maintain the full array of fauna.

2) Develop models predicting development of hollows in tree species and formation of logs, and their use by target species, in relation to size class (e.g. Mackowski 1984, 1987, Davey 1989). Combine this with models of stand dynamics and proposed silvicultural practices to determine prescriptions for habitat tree provision in perpetuity for each forest type (e.g. Mackowski 1984, 1987).

3) Undertake site-specific surveys to determine target species' presence, habitat requirements and densities. Where possible identify particular trees used by select target species (e.g. Kavanagh 1989b). Use actual findings as a basis for prescriptions with allowance made for predicted and potential occurrences and requirements,

4) Permanently mark habitat trees, and their replacements (Mackowski 1987). Monitor their effectiveness and accuracy of predictions at selected sites over time. Adjust prescriptions as required.

Prescribed burning

A single fire event has been found to have a significant effect upon fauna that inhabit or utilize the ground and shrub stratum (Cowley 1971, Fox and McKay 1981, Recher, Allen and Gowing 1985, Dunning and Smith 1986, Lunney, Cullis and Eby 1987, Wilson et *al*. 1990).

Species of small ground mammals exhibit a replacement sequence in reaching maximum abundance following fire, variously species may reach maximum abundance after one to eight years, with populations of some species found to be still increasing after six to eight years or even after 30 years (Fox and McKay 1981, Wilson *et al*. 1990). Populations of some species may be eliminated by fire (Wilson *et al*. 1990) and others may not establish populations in burnt areas for many years (Fox and McKay 1981, Lunney, Cullis and Eby 1987, Wilson *et al*. 1990).

Post-logging burns are commonly utilized to dispose of logging debris and encourage eucalypt regeneration. Such burning has been found to greatly compound the impact of logging operations on fauna (Recher, Allen and Gowing 1985, Dunning and Smith 1986), and is considered to have a greater impact on some small ground mammals and reptiles than logging (Shields and Kavanagh 1985, Dunning and Smith 1986). Post-logging burning leaves many large logs but due to their often being elevated by branches and other debris they commonly are severely charred, which can render them

unsuitable for many invertebrates and consequently vertebrates. Repeated burning gradually eliminates large logs.

Post-logging burns are of questionable silvicultural value and tractor clearing has been advocated to create the desired disturbance for regeneration (Dunning and Smith 1986), though this can have other undesirable consequences on soils (e.g. compaction). Kavanagh and Webb (1989) found that without burning the clearfelling of patches in their 50% canopy retention treatment resulted in better regeneration than the 'normally logged' treatment.

While populations of some species may recover in parallel with the rate of post-fire revegetation (Recher, Allen and Gowing 1985) it is considered that frequent burning (e.g. control burning) can result in degraded habitat and the loss of habitat components upon which species rely (Cowley 1971, McIlroy 1978, Leigh and Holgate 1979, Rohan-Jones 1981, Moon 1990, Wilson et al. 1990), such as understorey structure and plant species (Cowley 1971, McIlroy 1978, Leigh and Holgate 1979), habitat trees (Rohan-Jones 1981, Mackowski 1987), large logs and litter (McIlroy 1978, Dunning and Smith 1986). It is apparent that some of these habitat components may be restored within a few years but also that many will take many decades or centuries to be replaced.

The Forestry Commission prescribe burns some areas of forest every year (near plantations), every second year (high-risk areas near some roads or tourist facilities) or on frequencies of up to 5-7 years. Their ideal frequency is often not achieved due to labour and funding constraints. The greatest source of non-prescribed burns are graziers with forest-leases who burn vast tracts of forest (often in spring when peak flowering and breeding occurs) as frequently as every year. Grazier's fires must be stopped as a matter of urgency, if necessary their leases should be revoked.

Fuel reduction burns should be well planned, taking into account the frequency, area burnt, timing and intensity of fires (Wilson *et al*. 1990), and the demography, habitat requirements and responses to burning of target species. It is essential that a proper evaluation of burning and its impact on wildlife be undertaken and mitigation measures devised.

Roading

Roads (and other disturbance corridors and barriers) create avenues for the introduction and dispersal of non-forest and introduced species into forests (Dunning and Smith 1986, Richards and Tidemann 1988, Anon 1988, Andrews 1990, Bennett 1990, Gilmore 1990), isolate or restrict movement between populations of some species (Barnett, How and Humphreys 1978, Andrews 1990, Bennett 1990), are significant causes of mortality (Andrews 1990, Bennett 1990, Moon 1990), and have many other deleterious impacts on fauna (Andrews 1990, Bennett 1990).

Introduced predators, such as Foxes and Cats, have had a devastating impact on native wildlife (Jarman 1986, Kinnear 1987, Anon 1988, Bennett 1990, Eason and Frampton 1991, Potter 1991), affecting small and young mammals, birds, reptiles and invertebrates. They have been implicated in the extinction of an array of species. Forests in their pristine state are relatively resilient to invasion and it is roading that is facilitating their spread and hunting efficiency throughout forests.

There is an obvious need to consider wildlife in road planning. Fauna underpasses and overpasses must be incorporated into road design to; facilitate genetic exchange between isolated populations, minimise disruption to social organization, provide access to required resources, and enable migration. Further measures to minimise the impacts of roads are to: retain extensive areas of natural vegetation free of roads (i.e. Wilderness Areas); minimise road clearances through natural areas; close and revegetate forest roads not required for management purposes immediately after use, and; identify effective means of reducing road fatalities.

Rainforest protection

The Forestry Commission is still phasing out 'general purpose' rainforest logging and replacing it with unspecified 'speciality purpose' logging. Their restrictive definition of rainforest is based on aerial photograph interpretation where 20% canopy cover (or in practice even less) by eucalypts or Brush Box is considered sufficient to classify a forest as non-rainforest. This, coupled with often inaccurate typing, is not an acceptable ecological basis upon which to classify rainforest. As a consequence rainforest is still being logged on a 'maximum economic utilization' basis, and surviving rainforest species killed in post-logging burns. There is a need to define rainforests on an ecological basis (Cameron 1991).

The Forestry Commission is allowing logging to occur up to rainforest margins (by their definition) and is regularly constructing roads through rainforest. Logging of rainforest buffer zones has been found to make the rainforest significantly more vulnerable to fire incursions (Cameron 1991, Roberts 1991). The Victorian government has adopted a policy of not allowing logging within 20 m of rainforest where it is "generally linear in shape" and 40 m of other stands. For long-term fire protection Cameron (1990) recommends an unlogged buffer zone of at least 100 m around rainforest, and Roberts (1991) recommends a buffer of "two or three mature tree heights."

1080 baiting

Vast areas of NSW's forest and pastoral lands are aerially or trail baited with fresh meat injected with 1080 or factory prepared 1080 'crackle' baits every year, in efforts to control

wild dogs and Dingoes. Additional baiting with 1080 takes place to control rabbits and other herbivores.

1080 baiting for 'wild dogs' has been found to be taken by a variety of non-target animals, with birds and reptiles taking a large proportion (McIlroy 1986, Allen *et al.* 1991). Carnivorous marsupials have been found to be the most susceptible non-target species to 1080 (McIlroy 1982, Calver *et al.* 1989), with baiting's impact on quolls being the most concern (e.g. Calver *et al.* 1989). Active suppression of Dingoes can enable Foxes greater ingress into forested areas (Jarman 1986).

1080 baiting has been used to reduce fox predation on rock wallabies and found to greatly enhance their breeding success, even though poisoned foxes were rapidly replaced by immigrant foxes (Kinnear 1987).

Burying of meat baits has been found to make them far more target specific and significantly reduce their impacts on non-target species (Allen *et al.* 1989), though there is obviously far more research required to determine the effectiveness of this method. Burying of baits coupled with the retrieval of uneaten baits and poisoned animals four days later has been suggested as a responsible method (Anon 1988).

1080 rabbit etc. baiting is of greater concern because of the direct impact it can have on native herbivorous mammals and the further indirect impact on carnivores feeding on poisoned carcases.

1080 baiting is extensively utilized in State Forests, National Parks and on private lands for control of Dingoes and/or grazing pests (e.g. rabbits, wallabies). There has never been an Environmental Impact Statement prepared for 1080 baiting, even though it is an activity likely to have a significant impact upon the environment and thus an E.I.S. is required by the Environmental Planning and Assessment Act 1979. No further 1080 baiting should be allowed until the E.P.A. Act has been complied with and a Fauna Impact Statement prepared.

Other prescriptions

Grazing, chemical usage, mining and introduced diseases all have significant environmental impacts and their impacts on wildlife need to be fully considered and assessed for planned developments and activities.

1.0 CONSERVATION OF FOREST VERTEBRATE FAUNA IN NSW

Tyndale-Biscoe and Calaby (1975) state "The *Eucalyptus* forests of southeastern Australia and Tasmania support a rich and varied fauna of mammals and birds and together form the single most important refuge for wildlife in Australia. A greater number of mammal species are found in these forests than in any other broad category of habitat..."

McIlroy (1978) notes that within Australia 16% of birds and 17% of mammals are confined to rainforest and 16% of birds and 35% of mammals are confined to sclerophyll forest.

Neave and Norton (1990) state "The major threat to forest fauna arises through the fragmentation and loss of their habitat... The species at greatest risk of extinction are those which appear least resilient to habitat modification... The long-term viability of now disjunct populations of fauna may be compromised further by many factors including predation by introduced carnivores such as foxes... and episodic extreme events like fire, drought and outbreaks of disease... Additional problems include the inadequacy of the existing nature conservation reserves within forests... and the inconsistent regimes of forest management across State borders and land tenures".

Recher (1986) considers that to guarantee the rehabilitation and survival of forest wildlife there is a need to implement practices designed specifically to manage wildlife. He states "It is not enough to set aside samples of forest for nature conservation and expect these, by themselves, to ensure the survival of Australia's forest biota."

Recher (1986) emphasises the need to integrate wildlife conservation and management on private lands with those on Crown Lands and states "The lack of regional and national planning for forest wildlife planning can not be allowed to continue."

Bennett (1990) states "Reserved areas are vitally important for nature conservation, and it is essential that a representative set of natural ecosystems be protected with nature conservation as the primary objective. Nevertheless, this intensive approach is by itself is insufficient. We cannot rely on nature conservation reserves alone for the long-term protection and preservation of wildlife communities. We must develop a broader perspective and manage fauna at a regional, statewide and national scale, that includes lands used for a range of other purposes."

Norton and Lindenmayer (1990) state "Australia needs a coherent strategy to integrate the management of wildlife across all forested lands. The destruction and degradation of forested lands on the Australian continent since European settlement can be attributed to a variety of factors including the need for settlements to survive, ignorance, poor planning and lack of

concern for the environment. But these reasons will become lame if used any longer."

Davey and Norton (1990) state "It is clear that historical patterns of forest-use have had a significant, often detrimental, impact on the population status of many native, forest wildlife. At the same time, knowledge of the effect of these practices on most wildlife is not available. Many more species may have become extinct than is recognized."

Davey and Norton (1990) state "decision-making on the allocation of forest resources (wood, non-wood) appears to favour a perspective that is subjective and political rather than scientific. Political decision-makers have not, in general, adopted an approach in the allocation of these resources based on ecological and environmental principles."

Shaw (1983) states the general goals of wildlife conservation in state forests of Victoria are to: manage in order to maintain the diversity of species which are indigenous to that state's forests, and; manage for featured species (i.e. species of special social or ecological significance).

Loyn (1985) considers the primary objective of wildlife conservation is to ensure that no species becomes extinct or reduced in range. He states it is desirable "to conserve all species in major forest blocks and to do this populations must be maintained above critical levels needed for long-term survival."

1.1 THE BENEFITS OF MAINTAINING THE DIVERSITY OF FAUNA.

Gilmore (1990) states "There is increasing evidence that vertebrate wildlife are essential components of forest ecosystems and contribute to their long term stability and productivity. Vertebrate roles include: facilitating long distance pollen dispersal and outcrossing compared to Honey bees (*Apis mellifera*) and other insects...; consumers of herbivorous arthropods...; dispersers of fungal and higher plant spores and seeds... Passage through an animal's alimentary canal facilitates the germination of mycorrhizal fungal spores ... and the germination of seeds."

1.1.1 INVERTEBRATE CONTROL

Cowley (1971) notes that the majority of land birds are insect eaters, and each occupies an ecological niche relatively free from the competition of other species, stating "The combined effect of these birds on the insect population must be tremendous." He cites the beneficial effects of Pied Currawongs feeding on phasmatids, Yellow-tailed Black Cockatoos on wood boring insect larvae and cockatoos on the larvae of cerambyoid beetles and cossid moths. He notes that forests are the breeding areas for many species that spend most of their time in surrounding farm and pasture land.

A major problem associated with severe disturbance (particularly logging) of forests is the proliferation of the aggressive and territorial Bell Miners *Manorina melanophrys*. They exclude other birds while undertaking "farming" of psyllids, this results in the consequent death of regrowth trees.

Loyn (1985) found that when Bell Miners were removed from a psyllid-infested stand of mixed eucalypts there was an immediate influx of other birds which controlled the psyllids. He notes that the invading species were birds that are more abundant in mature forest than regrowth.

1.1.2 POLLINATION AND PROPAGULE DISPERSAL

Cowley (1971) notes the honeyeaters and lorikeets are important agents in the cross pollination of eucalypts, melaleucas, banksias and grevilleas.

Cowley (1971) notes the Mistletoe Bird is well known for its role in the spread of mistletoe.

Richards and Tidemann (1988) state "There is definitely a close relationship between fruit bats and the reproduction of many of their food trees, primarily through the pollination of flowers as nectar is consumed, and the dispersal of seeds in fruits that are eaten. These processes are vital to rainforest for the continued survival of some tree species and to the general cycle of rainforest regeneration."

Claridge (1990) notes the importance of the symbyotic relationship between mycorrhizae ('fungus-roots') and plants. He notes that hypogeal fungi usually contain their reproductive spores in buried indehiscent fruiting bodies and thus most probably rely upon the potoroos, bettongs and bandicoots which feed upon them to disperse their spores. He cites American research which has identified a similar relationship in coniferous forests.

1.1.3 OTHER BENEFITS

Cowley (1971) notes "The Superb Lyrebird is thought by some ecologists to play an important part in aerating the soil in mountain forests. It has been estimated that their scratchings in certain areas are equivalent to digging the entire forest floor once every two years."

1.2 STRATEGIES FOR MAINTAINING FAUNA DIVERSITY

Cowley (1971) stated "Our immediate objective should be to recognise, classify and conserve the widest possible variety of habitats, and by so doing conserve the greatest possible diversity of species." and "Single purpose reserves can readily be justified in certain cases, for example where there are rare or endangered species..."

Shaw (1983) suggests a number of measures that can be adopted until research provides the information needed to develop more specific guide-lines: planning to provide appropriate reserves and corridors of old growth timber; providing a range of uncut vegetation reserves which includes at least some that are 2 000 to 20 000 ha in size; considering and planning the arrangement of corridors and reserves in a regional, state and national context; providing buffer strips to corridors that are harvested on a selective cut rather than clear cut; and, focusing wildlife conservation on species of special significance.

Loyn (1985) considers three strategies to provide for species that require old trees or patches of old forest: leave enough trees for them on individual harvested areas; extend the rotation so that there is time for regrowth to develop suitable habitat and be recolonised by breeding populations before it is harvested again; and retain strips and patches of old forest within a mosaic of harvested areas. He considers the later strategy to be most effective.

Recher (1986) cites a number of positive management initiatives: establishment of fauna priority areas; lessening the impact of logging on forest types with a restricted distribution or which are rich in species: establishment of corridors to link drainages and allow movement between nature conservation areas; harvesting forests with high wildlife values on a longer cutting cycle; and, retention of known habitat trees and suitable developing habitat trees.

Davey (1989) considers that within production forest viability of strategic areas will relate to availability of habitat trees, movement corridors and the maintenance of reserves managed for the conservation of wildlife species. He emphasises the value of disturbed forests for conservation of many species and, where required, the manipulation of reserves to meet prescribed wildlife objectives.

Davey (1989) considers that it is necessary for a manager to work within a defined region covering all land tenures (which may extend across State or other boundaries) within which areas of wildlife priority or significance can be identified and managed accordingly.

Dunning and Smith (1986) consider "There are three approaches to conserving arboreal mammals in logged forest; (i) preservation in unlogged reserves or corridor systems; (ii) preservation within logged areas by appropriate rotation and spatial organisation of logging coupes; and (iii) conservation within logged compartments by modification of logging practice and reduction of logging intensity to maintain species and their essential resources at a lower but stable density."

Dunning and Smith (1986) state "The first approach is useful for disturbance intolerant species with broad habitat requirements, the second for species with good dispersal capability dependent on particular successional stages after disturbance and the third for disturbance tolerant species dependent on mature forest."

Dunning and Smith (1986) recommend that the conservation of arboreal mammals and reptiles in their study area may best be achieved by designation of three zones of management: (i) an unlogged rainforest gully corridor system and unlogged moist hardwood ridgetop corridor system; (ii) a moist hardwood zone where logging intensity is low (33% canopy retention); and (iii) a logged moist hardwood zone with the retention of 4-5 hollow nest trees per hectare."

Lunney, Cullis and Eby (1987) recommend a number of options for conserving small mammals, (i) minimizing fire, including control burning, (ii) retaining unlogged forest with dense ground cover, (iii) extending the time over which alternate coupes are logged, to avoid creating a forest of uniform regrowth, and (iv) minimizing disturbance to the ground cover by heavy machinery in the retrieval of logs.

Norton and Lindemayer (1990) propose "the following set of <u>ideal</u> and <u>minimum</u> goals for forest wildlife management:

1. identify the full range of forest ecosystems remaining within the forest estate;

2. determine precisely the size and spatial arrangement of the remaining forest ecosystems;

3. assess the degree to which each forest ecosystem has been, or is being, modified by human practices;

4. establish the current land tenure of these forest ecosystems;

5. quantitatively evaluate the representativeness and viability (in terms of the identified range, size, spatial configuration and degree of modification of forest ecosystems) of the present conservation reserve network within native forests;

6. identify all forest species and determine their geographic range within the remaining native forests. This will need to be undertaken sequentially with perhaps an initial focus on key vertebrate and invertebrate groups...;

7. characterise the variation in genetic diversity exhibited by populations of all species across their geographic range;

8. determine the minimum habitat requirements (i.e. shelter, breeding, food) for the conservation of all forest species;

9. develop and implement a conservation strategy (e.g. revise the existing conservation reserve network, promote a conservation ethic for the use of lands outside the reserve network:..) to accommodate all the needs identified in points 5. to 8.; and

10. establish a reliable, scientifically-based infrastructure which permits the strategy in point 9. to be monitored and updated regularly."

Norton and Lindemayer (1990) consider that: (i) the first two management goals could be addressed by the establishment of a geographic information system containing both environmental (e.g. climate, terrain, substrate) and biological data (e.g. location of remaining forest cover, reliable records of plant and animal distributions, forest floristics and structure), (ii) the third goal requires the development of a generally-accepted classification, (iii) the forth goal is readily achievable, (iv) the fifth goal relies on the success of other goals, and (v) goals 6, 7 and 8 depend upon identifying all forest species, their habitat requirements and degree of genetic variability within and between populations. They consider that because the geographic distribution, habitat requirements and genetic variability of almost all forest fauna are not well known, it is necessary to evaluate the possibility of using key species (indicator, keystone and mobile link species) or groups of species that may be indicative of the well-being of ecosystems *in toto* or known important components of ecosystems.

Milledge, Palmer and Nelson (1991) suggest that Yellow-bellied Glider and Sooty Owl, because of their sensitivity to forest perturbation, would make good management indicators in Mountain Ash and possibly Brown Barrel forests. They don't consider the Greater Glider a good indicator. They state "Whether management for the Sooty Owl and Yellow-bellied Glider will cater for other sensitive species in Mountain Ash forest needs detailed investigation."

Norton and Lindenmayer (1990) state "While knowledge of forest ecosystems and wildlife is limited, a number of practical steps can be readily adopted to facilitate more integrated conservation and management. These include a conservative use of forests and the need for more strategic and systematic research and planning. Current forest uses that are not, or do not appear to be, sustainable in the long term should be minimised or stopped. These include extensive forest clearing and the logging of old growth forests on fertile soils. At the same time, it is essential to quantitatively evaluate and upgrade the existing conservation reserve system within forests and to encourage more conservative land-use practices in forests outside of parks and reserves. Without the adoption of these steps in the short-term, it is unlikely that the ecological integrity of many forest ecosystems will be maintained in the long-term. As a consequence, considerable genetic diversity within species will be lost and the probability that forest wildlife will become extinct will continue to increase."

Davey and Norton (1990) consider "that both drought and fire needed to be considered within a wildlife planning framework, particularly in forests subject to logging."

1.3 THE URGENT NEED FOR RESEARCH

Tyndale-Biscoe and Calaby (1975) state "However, it is by no means a simple matter to ascribe a status to a particular species without a thorough study of its life history and ecology. Very few species of the forests we are considering have been so studied. Indeed it is still not possible to say with any precision what species occur in a given forest, how many of each species, nor what the minimum requirements of space and habitat are for long term survival of any species. To do this, inventories of species need to be prepared for selected areas throughout the range of forests and the requirements of each species determined. These later include short term or continuous requisites for individual survival, such as food, shelter and space, and long term requisites for the species' survival. The latter include special breeding grounds, refuges from drought or fire and space for a population of sufficient size to ensure genetic diversity and gene flow. Factors involved in this are density, mobility, fecundity, longevity and social organisation of the species."

Shaw (1983) considers the task of integrating wildlife considerations into forest management practices should be approached at two levels; research to answer basic biological questions concerning forest animals and the effects of forestry on wildlife, and management to translate research findings into actual forest management policies.

Richards and Tidemann (1988) emphasise that although bats constitute one-quartre of Australia's mammal fauna they have received the least attention from scientists, stating "we are still learning the basic biology of our bats, and have not yet even established the full complement of species inhabiting Australia."

Davey (1989) notes "Whilst some information is becoming available, the knowledge necessary to make a sound prediction on the consequences of forest operations upon wildlife does not yet exist."

Davey (1989) outlines some of the research required to enable rational fauna management: an adequate vegetation classification which can be used to delineate faunal habitat across Australian forests; information about the temporal resources of species; differentation/discrimination/identification of critical limiting factors to which a species responds; an understanding of the effects of habitat manipulation on target species; information on behavioural traits associated with physiological requirements; demographic studies of species; and information to enable

accurate prediction of the sizes of populations of forest wildlife.

Davey and Norton (1990) note the paucity of information available on wildlife and outline in some detail the research and planning systems they consider required to achieve scientific and rational forest planning and management for wildlife. They note "Few studies have addressed satisfactorily the meshing of an ecological understanding of wildlife into a forest planning framework. Such an approach, while considered necessary..., is still in its infancy."

Davey and Norton (1990) note "To understand population dynamics, data are required on the life histories (e.g. fecundity, mortality, dispersal) of, at least in the first instance, forest-dependent taxa or species considered to be indicators of biological diversity, guilds or ecosystem stability (e.g. owls, native marsupial carnivores). These types of information are critical for the viable management of functional forest ecosystems and wildlife in fragmented habitats or those subject to recurrent disturbance... Such data are a prerequisite for the determination of minimum viable population size or the planning and management of wildlife corridors."

Norton and Lindenmayer (1990) consider the central requirement to establish a coherent approach to wildlife conservation "is the need to establish a systematic research and management framework to identify important gaps in knowledge and to help set priorities for funding." They identify a number of issues that need to be addressed, including: (i) the feasibility and rationale for using indicators, keystone species and mobile link species, (ii) the effects of fragmentation, including edge effects, (iii) the role of forest corridors and the creation of new habitat in linking and enhancing viability of forest fragments, and (iv) establishing benchmark sites for monitoring ecosystem and population fluxes through time.

There are two major deficiencies with the majority of research into the effects of logging on fauna, (i) very few are comparisons of the same sites pre-logging and post-logging, most comparisons are between sites selected for their similar attributes with no certainty of the variables, and (ii) many sites are within close proximity to unlogged areas.

Gilmore (1990) states "Clearly we need to be able to specify the composition and structure of future stands under all potential management options, and to know what a particular part of the mosaic represents in terms of its suitability as habitat. A long term modelling and simulation capability must be developed, before it can be claimed that our planning and management is based more on science than faith.", and "How forest resources and dependent populations of wildlife are going to fluctuate in space and time, over timespans of several hundred years, needs to be determined. A planning period of this length is needed, as critical wildlife resources may take that long to develop".

Shields and Kavanagh (1985) state "enlightened wildlife management will rely on assessments of the impact of continued operational cycles of forest management on forest fauna."(p.26).

Tyndale-Biscoe and Calaby (1975) conclude "Reliable and worthwhile information cannot be collected in a short time and the deplorable thing is that changes to the forests are going on at such a rate that society may not be able to exercise its rightful choice between eucalypt forests as a timber resource and eucalypt forests as a refuge for wildlife."

1.3.1 FAUNA SURVEYS

Davey and Norton (1990) state "Clearly, forest surveys remain a fundamental component of any viable strategy for wildlife management but, at the same time, they need to be made cost effective. This can be achieved by moving, whenever possible, from one-off inventories towards surveys which record, at least, parameters readily adapted to Geographic Information Systems (GIS) and process models."

Davey (1990) states "Efficient planning for environment and wildlife management in our native forests now requires adequate ecological data bases collected by standardised methods to enable comparison between habitats, regions and years... A standard survey system should provide estimates, in a standardised unit, of relative abundance of the population detected. Techniques should be usable by individuals (an increasing requirement for forest wildlife surveys), should minimise variability between individuals, be both time and cost effective and be compatible with an integrated faunal survey. To be effective, the influence environmental factors have upon detectability and abundance must be known."

Recher. Rohan-Jones and Smith (1980) found that "Abundance, species number and the composition of the avian community differs between years for all plots on which we have two or more years data. The differences are often substantial with species number varying by as much as thirty per cent... and the number of individuals by fifty per cent." and "As the pattern of flowering varies from year to year, nectivorous birds show considerable yearly and seasonal variation in distribution."

Shields and Kavanagh (1985) state "to investigate or conserve animals, it must first be determined whether or not they are present in the areas under consideration."(p.10)

2.0 HABITAT RETENTION

Norton and Lindenmayer (1990) consider "that a reserve network stratified, in part, on regional environmental gradients might help capture the greatest range of forest wildlife... and be a useful basis for managing wildlife in light of climate change... Therefore, a practical approach to maintaining the present

diversity of wildlife in native forests needs to aim at ensuring the linking or networking of areas managed primarily for nature conservation across major latitudinal and elevational gradients. This approach would attempt to maximise the long term options available for managing forest wildlife and maintaining ecosystem integrity... and be amenable to modification as new scientific data became available."

Davey and Norton (1990) state "Planning for the conservation of forest wildlife presently centres around the principles of island biogeography, minimum viable population and optimal habitat. ... In general, present design involves the linking of reserves, drainage lines (filter strips) and areas unable to be logged for logistic or economic reasons (refuge areas) with unlogged forest through which wildlife can disperse (wildlife corridors). All these features within the design area remain unlogged."

Bennett (1990) states "in forests used for timber harvesting, corridors must form part of a linked system of retained habitat that will sustain, throughout the forest landscape, populations of species that are sensitive to harvesting. The system of retained habitats will include nature reserves and other existing reserves...; areas exempted from harvesting because of steep slopes, or because they are uneconomic for production; filter strips and buffer strips retained to protect water quality; designated sites of floral or faunal significance; rainforests and their associated buffer strips; and, a hierarchy of wildlife corridors. Initial planning and location of corridors may be most appropriately carried out on a forest block basis, but it is important that the system of retained habitat be co-ordinated and developed from a broader regional perspective."

2.1 RESERVING SUITABLE AREAS

2.1.1 Will existing reserves and steep unloggable country do?

Recher, Rohan-Jones and Smith (1980) state "We do not consider the National Parks and Nature Reserves in the Eden District adequate by themselves for the long term conservation of the region's wildlife.", "Alone each [National Park and Nature Reserve] is probably inadequate in area for the long term survival of the region's full complement of wildlife and their isolation means the prospect of recolonization between parks is remote for all except the most mobile animals.", "The parks west of the Pacific Highway have been located mainly on rough terrain and therefore sample higher elevation and ridge vegetation in greater proportion than the moist gully forest types known to be richest in wildlife.", and "With the exception of Nadgee Nature Reserve, none of the parks was established following a survey of their flora and fauna nor was the scientific community ... consulted."

Recher (1986) states "Generally, the forests reserved for nature conservation have been those in the wildest and most remote places or those on poor soils with limited commercial potential.

Preservation has seldom been preceded by any form of inventory or biological assessment and has been largely a political exercise in response to pressure from the conservation lobby."

Neave and Norton (1990) note "reserves have often been established only where other land use-options have not been considered economically-viable... As a consequence, representative samples of the remaining range of Australia's forest biodiversity are yet to be adequately protected... The size of existing reserves is also of concern as many may not be viable in the long-term without active management... Most reserves in forests are less than 15,000 hectares in size and few are larger than 50,000 hectares".

Kavanagh (1985b) considers that areas reserved because they are steep unloggable country "are likely to contain poor habitat for animals and may therefore be a poor source for the recolonisation of adjacent more favourable, but unlogged areas."

2.1.1.1 WHAT IS GOOD WILDLIFE HABITAT.

Recher, Rohan-Jones and Smith (1980) found that: (i) small ground mammals are most abundant in tall moist forest and low open forest, noting "Few individuals occur in dry open-forest... and, in our experience, forest along ridges is particularly poor for small ground mammals. These habitats are characterised by sparse cover with few shrubs.", (ii) arboreal mammals are uncommon throughout most of the dry forest types in the Eden sub-district and that they are "abundant in moist forest along gullies, creeks and swamp edges", and (iii) about half the bird species have broad preferences in forest-type, with 25 species characteristic of moist forests, 13 species characteristic of dry forests, 3 species most abundant in low forest with Banksia, 2 species most common in Spotted Gum forest and 3 species most common in tableland forest, noting "In terms of the mean number of species and individuals recorded per census, plots in dry ridge forest had poorer avifaunas than plots in the other four categories of eucalypt forest".

Binns (1981) reporting on Braithwaite's research in the Eden Region notes that arboreal mammals were concentrated in areas of favourable habitat rather than randomly or uniformly distributed (60% of animals were in about 5% of the forest area). More were found in tablelands wet sclerophyll types than drier coastal types, on more fertile soils and in areas from which severe fires had been excluded for at least 20-25 years.

Mackowski (1983) states that Braithwaite's findings that high concentrations of arboreal mammals occur only in high site quality forest is supported by preliminary analysis for north east NSW.

Shields and Kavanagh (1985 pp.81-82) state "the conservation of all possum - glider species depends not only on substantial areas of uncut, unburnt forest but also on retention of tree species diversity."

Gilmore (1990) states "Important determinants of the carrying capacity of a particular stand of forest for vertebrate fauna are, firstly *forest type*, which reflects a limited range of climate, soil and other site variables, as well as the quantity and quality of herbage, nectar and even insect populations available to consumers... Secondly, the *history of the stand* with respect to fire, silvicultural treatments, harvesting etc. The *size and context of the stand*, with respect to adjacent stands and potential sources of plant and animal propagules or colonists, microclimate and edge to area ratio can all influence fauna populations, such that a particular population is prevented from reaching the carrying capacity defined by summing the innate, resource based carrying capacity of a series of stands."

Recher *et al.* (1991) note "The structural and biological diversity of these forests is an indication of the greater availability of water and richer soils (i.e. nutrient status) along creeks and gullies than on ridges. Overall biological productivity is probably greater under these circumstances and greater population densities and richer faunas can be sustained.", and "The lowest population densities occurred in dry open-forests on ridges... These forests were characterized by low plant species diversity, a low, open canopy, poorly developed shrub and sub-canopy vegetation and often had skeletal soils."

Lunney, Cullis and Eby (1987) found that Bush Rat and Dusky Antechinus displayed a significant preference for south-east aspects over north-west aspects.

Neave and Norton (1990) consider the most favoured habitat of Greater Glider can be defined best by forest site productivity (fertile soils and a slope < 15 degrees) within its specific bioclimatic envelope.

Mackowski (1984) found "Blackbutt forest less than about 35 metres site height contains very low possum and glider populations".

Davey (1989) states "Habitat units encompassing optimum habitats for a number of 'target' species should where possible form the core areas as they will be viable sources of population from which a species can disperse."

2.1.1.2 WILDLIFE PRIORITY AREAS

Kavanagh and Webb (1989) state "Wildlife priority areas can be defined as those areas with particular significance to wildlife, either in terms of their richness of species or, in terms of their populations of sensitive and/or rare species."

Kavanagh and Webb (1989) considered that vegetation communities important for the most sensitive (to logging) species - Greater

Glider, Yellow-bellied Glider and Feathertail Glider - should be designated Wildlife Priority Areas, particularly where all three species are present. Kavanagh (1990) further notes that the Sooty Owl and Powerful Owl also need to be considered priority species.

Davey and Norton (1990) consider that significance of areas can be determined in a number of ways, including "(i) high value of optimal habitat reflecting high population density of a select species; (ii) high habitat-unit value (habitat-unit equates with a high diversity of habitats in a geographic area...); and/or (iii) high diversity or population density of select species. Select species are those that are rare, endangered or sensitive (detrimentally) to forest operations."

Davey (1989) considers the significance of an area for fauna can be determined in terms of either (i) habitat values approaching optimum, reflecting high population numbers of a target species, (ii) providing habitat for a lot of target species and/or (iii) high importance values of target species.

Recher *et al.* (1991) state "Those planning the conservation and management of the avifauna in southeastern [NSW] forests must recognise that species may have a restricted elevational range and/or specific habitat requirements. This includes species dependent upon mature forest, but others may have equally precise and particular requirements. Species with narrow habitat requirements (e.g. brown warbler, Lewin's honeyeater, glossy black cockatoo, spotted quail thrush, red-browed treecreeper) and those with special resource needs (e.g. hole-nesting birds such as cockatoos, treecreepers and owls, and bark-foraging species such as treecreepers and shrike-tits) justify the greatest concern from forest managers. Few of these species have shown the ability to adapt to the effects of logging".

Shields and Kavanagh (1985, p.15) state that "at present, conservation by reservation of the preferred forest types (eg. managing for habitat) is the safest option because it is not known what level of logging can be undertaken and still retain viable populations of animals, nor is the rate of recolonisation known for those areas which are rendered temporarily uninhabitable by logging."

2.1.1.3 MIGRATORY SPECIES

Birds and flying-foxes undertake significant seasonal migrations. Conservation of migratory species requires consideration of various species latitudinal migrations (mostly northwards winter movements), altitudinal migrations (mostly species that breed at higher elevations in summer and descend to lower elevations in winter) and nomadic wandering (mostly species following flowering sources).

Recher. Rohan-Jones and Smith (1980) note that in the Eden region 40% of birds "use different habitats during the breeding and non-breeding season and many range widely through the southeast and along the coast. The forest used when not breeding must be

considered as important to the bird as those in which it nests; for most birds the breeding season spans 3 months, the non-breeding season 9 months.", "Fifteen of the 94 forest bird species... are latitudinal migrants which are absent from southeastern N.S.W. during the winter... although small populations of four species... remain over winter. Migrants are most common amongst the cuckoos *(Cuculidae)*, cuckoo-shrikes *(Campephagidae)*, flycatchers *(Musicicapidae)* and honeyeaters *(Meliphagidae)*.", "Also present in the area during winter are birds belonging to the Tasmanian races of the Silvereye and Striated Pardalote.", and "Several species are altitudinal migrants, moving out of the Bondi State Forest during winter into lower altitudes on the coast or to other parts of the tablelands and western slopes.".

Recher. Rohan-Jones and Smith (1980) found that "Abundance, species number and the composition of the avian community differs between years for all plots on which we have two or more years data. The differences are often substantial with species number varying by as much as thirty per cent... and the number of individuals by fifty per cent. Changes are equally great in mature and regeneration plots, but plots do not necessarily change in unison.". They note "...we consider the changes reflect yearly variations in food resources with local and regional conditions affecting the numbers and kinds of birds occurring on any plot at any particular time of the year. The largest changes are almost certainly due to variations in the blossoming of eucalypts and other nectar producing plants.", and "Honeyeaters and lorikeets rely on nectar, however, and their movements are related to the availability of nectar-rich flowers. As the pattern of flowering varies from year to year, nectivorous birds show considerable yearly and seasonal variation in distribution."

2.1.2 The necessity for retaining old growth attributes.

Milledge, Palmer and Nelson (1991) state "Ecologically mature or old-growth forest is dominated by trees which have reached maximum vertical and horizontal expansion and provide fauna with a wide range of resources, including hollows suitable for hollow-dependent species. Mountain Ash is considered ecologically mature at approximately 150 years of age".

Mackowski (1987) interpreted the structure of natural unlogged (old growth) forest "as being an irregular unevenaged forest made up of an overlapping mosaic of even though different aged cohorts." He subjectively determined that two unlogged Blackbutt stands each contained 5 cohorts of trees in various size classes. The cohorts were assumed to have resulted from periodic regeneration events, notably fire induced.

Loyn (1985) considers that the species which need specific attention are those reliant upon old trees or old growth forest, particularly uncommon or rare species which are sensitive to harvesting.

Old trees provide a variety of resources which are either not provided, or provided in significantly lesser quantities, by young trees:

-hollows (e.g. Dunning and Smith 1986, Mackowski 1987, Milledge, Palmer and Nelson 1991, Smith and Lindenmayer 1988)
-large logs (e.g. Mackowski 1987)
-nectar (e.g. Loyn 1985, Kavanagh 1987b)
-some insects in the bark and foliage (e.g. Loyn 1985, Kavanagh 1987b)
-regular and abundant supply of insect food (e.g. Loyn 1985, Milledge, Palmer and Nelson 1991)
-nectar and fruit of mistletoe (Loyn 1985)

Loyn (1985) considers species most reliant upon old growth to be those utilising old trees for feeding, such as some honeyeaters and mistletoebirds which feed on mistletoe nectar or fruit, some insectivorous birds which feed from old eucalypt bark or among canopy foliage and some arboreal mammals which feed on sap and invertebrates from large eucalypt trunks and branches or on canopy foliage in tall eucalypts.

Richards and Tidemann (1988) note that most of the 20 or so species of bats that inhabit Australia's southern forests use tree hollows as refuges in which to roost during the day, and to rear their young, and as 'safe houses' during several months of inactivity or hibernation each winter.

Mackowski (1984) states "Hollows in eucalypt trees are an essential resource for most possums and gliders. Five of the ten possums and gliders occurring in central eastern Australia require tree hollows for denning - arguably nine species require tree hollows for nesting."

Milledge, Palmer and Nelson (1991) found "both the Yellow-bellied Glider and Greater Glider showed a significant association with old-growth forest, and the Sooty Owl and Yellow-bellied Glider were strongly associated with large areas of old-growth forest."

Bennett (1990) states "Species that have been identified as being sensitive to forest changes resulting from timber harvesting are primarily those that are dependent upon some aspect of a mature, or old-growth, forest environment... Animals that use tree hollows, such as forest owls, parrots, cockatoos, gliders, possums and bats, are prominent examples. Of particular importance are those forest-dependent species that naturally occur in low densities; predators (e.g. Masked Owls, Powerful Owl), species with large body size (e.g. Yellow-tailed Black Cockatoo), and those that are social, or have specialised foraging or habitat requirements (e.g. Leadbeater's Possum, Yellow-bellied Glider). For these species, the effect of broad-scale habitat changes are compounded by the need for larger areas to sustain viable populations."

Recher *et al.* (1991) cite research that suggests "the importance of both forest maturity (approximated by total biomass) and

productivity in determining the number of bird species which can co-exist at a site".

Davey (1989) considers sensitive species of fauna dependent upon mature forest need consideration as the lengths of time involved make it difficult to appreciate the long-term effects of forestry practice on these species.

Bennett (1990) notes "it is not uncommon for canopy trees to pre-date European settlement, particularly those trees in small remnants or scattered through farmland. However, there is often an obvious lack of successful regeneration, due to grazing by stock, to replace these ageing individuals. As remnant stands age and senesce we can expect even further depletion of forests and woodlands in the rural landscape, unless active measures are taken to promote regeneration."

2.1.3 Rainforest conservation

Conservation, Forests and Lands (1989) for Victoria define rainforest "ecologically as closed broadleaved forest vegetation with a more or less continuous rainforest tree canopy of variable height, and with a characteristic composition of species and life forms. Rainforest canopy species are defined as shade tolerant tree species which are able to regenerate below an undisturbed canopy, or in small canopy gaps resulting from recurring minor disturbances, such as isolated windthrow or lighting strike, which are part of the rainforest ecosystem. Such species are not dependent on fire for their regeneration."

Cameron (1991) proposed a new ecological definition for rainforest in Victoria:
"Rainforest is defined by a combination of ecological, floristic and structural attributes. In the event of ambiguity, ecological criteria are to be given precedence over floristic and structural criteria and floristic criteria are to be given precedence over structural criteria.

"Rainforest is defined ecologically as fire-sensitive forest composed of or dominated by primary or secondary rainforest species. Fire-sensitive forest is defined as a forest which exhibits a combination of fireproof site characteristics with fire-resistant or fire-retardant vegetation characteristics which minimise the risk of destruction of the rainforest canopy by running crown fire. (The ecological definition includes transitional (ecotonal) and seral (secondary or mixed) communities once they have developed a recognizable understorey canopy of rainforest species below an overstorey of sclerophyll emergents.) Primary rainforest species are defined as shade-tolerant species which are able to establish or perpetuate themselves (either vegetatively or from seed), in the absence of fire, below an undisturbed rainforest canopy, or in minor canopy gaps resulting from endogenous processes of renewal within the rainforest ecosystem, such as isolated windthrow or endemic forest pathology. Such species are not dependent on fire for their regeneration.

"Rainforest is defined floristically as vegetation with a characteristic composition which is consistent with that of rainforest communities or sub-communities described on the basis of a complete regional or statewide floristic analysis of reliable quadrat data. Rainforest may be recognised in the field using floristic field keys based on differential species.

"Rainforest is defined structually as forest vegetation with a rainforest canopy which provides the habitat for a characteristic diversity of dependent life forms. The rainforest canopy is defined as a more or less continuous closed canopy composed of primary and/or secondary species. Most primary rainforest species are broad-leaved and evergreen."

Cameron (1991) notes "A well developed rainforest buffer can shield rainforest from the direct impact of fire by creating turbulence in, and dispersing, oncoming air currents, by absorbing radiant heat and by reducing fire intensity (either by maintaining a moisture differential between the rainforest stand and adjacent sclerophyll vegetation or by having inherent fire retardant properties such as succulent foliage, for example *Myoporum insulare*, or non-flammable foliage with a low oil content, for example some acacias). Post-fire development of a rainforest buffer of secondary rainforest species can be instrumental in providing a nurse crop to nurture primary rainforest species toward maturity. Other biotic factors such as vertebrate and invertebrate grazing pressure, pest pressure, pathogen outbreak and weed invasion may have a significant impact on post-fire succession in particular circumstances."

Cameron (1991) considers "Land use practices such as clearfell harvesting and prescribed burning should be excluded completely from all ecological rainforest buffers because they damage the buffers directly and reduce the effectiveness of homoeostatic mechanisms... which maintain the structural integrity of rainforest. These same land use practices should also be excluded from all catchment based sites of significance for rainforest because they modify fire regimes by increasing flammability, removing old growth eucalypt forest and sharpening moisture gradients."

Roberts (1991) found "The Black and White aerial photographs flown in 1946, over the wet sclerophyll forests in the Otways, just seven years after the 1939 fires, showed clearly the path of the fire through eucalypt forest and rainforest. Although no delineations of rainforest were made on these photographs, it was obvious that clearing for agriculture and heavily logged areas adjacent to rainforest had intensive fire on them which rendered the rainforest extinct or severely damaged, i.e. most rainforest sites on the northern and eastern fall of the Otways. Similarly rainforest areas burnt in the 1919 wildfire were more severely damaged in areas that had been intensively logged or cleared.", and in relation to the 1983 fires in East Gippsland he observed "that many rainforest sites which had intensive selective logging or clearfelling onto the margins or into the rainforest, had severe crown scorch compared to rainforest with no logging around them, which suffered less crown damage and sometimes only a ground fire. Wildfires appear to be severe in dense young eucalyptus regrowth stands..."

Roberts (1991) notes "The intensity of a fire burning into the margins of a rainforest will be far greater through a younger regenerating eucalypt forest than through an old eucalypt rainforest.", and "It is of concern that most patches of rainforest in the state are suffering from clearfelling during the 1970's and 80's around their margins, and that this fact places the rainforest estate at a far greater risk from wild fire, than it has been for millenia. We are possibly twenty years too late fot a large percentage of our rainforest sites. It could only take two dry summers!"

Conservation, Forests and Lands (1989) state "Rainforest must be excluded from timber harvesting, and must be protected by appropriately managed buffers. Timber harvesting operations must be excluded from a buffer area surrounding rainforest. Where the rainforest is generally linear in shape, such as along gullies and streams, the minimum width of the buffer is to be 20 m. Elsewhere the minimum width is to be 40 m. Care must be taken to ensure that no tree is felled into the buffer. Trees which are likely to disturb the buffer must not be felled."

Roberts (1991) considers that clearfelling operations should not take place within a buffer equivalent to two or three mature tree heights from the margins of all old rainforest to "reduce the risk of fire entering rainforest and keep wind turbulence patterns in a more natural state." Cameron (1990) recommends a minimum prescribed buffer width around rainforest of 100 metres.

2.1.4 Habitat fragmentation

Bennett (1990) considers habitat fragmentation "one of the major issues confronting wildlife conservation on a global scale. In Australia, clearing and fragmentation of natural vegetation is also of major importance, and it is having a profound effect on our native fauna." He notes that documented examples of species' extinctions have frequently shown an initial pattern of major range reduction and fragmentation followed by successive extinctions of local populations.

Neave and Norton (1990) state "The major threat to forest fauna arises through the fragmentation and loss of their habitat... The species at greatest risk of extinction are those which appear least resilient to habitat modification... The long-term viability of now disjunct populations of fauna may be compromised further by many factors including predation by introduced carnivores such as foxes... and episodic extreme events like fire, drought and outbreaks of disease..."

Possingham (1990) notes "Integrated harvesting fragments populations. Fragmentation can result in a species occurring as small isolated populations, each of which is unlikely to persist. Migration between these small populations is essential to the long-term survival of the species."

Bennett (1990) states "Fragmentation of wildlife habitats can also occur in large, seemingly intact, tracts of vegetation. Timber harvesting, for example, leaves isolated or loosley-connected patches of mature forest (old-growth forest) amid stands of regenerating forest. With the increasing intensity and scope of forestry activities in south-eastern Australia, areas of mature forest outside reserves are becoming fewer in number, smaller in size, and more and more isolated. For the fauna that is dependent upon mature forests, the degree of isolation of populations in these patches is related to their ability to pass through or utilise forests of earlier successional stage. Fires, both natural and of human origin, can also create patches of differing successional stages within extensive natural areas, and so isolate faunal populations that may depend upon a particular seral stage."

Bennett (1990) considers there are three main consequences of habitat loss and fragmentation:

(i) changes in the number of species in fragments - there is a highly significant relationship between the area of a fragment and the number of species that are present, with larger fragments likely to have sampled a greater diversity of fauna habitats and fauna, and larger more viable populations;

(ii) changes in the composition of faunal assemblages - smaller patches support the most widespread and 'edge' species and larger fragments the more uncommon and 'forest-interior' species; and

(iii)changes in the ecological processes - the loss of native species and invasion by exotic species disrupts or modifies ecological processes such as food chains, predator-prey interactions, plant-animal pollination and dispersal associations, and nutrient cycling pathways.

Saunders (1990) in his study of Carnaby's Cockatoo (in remnants in Western Australia) found that nesting attempts at one fragmented site declined from 23 in 1970 to none in 1977, and they have not been recorded in the area since. He observed that at least one nestling was killed by a cat and at least seven nest hollows were invaded and taken over by Galahs. He notes that the galah was not found in the south-west of Western Australia prior to European settlement but has quickly expanded into agricultural areas with clearing of native vegetation, this, coupled with the cockatoo's need to forage widely and consequent inability to adequately defend its nest, has left the cockatoo vulnerable to competition with galahs.

Milledge, Palmer and Nelson (1991) found that in the Mountain Ash forests they studied most records of Sooty Owl and Yellow-bellied Glider were clustered in and about old-growth stands with a core area greater than 1 km^2. They state "The fragmentation of large areas of old-growth forest will also have a severe impact on the numbers of Sooty Owls and Yellow-bellied Gliders."

Jarman (1986) believes "Remnant communities of wildlife will become more vulnerable to foxes as suitable habitat becomes fragmented."

Gilmore (1990) notes that "many small remnant populations will continue to disappear, as time since isolation is one of the independent variables influencing extinctions in remnants."

2.1.5 Edge effects

Andrews (1990) states "The edge is a human artefact where two contrasting habitats suddenly converge without the natural graduations. The human made edge is usually inimical to most wildlife, and species from the natural interior do not inhabit edges. Species with excellent dispersal abilities, capable of invading and colonizing disturbed habitats, are attracted to edges, and move into the core of natural habitats if a road or utility corridor carries the edge into a previously undisturbed area. The edge experiences a different wind and radiation effect, leading to a different microclimate. If habitats are fragmented too much, and the ratio of edge to interior favours edges, the habitat will no longer be suitable for the interior species we most need to conserve. The core of areas important for conservation should ideally not be dissected with roads and utility corridors which create edge effects."

Bennett (1990) outlines some of the effects of edges:

(i) micro-climate changes - including changes in solar radiation, incident light, humidity, temperature, and windspeed.

(ii) changes in the composition and structure of plant communities - species from adjacent habitats, including weeds, can invade and compete with forest plants,

(iii)wildlife species that are edge specialists and those typical of adjacent developed habitats can invade the edge and become predators, competitors, or parasites of interior species,

(iv) edges are prone to a range of disturbances - including the drift of fertilizers and chemicals from farmland, trampling and grazing by farm animals, fires escaping into forest edges or riparian buffer zones, the placement of access tracks and control burns along edges, and recreational disturbance and littering.

Gilmore (1990) cites research that suggested "that forest-edge and farmland bird species exclude certain forest dependent bird species from smaller forest fragments more than area-dependent changes in habitat or degree of isolation." He notes that a variety of researchers "have all differentiated bird species by the degree to which their populations increase or decline with different degrees of habitat fragmentation."

Bennett (1990) cites various overseas research that found; (i) in terms of vegetation structure the width of the edge was less than 13 m. but based upon the distribution of birds nests the functional width of the edge ranged from 9-64 m., (ii) elevated levels of predation on birds nests at the forest-farmland edge declined with increasing distance into the forest, and were still higher at 100 m than 200-500 m. into the forest, and (iii) changes in the microclimate of forest patches adjacent to farmland extended from 30 m to more than 100 m. depending on aspect.

Gilmore (1990) notes "The creation of a large ratio of edge per unit area between stands of different age will benefit non forest-dependent species. Recent studies overseas indicate that edges and roads are utilized to a greater degree by predators and nest parasites."

2.1.6 Global warming and increasing ultra-violet radiation.

Arnold (1988) notes "that in a relatively short time span man has wrought massive changes on Australia's natural environment. Many species are still adapting their range and abundance to the changes, or are moving slowly towards extinction. The rapidity of the climate changes mean that we will never know what the equilibrium status of different species exposed to the changes imposed by land clearance for agriculture and urban development, and to pastoral activities would have been. Thus it is difficult to assess what additional effects further major changes in the environment will cause."

Main (1988) considers "The critical aspect for understanding the impact of climate change is the appreciation that patchiness is characteristic of natural environments and that this patchiness is maintained by disturbing factors, many of which are related to climate. Consequently, following climatic change the abundance of both animal and plant species will change, and in some cases rarity and commonness may alter. These changes will pose serious problems for management which will have to be within a dynamic context in which not only the impact of climatic change will operate, but also the effects of predators, competitors, and diseases of the indigenous biota may also change dramatically."

Main (1988) notes "The one certainty is that following climatic change the perturbation regime will lead to alterations in the floral composition, species dominance and ecosystem structure, and in the distribution and abundance of species. ...widespread responses of the fauna and flora such as occurred in the past cannot take place now because the natural environment is only represented by remnants of its former distribution. ...Much of the land between remnant areas is unsuited to the passage of many animals or native plants which consequently will be unable to

change their ranges in response to the alteration of climate. The consequences of this will be that some species will be restricted to environments at the limits of their physiological or ecological tolerances and hence be at risk of extinction."

Busby (1988) used a proposed climatic change scenario for the year 2030 to model the impact of global warming on the Long-footed Potoroo and Antilopine Wallaroo and concluded "The future of species which are currently rare and endangered, such as [Long-footed Potoroo], must be urgently considered. The climates of their present habitats are predicted to change, and potentially 'suitable' climates may or may not appear at some other location. In most cases suitable migration corridors will not be available, largely because of major habitat changes around their present locations."

Page (1989) discusses the impact of rising sea levels and shifting climatic zones on ecosystems. He notes that the life zones that circle mountains in tiers would move up vertically and that the higher a life zone moves the smaller it becomes. He states "As an ecosystem becomes smaller, it supports fewer individuals. At some point, an increasingly small population becomes inbred - usually with lethal effects."

Arnold (1988) considers "In previous times when climate changed, those species that were adversely affected became restricted to the most favourable habitat sites. These 'refugia' then acted as sources of conservation from which the species recolonised areas when environmental conditions improved. For many species this state exists now as a consequence of man's impact, and unfavourable climate changes will result in extinctions. For other species, 'refugia' may exist but be isolated by land clearance, and species preservation will depend on man translocating the species to them. Barriers created by man mean that for many species, natural recolonisation can never again occur."

Busby (1988) considers "The climate-change scenario makes it even more imperative that every effort be made now to secure a wide range of present vegetation and landscape types in nature conservation reserves. Emphasis might, perhaps, be placed on areas containing significant altitudinal (Hence temperature and precipitation) variation. This is essential not only for the continued management of currently rare and endangered species, but also for species such as [Antilopine Wallaroo], a presently widely-distributed species of minimal conservation concern, which may become rare and endangered as a consequence of climate change."

2.1.7 Designing adequate reserves

Davey (1989) outlines the five principles that have been applied to the survival of populations on marine islands:

i) as the size of a reserve increases, the probability of any one species becoming extinct diminishes;

ii) a single composite area is preferable to several smaller reserves of equal total size;

iii) if fragmented, reserves should be connected by corridor systems;

iv) if fragmented, reserves are better where equidistant; and

v) if fragmented, reserves are better where close together.

Davey (1989) considers that the forest analogy to 'islands' results from the planting of exotics, clearing for agriculture and intensive logging of native forests on short rotations, which break up the continuity of mature forests.

2.1.7.1 MINIMUM VIABLE POPULATIONS

Tyndale-Biscoe and Calaby (1975) note that an "Effective population number is the population size that will retain the original genetic diversity of the species, or a large fraction of it, in perpetuity and provide the genetic means for continued evolution. It must take account of natural fluctuations and be large enough to withstand the vicissitudes of fire, disease and drought; it is the lowest number that the population can fall to under these circumstances."

Possingham (1990) states "The themes of chance, luck and uncertainty are central to the study of population viability." and "To make a prediction... we first need to understand the processes that may contribute to extinction. These are: demographic uncertainty; inbreeding; loss of genetic diversity; environmental uncertainty; catastrophes. Besides these processes we need to bear in mind several characteristics of a species that influence the probability it will become extinct." He also notes "Australia's environment fluctuates enormously from year to year. These fluctuations add yet another degree of uncertainty to the survival of species. Catastrophes such as fire, flood, drought or epidemic may reduce population sizes to a small fraction of their normal level. When these two additional elements of uncertainty are taken into account the population size necessary to be confident of persistence for a few hundred years increases to several thousand." and "Some scientists present an even more pessimistic picture of species extinction. Studies on mammals that only occur on isolated mountain tops in the south-western United States suggest that a potoroo-sized organism requires a population size of tens of thousands to have a 95 per cent chance of persisting for 1000 years."

Possingham (1990) notes "On the one hand small isolated populations are more likely to become extinct than large populations, however species restricted to a single locality can be extinguished by a single catastrophe." and "Without genetic

variability a species lacks the capacity to evolve and cannot adapt to changes in its environment. The ability of a species to adapt to a changing environment, new predators and new diseases, is essential in this time of increasing environmental change."

Tyndale-Biscoe and Calaby (1975) adopt an effective population of 1,000 individuals as near to the minimum to ensure the continuance of genetic variability and took 5,000 as an effective population size above the minimum for dependent residents of Tall Open forest. Using this they calculated that the area required to support an effective population of Greater Gliders in the area (near Tumut) they studied to be 6,656 - 10,870 hectares.

Tyndale-Biscoe and Calaby (1975) note the futility of setting aside small blocks of land of a few hundred hectares or less as wildlife refuges because (i) species with high attachment to their homesites do not move to other areas because these are already occupied, and (ii) the number of animals that the small reserve can support in isolation is quite inadequate for the species long term survival.

Davey (1989) considers that emphasis in forest planning and management needs to be placed upon maintaining a minimum viable population that will safeguard against genetic degradation and determining the habitat units that will support this population.

Davey (1989) notes that to derive the theoretical breeding population size required to ensure that the population, genetically, does not deteriorate the effective minimum population level (50+) must be adjusted for (i) variance in progeny of females, (ii) sex ratio, (iii) over-lapping generations and (iv) population fluctuations. A multiplication factor of 10 is then applied to allow for long term evolutionary fitness.

Using this formula Davey (1989) calculates that the theoretical long-term breeding population size of Greater Gliders would be 2375 animals, but notes that as the estimate was derived from a poor data base the long-term viable population size of 5 000 suggested by Tyndale-Biscoe and Calaby may well be realistic.

Dunning and Smith (1986) adopt "the minimum population size of 500 proposed by Franklin (1980)", and state "This value increases to an effective population number of 521 for P. volans [Greater Glider] ...when the uneven sex ratios are taken into account.... Examination of the spatial distribution of logged and unlogged moist hardwood ... indicates that this total population [of Greater Gliders] is split into 3 major groups separated by rainforest. An effort should be made to maintain 521 individuals within each of these isolated areas. At present these isolated patches contain approximately 721 P. volans in the west patch, 285 in the central patch and 764 in the east patch. This central patch is the most vulnerable to the effects of inbreeding and loss of genetic variability."

Mackowski (1986) adopted a minimum population size of 500 individuals as "sufficient to maintain heterozygosity for continued evolution depending on even sex ratios". He noted that Yellow-bellied Glider "occurs in foraging groups of two to six individuals... Two hundred and fifty home ranges should represent an effective population size of 500 individuals. The upper limit of reported home ranges for *P. australis* is about 60 ha... Using 250 home ranges of 60 ha each, an unfragmented area of 15,000 ha of suitable habitat should support a minimum effective population of *P. australis*."

Mackowski (1987) states "The planning process should consider the absolute size of wildlife populations to ensure the genetic viability of contiguous wildlife populations in refuge zones and temporally contiguous populations in logged zones."

Possingham (1990) cites Dr. Michael Soule as stating "...it is necessary to stress that MVPs (minimal viable populations) will likely span a range of two or three orders of magnitude (several hundred to several hundred thousand), and that citing the 'few thousand' estimate to a given species... deserves all the contempt that will be heaped on him or her. A variability analysis must be performed for each case, because each case is different. 'Few thousand' is not a rule-of-thumb. Rather, it is a possible, order of magnitude lower boundary... Estimates below this range should be an automatic signal for scrutiny."

Clark, Backhouse and Lacy (1991) report on Population Viability Analysis using the computer program VORTEX for six species, including Long-footed Potoroo and Mountain Pygmy-Possum. They note that most species and populations were highly susceptible to local extinction, stating "Any further habitat loss or fragmentation or reduction in population size or density would result in rapid extinction. ...Options included strict habitat protection, enhancement of existing habitat or restoration of lost habitat, captive breeding, and reintroduction of animals to existing habitat patches in which the species has become extinct in recent decades or to newly created habitat. ...the stimulations demonstrated that if proactive conservation management had been undertaken even five or ten years ago when populations and habitats were considerably larger, the task of present day managers would be much more tractable."

Davey and Norton (1990) note "The crux of the problem for wildlife management is that the habitat needs to be made available to support viable populations of taxa. Currently, there are only a very few species of Australian vertebrates for which there is adequate information to enable an estimate of a minimum viable population. Few studies have attempted estimates for other taxa."

Milledge, Palmer and Nelson (1991) state "To achieve conservation of viable populations of all species with confidence requires knowledge of their individual distributions, abundances, ecological requirements and population dynamics. This task, given current time and financial constraints, is beyond researchers at

present. However, an approach which could offer a partial solution to this dilemma is the adoption of management indicator species."

Possingham (1990) considers "Managing the forest for viable population sizes of a small number of *key species*, may be the most economic way of minimising the loss of biodiversity. The key species should be relatively easy to study and represent the entire range of organisms present in the forests. Some potential candidates include the powerful owl, the yellow-bellied glider and the platypus. Several invertebrates, such as the evolutionarily significant *peripatus*, should be included in the list of key species."

Recher, Rohan-Jones and Smith (1980) note "None of the birds and mammals found at Eden are confined to the district and in a continental context may not be threatened. However, any contraction of a species range increases its vulnerability to other disturbances (e.g. fire, disease) and risks the extinction of the species. With the rapid changes in forest management throughout Australia, it is best to be cautious and ensure that populations of all species are retained in each forestry district.".

2.2 FAUNA CORRIDORS

Bennett (1990) states "Essentially, corridors are linear habitats that differ from a more extensive, surrounding matrix. Frequently, they link one or more patches of habitat in the landscape and may be a pathway for animal movement, but they may occur as isolated lines of habitat."

Bennett (1990) notes that there are a variety of fauna corridors; riparian habitats, hedges, shelterbelts and plantations, fencerows, roadsides, tunnels and underpasses

Bennett (1990) notes that streamside riparian habitats are natural corridors comprised of a band of vegetation that usually is structurally and floristically distinct from adjacent habitats, with which it intergrades. Frequently they support species that do not occur in adjacent habitats or provide necessary habitat components for more widespread species.

Bennett (1990) considers that the structural connectivity of corridors is influenced by the (i) distance they extend, (ii) number and length of gaps, (iii) number of junctions with other corridors, and (iv) presence of 'nodes' of habitat along the corridor.

Bennett (1990) considers that the functional conectivity of corridors depends on (i) the behaviour of the species utilising the corridor, (ii) the scale of the species movements, and (iii) the species response to the width and quality of habitat in the corridor.

2.2.1 The need for Fauna Corridors.

Bennett (1990) considers "Habitat corridors have the potential to make a major contribution to regional conservation strategies by ameliorating the detrimental effects that habitat fragmentation and isolation have on wildlife populations."

Bennett (1990) notes that the island biogeographic theory predicts that corridors will increase the conservation status of habitat isolates by maintaining a higher level of species richness at equilibrium. This is achieved by (i) increasing the rate of colonisation of species to the isolate, and (ii) supplementing declining populations, and reducing the rate of species' extinctions.

Bennett (1990) considers that animals living in remnants can be viewed as 'metapopulations' when there is some level of interchange between them, so as to enable recolonization of populations that have become locally extinct and supplementation of declining local populations. The fragmented populations can thus be considered as one larger population.

Bennett (1990) considers that corridors can fulfil three main beneficial functions in the landscape, (i) habitat for certain species, (ii) facilitate the movement of plants and animals between fragments, and (iii) provide habitat components for species utilizing surrounding habitat.

Bennett (1990) cites various research that has conclusively established the benefits (and often necessity) of streamside habitats, hedges, shelterbelts, plantations, fencerows and roadsides for fauna utilizing them for refuge, foraging, dispersal, migration or as a resident habitat.

In the south east of NSW Kavanagh (1985a) undertook a series of logging trials at Waratah Creek, in which 100 metre buffer strips were left along streams, giving a total width of 200 metres of unlogged forest. He noted that before logging most animals were clustered in or around the 100 metre wildlife corridors and that after logging these corridors appeared to contain most animals within them. Kavanagh (1985b) states "most animals which were found well away from creek reserves before logging were not found in these areas after logging". Kavanagh (1985a) states that "the provision of wildlife corridors appeared to play a major role in retaining populations of arboreal marsupials throughout the areas which were logged." Kavanagh and Webb (1989) note that approximately 50% of the original populations of arboreal marsupials remained after logging, partly because they were most abundant in creek reserves prior to logging.

Saunders (1990) considers the lack of connecting corridors of native vegetation hampered Carnaby's Cockatoo's ability to locate patches of remnant vegetation suitable for feeding, stating "When patches are visually isolated, finding a suitable patch may be a chance event." He cites a previous paper where he "pointed out

that avian species will continue to be lost in some locations because very small populations of many species have been isolated on remnants and because many Australian bird species have poor colonizing abilities ...There is a need to provide corridors of native vegetation to link isolated remnants and allow movement between them."

Mansergh (1984) states "as no comprehensive system of corridors between reserves has been incorporated into the reserve system there is a possibility that the Victorian populations of [Tiger Quoll] will be further fragmented."

Moon (1990) notes "Koalas disappear from their usual feeding area from time to time, leading to the conclusion that both corridors and alternate feeding areas are essential to the conservation of a koala population."

Page (1989) notes that there is a need to consider migration of species at higher latitudes and higher altitudes of their range in response to global warming. He notes the vital necessity of corridors as pathways that creatures might take to remain in a familiar climate.

2.2.2. Adequacy of Fauna Corridors.

Bennett (1990) notes that gaps in a corridor can severely disrupt animal movements along the corridor, or the continuity of a resident population within the corridor. He states "For a forest animal, a gap in a forested corridor could be a stream, a road, a strip of grassy vegetation, a burned patch of forest, a break in the canopy, or even a different forest community."

Bennett (1990) considers the length of a corridor can influence its effectiveness in several ways; (i) with increasing length there is a reduced likelihood of single animals (particularly small terrestrial animals) traversing the length of the corridor, and an increased reliance on self-sustaining populations in the corridor to provide habitat continuity, (ii) greater cumulative impact of edge effects (e.g. risk of predation) from adjacent habitats, and (iii) greater vulnerability to sudden disturbance or catastrophe that can cut the corridor (e.g. fire, grazing by stock).

Bennett (1990) notes that the linear shape of corridors means that the ratio of edge to area is very high, which makes them very vulnerable to edge effects. He considers that narrow corridors within farmland may effectively be entirely edge habitat while in contrast, a mature forest corridor surrounded by earlier successional stages of the same forest type is more likely to have an interior habitat and support interior species.

Gilmore (1990) notes "If remnant habitat is long and narrow, such as many retained wildlife corridors and filter strips along gullies, the mean distance between the centre and a series of random points within that home range increases as the home range deviates from circular. Thus species with large home ranges may be excluded theoretically from occurring not by absolute area, but by the shape of the remnant habitat... Obviously the width of wildlife corridors should be adequate to accommodate the diameter of the home range of the vertebrates inhabiting the area, rather than arbitrarily determined values." and because of the edge effect "many wildlife corridors and other linear reserves are probably a suboptimal habitat and inhabitants have lower reproductive success compared to those in continuous habitat."

Kavanagh and Webb (1989) note some deficiencies with the corridor system applied by the Forestry Commission: uncertainty that the creek reserve system contains habitat suitable for the conservation of all sensitive species; uncertainty regarding the minimum number of individuals needed to comprise a "viable" population when the animals are confined to a reserve; low probability of success in maintaining populations of some species in narrow (<100m) linear corridors of mature forest; and, lack of knowledge about the rate of recolonisation of forest regenerating after logging by species initially confined to adjacent corridors and reserves, and whether this can be accomplished within the duration of the logging cycle.

Milledge, Palmer and Nelson (1991) consider that the impact of logging upon Greater Gliders, Yellow-bellied Gliders and Sooty Owls "is unlikely to be mitigated by environmental prescriptions such as those applied to the clearfelling system... where stands of old-growth forest are only maintained as linear stream-side reserves and corridors."

Kavanagh (1985b) notes that Yellow-bellied Gliders "are not easily managed in creek reserves" and populations "apparently can not be maintained unless creek reserves are very large." That is well in excess of the 100 metre each side of streams prescription.

Shields and Kavanagh (1985) note that "the preferred habitats of many species do not include narrow riparian strips or steep unloggable country. Consequently, it is often necessary to take other measures to reserve suitable areas of preferred habitats to ensure conservation of some species."

Recher *et al.* (1991) in their study of birds in the Eden woodchip area conclude "Attention has therefore focused on moist forests along creeks or in gullies where narrow strips (20 m to either side of the drainage) of undisturbed vegetation are normally retained as filtration strips to control erosion and protect water quality. These recommendations, which have been substantially implemented, offer a measure of protection to species at lower elevations that have been shown to have the most restricted habitat requirements. These areas also reserve habitat for a large number of more widely distributed and abundant birds. Reserves along creeks and gullies in tableland forests, although effective, are likely to conserve a smaller proportion of the local avifauna because of the greater area of wet sclerophyll forest in escarpment areas. A problem with implementing these

recommendations in forests affected by integrated logging can also occur where catchments for gullies are small and filtration strips are not required". and, "Birds restricted to dry sclerophyll forests or woodlands are not necessarily protected by reserves or corridors along creeks and gullies. A conservative interpretation of the requirements of the forest avifauna in southeastern New South Wales suggests that it is also necessary to retain areas of mature forest along ridges and on slopes."

Recher *et al.* (1991) note that where narrow creekside reserves (< 80 m. total width, and > 100 m. total width) were retained in areas being converted to pines, they suffered a drop in forest-dependent species and an influx of open-country or non-forest birds within a few years.

Mackowski (1984) notes that "Corridor retention strategy in gullies on a regional basis at Eden (southeastern N.S.W.) is teleologically evident because, at Eden, possums and gliders concentrate in gully areas... However, there are many situations in north coastal N.S.W. where large scale corridor retention in gullies will not preserve the type of habitat that is utilised by the possum and glider community of adjacent logged areas.", and "A drawback of the corridor strategy is that the recruit regeneration event (fire or other disturbance) may have to be specifically allocated to retention corridors as it may be excluded from adjacent forest management."

Shields and Kavanagh (1985) note that "the effect of the Bombala fire on the avifauna of retention strips was drastic - in effect, complete removal of birds."

Andrews (1990) cites a survey of 7 fauna tunnels constructed under a 35 km length of new railway line by the New South Wales Rail Authority which raised the problem that feral predatory mammals could focus their activities on the tunnels which acted as funnels for prey. A comparison with the use of existing culverts showed small mammals used these more, as vegetation cover was well established, and they were too small to allow entrance of some predators.

2.2.3 Design of Fauna Corridors.

Bennett (1990) states "Much of the evidence for the use of corridors by wildlife is observational and concerns remnant corridors that have survived by default rather than by good management (e.g. roadsides, fencerows). There are few planned systems of corridors, and there is little empirical data that addresses practical questions to which wildlife managers and planners require answers in order for ecologically sound corridors to be established. ...Clearly there is an urgent need for quantative, process-orientated research to provide a more satisfactory basis for such planning." He outlines in some detail recommendations for research and management.

Bennett (1990) states "Identification of the species or species assemblage for which a corridor is required, and a basic knowledge of their ecology is a first requirement for corridor design. Knowledge of the spatial scale of a species movements is of particular value. ...Information concerning the habitat requirements, diet and other necessary resources, will assist in optimizing the habitat within the corridor. Other behavioural and ecological attributes, such as the ability to cross gaps, the role of dispersal in the life history, the age of dispersing individuals, social organisation, and behavioural spacing mechanisms within the population, will also influence the ability of species to effectively utilise corridors. ...Design of corridors to provide habitat and effective population continuity for those species with the largest movement patterns and more-specialized habitat and foraging requirements should also encompass the requirements of many other species."

Bennett (1990) considers population continuity between patches of habitat can be achieved by three types of movement along corridors; (i) direct movement by single individuals, (ii) movement by a single individual, punctuated by pauses of hours or even months in the corridor, or (iii) most effectively by genetic flow through resident populations of target species within the corridor.

Bennett (1990) states "Corridor length is obviously determined by distance between habitat isolates, but several measures that may reduce the risks associated with corridor length include: duplication of the corridor; creating a network of corridors; and increasing the width of the corridor to reduce edge effects."

Bennett (1990) states "Incorporation of nodes of habitat along the corridor can increase its effectiveness by providing additional habitat in which animals can pause during lengthy movements, or maintain a larger breeding population, thus introducing more dispersers into the system."

Recher *et al.* (1991) cite previous researchers who "recommended modifications to the creek reserve and corridor system to include the reservation of larger areas (e.g. entire coupes) of forest at periodic intervals along drainages on which creek reserves were established." They note that intent of proposals to add such nodes and retain mature forest along ridges and on slopes "was to include within the corridor system a complete sample of the fauna and their resource requirements along a topographical gradient from gully to ridge as well as providing larger areas of old growth forest for species requiring large, non-linear habitats."

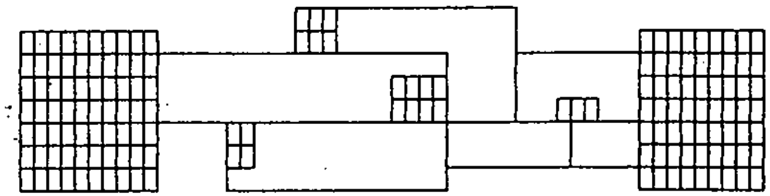

Fig. 1.
A corridor system that provides continuity, multiple pathways and nodes of habitats along the way is likely to be the most effective way of linking animal populations in remnant habitats (adapted from Bennett, 1990)

Bennett (1990) states "The width of a corridor is a particularly important consideration in corridor design as it influences most aspects of corridor function. Maximising the width of corridors is one of the most effective options that wildlife managers can exercise to increase the effectiveness of corridors for wildlife conservation." He notes that increasing width increases species richness and can make corridors more suitable for sensitive species with greater spatial requirements or specialized feeding and habitat requirements.

Bennett (1990) states "The retention of existing natural vegetation to create a corridor is more effective than attempting to reconstruct or revegetate a corridor. A high quality habitat for wildlife requires the full diversity of natural vegetation, and it is maintained by the functioning of natural ecological processes. Resources such as litter, tree hollows, dead trees, hypogeal fungi, and diverse invertebrate communities cannot be created simply by planting trees and shrubs in rows. They require the operation of natural ecosystem processes. There is an urgency, therefore, to retain and protect corridors and natural links that are still present in the landscape before they are lost."

Bennett (1990) states "When corridors link large tracts that include several contrasting habitats (e.g. ridges and gullies in mountainous forest, dunes and swales in arid environments), the corridor must be suitable for species that occur in all habitats. This can be achieved by a broad corridor that encompasses the range of habitats, by duplication of corridors, or by placement of the corridor in a habitat that all species can utilise."

Bennett (1990) envisages a hierarchy of corridors;

(i) Regional corridors to restore natural links between formerly continuous large blocks that are isolated by developed land - because they are generally surrounded by farmland or other developed land, they are likely to experience greater levels of disturbance and consequently a broad swathe of forest will be required to maintain the integrity of the corridor habitat,

(ii) Major wildlife corridors within production forests to provide links between important reserved areas - they could follow the larger river systems,

(iii)Wildlife corridors forming common linkages in the system of retained habitat in a co-ordinated network throughout the forests - research is needed to determine optimum width but in the interim a minimum width of 100 m., with no logging, should be adopted.

Recher, Rohan-Jones and Smith (1980) recommend that:

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

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

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

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

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

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

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

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

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

A.H.C. and C.A.L.M.'s (1992, vol.5) proposed management practices to protect National Estate values in Western Australia include: "CALM has developed a new system of undisturbed strips and patches of vegetation (including mature forest) to provide for wildlife, hydrological and aesthetic values. This system will also be an important source of protection for some national estate values. In particular these patches will help protect some endemic invertebrate fauna and some gondwanic fauna species.

"It is recommended that:

1. all streams, permanent and ephemeral, including valley headwaters and seepage areas will be protected by riparian zones. Timber harvesting will be excluded from these zones;

2. riparian zone width will be variable according to a range of criteria (soil type, slope, type of harvesting, rainfall zone and stream order);

3. ecological boundaries will be used to guide the selection of riparian zone boundaries;

4. the following guideline will be used for selection of riparian zone width:

Stream Order	Width either side (approx)	Total width (approx)	Minimum width either side
First	30	60	20
Second	30	60	20
Third	30	60	20
Fourth	75	150	50
Fifth	200	400	100
Sixth	200	400	100

5. diverse vegetation communities will be protected. These include rock outcrops (>0.2 ha in size), lakes, swamps and other wetland, heathlands, sedgelands, herblands, and

woodlands. Ecological factors will also be used to determine the selection of boundaries of these areas. Transitional vegetation (ecotones) should be kept undisturbed for at least 50 m from the edge of the feature;

6. aesthetic zones along roads and other travel routes will be selected and managed according to Visual Resource Management classification and management guide-lines. The width of these zones will be variable in accordance with VRM criteria. A minimum width of 200 m will be kept free of disturbance on level 1 travel routes and 100 m undisturbed on level 2 travel routes;

7. movement corridors or links between aethetic, riparian and diverse ecotype zones will be provided. These links will be chosen to optimise the mosaic pattern of undisturbed forest. Sites with high moisture and high nutrient status will be favoured in the selection of links. The boundaries of upland linkage corridors should be chosen using VRM criteria as well as ecological criteria;

8. no timber harvesting or vehicle movement will occur within designated riparian zones and diverse ecotype zones. Vehicle movement across riparian zones should be restricted to properly engineered and sensitively constructed stream crossings; and

9. road construction activities will avoid transitional vegetation (ecotone) sites and preferred alignments will be located in high open forest communities."

Conservation, Forests and Lands (1989) in Victoria consider that wildlife habitat must be retained by "linking areas excluded from harvesting and reserves of various seral stages by the retention of forest strips along specified watercourses, mid-slopes and/or ridge-tops, to act as wildlife movement corridors. Wildlife movement corridors are strips of forest at least 40 m wide which are reserved from harvesting to provide for the movement of wildlife and for sufficient diverse habitat to maintain resident wildlife populations. In certain situations it may be desirable to retain much wider corridors. Where such corridors are at least 80 m wide, selective logging is permissible on the outer 50% of the extra width (i.e. 25% on each side)".

Kavanagh (1989b) recommends the retention of 100m wide wildlife corridors for a radius of 2.5km around known localities of the Powerful Owl and Masked Owl. For Sooty Owls he recommends 200m wide wildlife corridors for a distance of 1km.

Saunders (1990) states "The optimum width of the connecting strip is not known and would be expected to vary for different species, but several general principles must be borne in mind by planners. Roads and railway lines should be placed to one side of the corridor, not in the middle as is presently standard practice in Western Australia. A road or railway line may act as a barrier to movement from one side to the other (in some species), doubles

the amount of edge of the remnant vegetation and increases the chances of highway fatalities. In addition, linear reserves should be wide enough to retain their integrity and to resist the degrading physical and biotic influences of edge effects. ... In the agricultural areas of Western Australia these connecting corridors should be at least 200 m wide and any road or railway line should be located on one side. Such reserves should not be restricted to road and railway reserves, as these pose dangers to animals through collision with transport. Linkages are, where possible, better placed along paddock boundaries and drainage lines."

Dunning and Smith (1986) state "Results of this study suggest that two corridor systems are necessary for the conservation of arboreal mammals. One continuous gully system should incorporate the unlogged rainforest gullies throughout the study region. This corridor system would preserve rainforest inhabiting species, principally [Rufous Ringtail Possum, Mountain Brushtail Possum and Fawn-footed Melomys]. A second interconnected ridgetop corridor system of unlogged or lightly logged moist hardwood forest will be necessary for conservation of mature hardwood dependent species such as [Greater Glider]. [Greater Glider] cannot be conserved within a rainforest gully corridor system ... The ridgetop corridors may only need to be relatively narrow (approximately 100 m) if they are sited adjacent to or continuous with ...low intensity logging and tree hollow retention zones".

Dunning and Smith (1986) consider "The unlogged ridgetop moist hardwood corridor system should have side branches that link up with the rainforest corridors to provide an avenue for movement of species that utilise both habitat types, and to increase the area of contact between logged forest and unlogged source areas for species that can recolonise after logging.", and "The proposed corridor system may possibly prevent the isolation of [Greater Glider] populations and allow genetic exchange through juvenile dispersal."

Mackowski (1984) states "Strip/corridor management needs the managerial control input of knowing what possum and glider communities occur in all forest types. This is so that a particular community is not missed in the strip retention system without justification."

Davey (1989) recommends that corridors may be improved by maximising diversity of stream side reserves through not stipulating constant width and enabling boundaries to maximise the structural and species diversity, and designing movement corridors through forest where it can be shown movement actually occurs.

3.0 MANAGEMENT FOR WILDLIFE AND OTHER PURPOSES

Tyndale-Biscoe and Calaby (1975) state "it is by no means easy to determine how much alteration the wildlife can tolerate when the forests are used as a resource for other commodities. This is due to our great ignorance about the majority of forest species."

McIlroy (1978) stated "There is general public support in Australia for policies of multiple use management of forests including, in particular, the conservation of wildlife. The problem is that in any single forest area it is impossible to satisfy the requirements of every animal species. A choice must be made between various management plans."

Mackowski (1987) states "The strategy of multiple use can be criticised because management is incapable of rigourously valuing options... Therefore multiple usage tends to default to the single use that is most conveniently valued".

Mackowski (1987) notes "Wildlife and other environmental objectives are often considered as constraints when discussing commercial forest management."

3.1 TIMBER

3.1.1 Does Multiple Purpose management work?

Dunning and Smith (1986) state "Under the Forestry Act, the Forestry Commission of New South Wales is obligated to conserve native wildlife in State Forests, but when this objective conflicts with that of timber production, as it clearly does in many regions, timber production has generally achieved management priority over wildlife conservation. Wildlife conservation has largely been achieved inadvertently in unlogged, erosion control streamside corridors, areas of inaccessible or excessively steep terrain, or low site quality forests with a high proportion of 'defective' trees."

Mackowski (1987) states "Historically, the general approach to Australian wildlife management has been exterminate then deify - or, don't bother at all.", "Incidental management of wildlife is the management (of wildlife populations) that occurs due to natural resource management that does not consider wildlife and has non-wildlife objectives. The management of arboreal wildlife in Australia has been subject to a long tradition of incidental management.", "Natural resource managers often cannot rely on continued consensus following compromise advice from disciplines with opposed goals..., and may consider co-operation between such disciplines as unnatural acts... As well as immiscibly compromised advice, management organisations have to deal with inertia of established personnel to the acceptance of novel management goals... This inertia has occurred in north American commercial forests, where there has been a lack of implementation of hollow tree management policies... The potential for similar

lack of implementation in Australia's commercial eucalypt forest should not be overlooked."

Davey and Norton (1990) state "Despite the creation of seemingly appropriate legislation and formal structures relatively early in the development of the forestry industry to oversee the wise management of resources , it is clear that wise management has not been achieved. Several commentators have concluded that, in practice, forestry in Australia has been conducted within a philosophical framework, albeit unwritten, of wood primacy... That is, its practitioners believed that the principle function of forestry was wood production. Multiple-use management was considered to be wood production plus other uses." and, "...this history of resource management has had a significant impact on, at least, the past and current status of forest wildlife. Most State Forests have been cut over and few old-growth stands remain. Wildlife habitats have been removed, modified, fragmented and created."

Dunning and Smith (1986) describe the "normal logging" of "moist hardwood" forest in northern N.S.W.; "This generally involves 75%-95% of canopy removal, depending on the timber quality in the stand, followed by a post logging burn and minimal stand improvement. Large defective trees may be removed by ringbarking or felling and regeneration may be aided by planting with seedlings during logging operations in what is referred to as 'timber stand improvement" (TSI) operations. Current practice in the study region now favours defective tree retention and regeneration by natural means, a policy of 'minimal stand improvement'."

Kavanagh and Webb (1989) describe "normal logging" in southern N.S.W.: "Integrated logging as normally practised in the region results in the retention of about 10% of the original tall canopy cover in the forest, although this may vary depending upon the nature of the terrain and the proportion of commercially acceptable tree species. This cover is comprised mainly by the 4-5 evenly spaced mature trees retained per ha to act as a source of eucalypt seed, the 5 'overmature' hollow-bearing trees per 15 ha left specifically to enhance the requirements of wildlife for habitat, and other trees which may provide good sawlogs in the future". Their normally logged coupe retained 28% of the original canopy cover, 21% of the original basal area (m2/ha), and 6 trees > 80 cm. dbhob.

Recher, Rohan-Jones and Smith (1980) expected the following effects of logging in the Eden District to become manifest:

"1. There will be a decline in the abundance of animals which require mature forest. The impact will probably be greatest on species which require large trees or tree hollows. A number of birds and mammals may be threatened with extinction on a regional level.

2. Open-country, shrub and heath species of birds will increase in abundance. Some ground mammals may also become more abundant.

3. Changes in the pattern of flowering and the abundance of nectar will affect the movements and numbers of nectivorous

birds. There will be fewer opportunities for reproduction of these species and there may be a decrease in the abundance of nectar feeders north and south of Eden.
4. There may also be other changes in abundance, patterns of movement or nesting cycles which will not become apparent until a significant part of the existing mature forest is logged and replaced by regeneration."

3.1.1.1 MAMMALS

Recher, Rohan-Jones and Smith (1980) compared plots in unlogged and logged (2-3 years after clearfelling) dry open forest and low open forest and found that Brown Antechinus, Bush Rat, Swamp Rat and House Mouse were most abundant on the logged plots, Dusky Antechinus more abundant on unlogged low open forest and logged dry open forest plots, and White-footed Dunnart only found on one unlogged dry open forest plot. They state "Clearfelling eliminates arboreal mammals from the logged area. ...small numbers of arboreal mammals (e.g. Greater Glider, Mountain Possum) persist in patches of mature forest... or in the strips of forest retained along watercourses."

Recher, Rohan-Jones and Smith (1980) state "At this stage of our research, we consider that all gliders (*Schoinobates, Petaurus,* and *Acrobates*), the Koala (*Phascolarctos*), and several forest bats (e.g. *Myotis, Miniopterus, Nyctophilus,* and *Tadarida*) ... among the native mammals are probably sensitive to the effects of integrated logging ...Populations of Pygmy Possum (*Cercartetus*), Short-eared Possum (*Trichosurus*) and Dunnart (*Sminthopsis*) may also be reduced."

Dunning and Smith (1986) state "In general, the effects of logging on arboreal mammals were consistent with each species food and general habitat requirements. Clearfelling (5% canopy retention) caused a significant decline in populations of [Greater Glider, Rufous Ringtail Possum and Brown Antechinus] and an apparent decline in numbers of [Mountain Brushtail Possum]. This result presumably reflects loss of food and foraging substrate for all these species and is consistent with the results of previous studies."

Dunning and Smith (1986) state "The conservation of arboreal mammals in logged forests is a function of individual species preference for particular seral stages after logging, dispersal ability and proximity to recolonisation source populations and the availability of nest sites."

Dunning and Smith (1986) found that the abundance of Ringtail Possum, Greater Glider and Brown Antechinus declined significantly following normal logging, with no Ringtail Possums found 2 months after logging and no Mountain Brushtail Possums 5 months after logging (they note that numbers of these later two species increased in unlogged areas and areas logged to a lesser intensity - suggesting movement out of 'normally' logged areas). They state that the Greater Gliders observed following normal logging "were on the borders with the 66% retention and the control II zones and it is assumed that their territories may have overlapped this area prior to logging. No animals were observed away from boundaries."

Milledge, Palmer and Nelson (1991) found that Yellow-bellied Gliders had a strong relationship with old-growth forest and made "little use of young forest even where stags or scattered old trees apparently suitable for nest and den sites were available.", with "Most records were clustered in and about old-growth stands with a core area greater than 1 km^2". They found that the Greater Glider was more abundant in old-growth forest and considered its distribution was more closely linked with hollow availability. They concluded that conversion of old-growth Mountain Ash forest to a series of stands younger than 80 years of age will cause substantial reductions in densities of the Greater Glider and the likely loss of the Yellow-bellied Glider.

Tyndale-Biscoe and Calaby (1975) "predict that about ten species of mammal resident in Eucalyptus forests will probably disappear altogether from areas clear-felled. For these species, reserves of indigenous forests are the only means for their long term survival."

Kavanagh (1985a) stated that "the 10% and 25% canopy retention treatments clearly form no part of the management strategy designed to maintain populations of arboreal marsupials where these animals are to be given priority. The value to arboreal marsupials of the 50% canopy retention is also doubtful."

Kavanagh and Webb (1989) found "Species which remained more abundant in unlogged forest compared with all logging treatments were the Greater Glider, Yellow-bellied Glider, Feathertail Glider, and the lizards *H.maccoyi, S.tympanum* and *L.coventryi.*"

3.1.1.2 BIRDS

Shields and Kavanagh (1985 p.78) cite research that found the greatest effects of logging on birds fell among the hollow nesters, eucalypt canopy feeders, the moist ground litter feeders and the non-passerines in general. They also note that regenerating forests lose some 20% of the bird species found in mature forest (pp. 18,43,67).

Recher, Rohan-Jones and Smith (1980) found "The early stages of regeneration in the Eden District support bird species found also in the ground and shrub layers of mature forest. ...In addition regeneration supports bird species typical of heath, scrub and open-country habitats and which are not normally found in mature forest. A number of open country and shrub birds appear to be increasing in abundance as a result of integrated logging... Birds which feed in the canopy of mature forest (e.g. Spotted Pardalote) or on the trunks and branches of trees (e.g. White-throated Treecreeper) are absent or scarce in young regeneration.", and "In effect, logging regeneration up to ten years of age supports fewer than half the breeding bird species expected in mature forest on a comparable site... In particular, species which nest in hollows or in the canopy and those which forage on tree trunks or in the canopy are absent from young logging regeneration. ...A young forest with some older trees which provide nest and foraging sites will have more birds than a forest of the same age where older trees are absent."

Recher, Rohan-Jones and Smith (1980) state "Among the birds, 10 to 15 per cent or more of the terrestrial avifauna is sensitive to the effects of clearfelling ...The most sensitive birds in our estimation, are the cockatoos (*Calyptorphynchus* and *Callocephalon*), lorikeets (*Trichoglossus* and *Glossopsitta*), owls (*Ninox* and *Tyto*), parrots (*Aprosmictus* and *Platycercus*), Owlet-nightjar (*Aegotheles*), Sacred Kingfisher (*Halycon*), and tree-creepers (*Climacteris*). These constitute 10 per cent of the terrestrial avifauna. Each of these birds and mammals requires tree hollows as nest or den sites. Species which need tree hollows are the species *most likely* to be affected by integrated logging."

Milledge, Palmer and Nelson (1991) found that the relative frequency of records of the Sooty Owl in different age classes suggests that its optimum habitat is large patches of old-growth forest. They note "The Sooty Owl was most abundant in old-growth forest, but often occurred in young stands... The proximity of some records in young stands to old-growth stands... suggested that some pairs of Sooty Owls include areas of both young and old-growth forest in their extensive home ranges... However, some findings in young forest removed from old-growth forest ...indicated that other pairs were able to occupy stands lacking high densities of old live trees.", and "Most records were clustered in and about old-growth stands with a core area greater than 1 km^2". They concluded that conversion of old-growth Mountain Ash forest to a series of stands younger than 80 years of age will cause substantial reductions in densities of the Sooty Owl.

Mackowski (1987) notes the importance of downed timber to wildlife, stating "The harvest of timber from cohorts in a rotation < 40 y.o. would leave a minimal volume of down timber behind in the forest. This down timber would be of smaller piece size, and contain proportionately more sapwood, than that left following similar logging of older forest cohorts. This timber would be less in volume than what falls to the forest floor in natural forest and would also be less resistant to decomposition by decay and fire. This may have significant effects on carbon flow through the forest ecosystem to soil organic matter, and on energy flow to decomposer organisms and organisms at higher trophic levels that provide food for ground dwelling vertebrate wildlife and for tree nesting but ground foraging carnivores..."

Gilmore (1990) states "Lowered soil moisture in dry seasons and reduced stream flows consequent on the establishment of densely stocked plantations, beyond the stage of crown closure, has the potential to influence the suitability of gully habitats and streams for amphibians, and possibly other vertebrates. Clearly these effects will depend on the temporal and spatial mosaic of plantation types and age and treatment of stands and of other land cover within the catchment. Effects are likely to be greater for species dependent on gullies and low order streams within smaller catchments, but the extent of the impacts on fauna has not been investigated so far."

Recher, Rohan-Jones and Smith (1980) note "If we are dealing with a single avian community and not a series of discrete populations along the coast, then changes in resource abundance (i.e. nectar) in the Eden District will affect the numbers of nectivorous birds outside the region."

Recher, Rohan-Jones and Smith (1980) state "We are in a similar dilemma when it comes to predicting the escalating impact on fauna as the area of mature forest is progressively reduced in area. It is possible that some populations of dependent fauna which we presently record in buffer strips, on reserves and in regenerating forest are derived from animals bred in the large area of mature forest which remains (i.e. in 1979) in the Eden District. There may come a time in the logging cycle when the area of mature forest is reduced to a level where the numbers of animals produced are insufficient to maintain these populations. If this critical point is reached, there would be a precipitous decline in species number and abundance, leaving little scope for remedial action."

3.1.2 Habitat tree retention prescriptions

Mackowski (1984) notes "Management for adequate, uniformly distributed hollow trees and recruits does reduce problems of fragmentation and adequacy of reserve size suggested by biogeographic island theory".

Mackowski (1987) states "The occurrence of arboreal wildlife in eucalypt forest is dependant on a suite of critical resources that differ for different species... Tree hollows are resources that are measurably separate to other resources, and are critical to a large number of arboreal wildlife in eucalypt forest".

Smith and Lindenmayer (1988) note that "Approximately 75% of arboreal marsupials use tree hollows as daytime refuges for shelter or reproduction".

Mackowski (1987) considers "The tree hollow resource in eucalypt forest may vary as to: (i) number of trees with hollows, (ii) number of hollows in each tree, (iii) size and disposition of hollows, and (iv) suitability of hollows for various species of wildlife."

McIlroy (1978) emphasises that to define how many trees and logs containing appropriate hollows should be retained, and at what stage the remaining or regenerating trees and logs will become useful to certain animals, further research is needed on (i) the types or characteristics of hollows required by different species, (ii) the specific number and distribution of hollow-containing trees and logs and the density of the surrounding canopy and understorey that each species requires, (iii) the relationship between the number of such nesting, roosting or homesites and population levels, and (iv) the competition between different species for their use.

Loyn (1985) states "The number of trees that need to be retained to provide breeding habitat for individual species of forest animal is not known." He considers that the highest densities of old trees are needed by species which use them for feeding, whether or not they also need them for nesting.

Smith and Lindenmayer (1988) state "Under conditions of resource limitation, the density of tree hollow dependent arboreal mammals should increase approximately linearly with tree hollow density and then plateau once tree hollows are present in excess and other resources such as food become limiting."

Mackowski (1983) states "Presently the Forestry Commission logs its eucalypt forests without measuring impact on, and with minimal regard for, arboreal wildlife populations, although in clearfelling/clearing situations occasional possum trees are left behind, these have no more prescription than 'it looks good to the eye'. This is incidental wildlife management..."

Kavanagh (1985b) states "The results of this study should be taken as an early warning of the probable inadequacy of current 'habitat tree' retention specifications for wildlife (arboreal marsupials) in forests subject to integrated logging. Management for wood production will inevitably take precedence over management for wildlife in most areas. However, it should be recognized that in other areas a strong commitment must be given to managing wildlife and that normal tree retention specifications (and creek reserves) are likely to be inadequate. The appropriate specifications for such areas are still unclear."

Kavanagh and Webb (1989) note that the present approach is deficient because of lack of knowledge about the number of mature and hollow-bearing trees that should be retained in logged areas to provide for the present or future requirements of mature forest-dependant wildlife.

Davey (1989) outlines a number of requirements for the management of fauna requiring hollows: knowledge of the rate at which hollows develop in a suite of species over a range of site qualities; identification of characteristics of hollows for all species utilising them; and determination of seasonal use of hollows. He advocates the development of models predicting development of hollows in tree species in relation to size class of trees.

Loyn (1985) notes "The problem with the retention of large numbers of scattered old trees is that regrowth is suppressed by these trees ...and wood production is accordingly reduced. This increases the pressure to extend harvesting operations into mature forest which might be better reserved as habitat for the most sensitive plant and animal communities that could be damaged even by intermediate levels of selective logging."

Mackowski (1987) notes that where forests abut non-forest habitats (e.g. estuarine, mangrove, billabong, swamp, heath, pasture) the hollow trees in the forest "are significant resources for the hollow tree dependant wildlife that forage in adjacent non-forest habitats."

3.1.2.1 OCCURRENCE OF HOLLOWS

Mackowski (1987) considers "Hollows used by arboreal wildlife occur in trees that have attained a dbhob greater than the dbhob at which crown size increment declines reflecting a culmination of growth and the shedding of major branches."

Dunning and Smith (1986) found "The number of hollow bearing trees (>96 cm d.b.h.), in the Mt. Boss study, varied from 0.5 per hectare on some logged sites to on average 16 (8-30) per hectare in mature unlogged forest sites. Factors other than hollows would appear to limit arboreal mammal populations in mature moist hardwood, while in heavily logged forest the lack of hollows almost certainly limits population density."

Mackowski (1984) found that two stands of unlogged blackbutt forest had stockings of 6.7 and 13.4 hollow bearing trees per hectare. Kavanagh and Webb (1989) found their unlogged areas had averages of 26.9-40.8 trees > 80 cm. per hectare.

Mackowski (1987) found that in 40 m site height forest "although hollows occurred in blackbutt older than about 40 y.o. these hollows were not suitable for wildlife unless the blackbutt was > 144 y.o. [> 100 cm dbhob] and also, these hollows were not suitable for large hollow dependant wildlife unless the blackbutt was > 224 y.o. [> 140 cm dbhob]." and "Blackbutt longevity is about 300 years old, when blackbutt is about 180 cm dbhob in 40 m site height forest."

Smith and Lindenmayer (1988) found that Leadbeater's Possums: were not found in trees less than 1 m dbh; strongly avoided living trees less 2.1 m dbh and preferred those greater than 2.5 m dbh, and; exhibited a significant preference for dead trees of 1.1-2.5 m dbh. They cite work that predicted that Mountain Ash trees of 2.1 m dbh were about 190 years old, and that Shining Gum have an approximately 20% slower growth rate.

Mackowski (1987) notes "there is a mortality of about 1 tree/ha every 8 years during the 80 years the cohort takes to grow from 100 to 140 cm average dbhob, and about 1 tree/ha every 18 years during the 80 years the cohort grows from 140 - 180 cm average dbhob."

Mackowski (1987) notes "The average age of blackbutt with wildlife hollows is 185 years... Thus they have an average life of about 120 years left... Trees with large hollows have an average life of only about 50 years left... If primary logging in blackbutt forest leaves existing hollow blackbutt as wildlife habitat, and relies on regeneration to provide tree hollows when existing hollow trees die, then it is probable that there will be a temporal gap in the availability of hollow trees for arboreal wildlife. It is almost certain that there will be a period without trees with large hollows in forest managed in this manner."

Mackowski (1983) notes that previously logged areas often have low stockings of hollow trees and states that "salvage logging in these areas will remove more hollow habitat, and continued management for timber will remove recruits to the hollow tree class."

Milledge, Palmer and Nelson (1991) state "There are practical difficulties in maintaining the prescribed densities of hollow-bearing trees and stags on logged coupes when these are often incinerated during post-harvesting burning or collapse when exposed to wind... In any case, the survey results for the Yellow-bellied Glider indicate that the problem of conserving hollow-dependent vertebrates in Mountain Ash forests is unlikely to be resolved simply by maintaining an arbitrarily determined density of hollow bearing trees and stags throughout the forests."

Recher, Rohan-Jones and Smith (1980) state "The sudden exposure of large trees to new wind stresses after clearing the adjacent forest commonly leads to these trees dying or being thrown by the wind." Mackowski (1987) notes that habitat trees are lost or damaged by fires, lightning or windstorms.

Smith and Lindenmayer (1988) note "The number of large hollow-bearing overstorey trees in regrowth timber production forests is declining however, through a combination of natural decay, deliberate culling of dead trees, harvesting of large living trees, and incidental loss during post-logging, slash-burning operations."

3.1.2.2 UTILISATION OF HOLLOWS

Mackowski (1987) lists 13 species of marsupial, 13 species of bat, and 49 species of bird that use tree hollows and occur in northeastern NSW. He also found 3 species of lizards in tree hollows he dissected.

Smith and Lindenmayer (1988) found "A strong linear, almost 1:1, relationship occurred between the total number of all species of possums and gliders recorded emerging from tree hollows and the density of PNT [Potential Nest Trees] on each site." They predicted that when less than 1.5 PNT per 3 ha. remained that the density of possums and gliders would average zero and that

minimum number of PNT necessary to sustain animal density at the average maximum (11.3 per 3 ha) was 12 PNT per 3 ha.

Smith and Lindenmayer (1988) found that "the total numbers of possums and gliders per site, were significantly related to the number of 0.25 ha blocks on each site supporting PNT [Potential Nest Trees]. ...The total number of possums and gliders increased linearly from a predicted value of zero when the number of 0.25 ha blocks with PNT was 0.6, to an estimated maximum of >12.8 animals per 3 ha when the number of 0.25 ha blocks with PNT exceeded 10. ...it is possible that maximum possum and glider density will only be reached on 3 ha sites in which all [12] 0.25 ha blocks support PNT."

Mackowski (1987) states "The characteristics of tree hollows that may influence their use by wildlife include: hollow orientation (vertical, horizontal, aspect); the type of entry (smooth, jagged); the type of surrounding wood (green, wet, dry, cracked); entry size; hollow volume; drainage; ventilation; availability of water; biotic agents (predators, competition, parasites); hollow numbers; and availability of non hollow resources".

Mackowski (1987) states "Only trees > 100 cm dbhob were utilised by wildlife... Larger trees (> 140 cm dbhob) were utilised by more wildlife than were trees 100 -140 cm dbhob. Larger hollow utilising birds such as ducks, cockatoos and owls... are probably restricted to nesting in blackbutt >140 cm dbhob as larger hollows mainly occurred in these trees".

Mackowski (1987) notes "Arboreal marsupials the size of yellow-bellied glider and larger appear to require hollows > 100 cm^2 entrance size, these hollows only occur in blackbutt > 100 cm dbhob and are most abundant in blackbutt > 140 cm dbhob".

Lindenmayer, *et al.* (1991) found that of the 823 trees they stagwatched only seven (0.9%) were occupied by more than one species, noting "Where co-occupancy did occur, nest trees were typically inhabited by a large and small species".

Mackowski (1987) identified three forms of wildlife hollows: branch, main stem and top. He found that 83% of hollows were branch hollows, and "Most of the wildlife occurrence, in hollows... was in branch hollows." He also found that about half of the branch hollows were not seen by ground level observers.

Mackowski (1987) found that the two thirds of hollows which had jagged wood entries were utilised by Feathertail Gliders and lizards, while "All the non feathertail glider/reptile arboreal wildlife in blackbutt forest is restricted to choosing suitable hollows from the one third of blackbutt hollows that are smooth overgrown hollows."

Mackowski (1987) considers "that parrots (and large cockatoos?) may require deep vertical hollows to reduce egg and chick predation". He found evidence of use by parrots in three large hollows, all greater than 3 m deep.

Lindenmayer *et al.* (1991) state "Our results indicate that small species... prefer nest sites with a small entrance cavity, particularly holes. The dens of larger species... had a large entrance, such as a hollow-branch or spout. Medium-sized species... showed no particular preference for any type of nest entrance although holes were the most commonly used."

Lindenmayer *et al.* (1991) found that the dens of gliding marsupials were usually higher than those of non-volant species. They noted "Differences in the type and height of the entrance to the nest, together with the time of emergence from the den, indicate partitioning of the nest tree resource between the various species..."

Mackowski (1984) notes that "low numbers of hollow trees means more interspecific competition for hollows'

Smith and Lindenmayer (1988) found that Leadbeater's Possum on average occupied only one in three Potential Nest Trees, they considered that available evidence suggested three factors may operate to some extent, if: "Approximately only one in every three PNT contain suitable hollows for the species; Leadbeater's possum is excluded from potentially suitable hollows by other species of possums and gliders; or if each Leadbeater's Possum colony requires access to more than one PNT." They note that when PNT occur at low density "The species most likely to be disadvantaged are those of poor competitive ability (e.g. small size) with specialised hollow requirements."

Recher, Rohan-Jones and Smith (1980) note "Dead trees appear to be unsuitable to many (although not all) species of birds and mammals which require tree hollows".

3.1.2.3 DETERMINING HABITAT TREE RETENTION PRESCRIPTIONS

Recher, Rohan-Jones and Smith (1980) recommend that:

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

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

3. Individual trees of species known to develop into habitat trees should be selected and protected from logging so as to ensure the continuous maturation of such trees throughout the forest. Ideally such trees should be located near a known habitat tree (and can be part of the patch shielding that tree) and should be selected for their youth and vigour. Intuitively the

healthiest and most vigorous individuals will develop into the largest and longest-lived trees with an abundance of hollows.

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

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

Mackowski (1984) found "that low possum and glider populations occur in blackbutt forest of 40 metres site height with less than 3 hollow bearing trees per hectare." He presents results from 10 spotlighting transect estimates of Greater Glider and Brushtail Possum densities in blackbutt forest of 35 - 45 m site height which show that on the seven sites with some 3 or less hollow trees per hectare there were less than 0.09 animals per hectare, while on the 3 transects with more than 3 hollow trees per hectare the densities were greater than 0.27 per hectare.

Smith and Lindenmayer (1988) from their study in Mountain Ash forest concluded "a minimum of 10-12 PNT [Potential Nest Trees] need to be retained in each 3 ha patch of ash forest to ensure maximum hollow availability for tree-hollow dependent species of possums and gliders. In logged forests at least an equivalent number of younger trees will also be required to provide replacements for existing PNT in the event of natural or logging-induced PNT losses. Furthermore, replacement trees will need to be maintained in spatial isolation from existing living PNT to prevent their suppression and slowed hollow development. In other words, the retention of trees in small clusters does not allow for tree hollow replacement." It is worth noting that the arboreal mammal density they were considering was about 4 per ha.

Smith and Lindenmayer (1988) recommended "Rather than attempt to integrate and compromise wood production and wildlife conservation" that all remaining areas of mature and multiage structured forest (with >12 living PNT per 3 ha) be reserved or subjected to only low intensity selective logging and that no living PNT be felled in other areas.

Dunning and Smith (1986) used the results of studies in Victorian Mountain Ash forests and Mackowski's findings to recommend "The number of hollow bearing trees to be retained in the zones managed primarily for timber would be a minimum of 3 evenly spaced or 5 randomly spaced self sustaining potential nest tree clusters in each hectare of logged forest."

Loyn (1985) found that at Boola Boola retention of about 14 mature trees per hectare apparently failed to provide habitat for a significant small group of arboreal birds and mammals, even up to 70 years after harvesting.

Kavanagh (1990) suggests minimum numbers of habitat trees for four groups of forest types: from one per hectare on the poorest sites, through three and five to 10 on the richer sites.

Kavanagh and Webb (1989) in their study found that populations of Greater Glider, Yellow-bellied Glider and Feathertail Glider "were markedly reduced when less than 10 large (> 100 cm dbh) trees were retained per hectare."

Mackowski (1984) states "The retention of scattered hollow bearing veterans in heavily logged forest, when first logged, serves to ameliorate the impact of logging on hollow dependent fauna - but this is only of short term benefit.", "The retained veteran in first logged, heavily logged blackbutt forest will average 250 years of age at the time of logging. With a longevity of 300 years this means an average length of service as possum and glider habitat of only fifty years (30 years with adequate foraging substrate). The regeneration cohort will be 200 years old before it can provide hollows - there will be a period of 150 years during which there will be no hollows. Obviously larger sized trees need to be retained as recruits to the hollow tree class.", and "When managing a forest for possums, gliders, and timber, it is not a question of how many hollow trees to leave when logging - rather how many hollow trees to manage for. To maintain hollow trees in perpetuity requires the management of the forest so that new hollow trees are recruited as old hollow trees die."

Mackowski (1987) states "If the provision of wildlife hollows is to be continuous then there is a need, both in natural forest and in managed forest, for an unevenaged forest structure with regeneration events less than about 120 years apart for small hollow dwellers, and probably a 50 year periodicity of regeneration events for large hollow dependant wildlife."

Mackowski (1987) states "A continuous flow of 3 hollow trees/ha can be achieved, on a broadacre basis in 40 m site height blackbutt forest, by retaining 4 sound trees/ha as recruits of variable size between 60 and 100 cm dbhob, plus 2 hollow trees/ha of variable size between 100 and 140 cm dbhob, plus one hollow tree/ha >140 cm dbhob, at the primary logging and by managing the forest so as to maintain this distribution of tree sizes into the future. In a commercial forest where multiple use is the current management system, but where adequate hollow trees have not been retained in the past, a greater proportion of larger recruits should be selected (rather than evenly distributed between 60 & 100 cm dbhob) to facilitate the early return of hollow trees and the immigration of hollow dependant wildlife if it occurs nearby."

Mackowski (1984) states "Management for hollows on a small area basis requires a uniform distribution of hollow trees and their recruits. It requires the managerial control input of knowing hollow and food removal responses of possum and gliderü communities in different forest types."

Mackowski (1987) notes "The retention of trees across species is meant to be on a pro-rata basis so that the existing tree species mix is maintained in the hollow bearing tree community. However some species appear to have different hollow bearing characteristics to blackbutt and should not be relied on to produce wildlife hollows similar to blackbutt."

Mackowski (1987) suggests a "rapid method of predicting hollows, in forest of unknown producing character, is to determine dbhob/crown width curves and assume wildlife hollows occur in trees of dbhob greater than at which crown width levels off."

Mackowski (1987) states "The planning stage needs to look at hollow tree values of adjacent land use and land tenure. Adjacent retained/réfuge areas may contain plenty of hollow trees but may be of a forest type that does not carry the same wildlife species as blackbutt forest (eg: low site quality forest of poor nutrient status, or riparian rainforest, both contain different suites of hollow dependant wildlife than occurs in blackbutt forest - unpub. data)."

Mackowski (1987) recommends permanent marking of all habitat trees and identified potential replacements with stainless steel ribbon.

3.1.3 Logging on long rotations

Recher, Rohan-Jones and Smith (1980) state "Existing management proposals suggest that a cutting cycle of 40 to 45 years will be followed in the Eden Woodchip Concession. This means that by AD 2015 all forest in the district except that reserved in buffer strips, unlogged reserves or National Parks and Nature Reserves will be regeneration between 0 and 45 years. Forest of this age is unsuited for birds and mammals which require older trees. To ensure the survival of these species in the Eden district, the length of the logging cycle should be staggered through space and time. The following are recommendations:

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

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

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

A.H.C. and C.A.L.M. (1992, vol.5) in their recommended practices to protect National Estate values in Western Australia state

"Forest values will also be protected by extending the rotation length (up to 250 years) in some patches. This rotation length more closely approximates the average physiological rotation age of Jarrah and Karri. Retention of these additional patches of undisturbed forest beyond the first harvest cycle will ensure that mature and senescent characteristics are perpetuated in the stand until maturation of younger regrowth."

Davey and Norton (1990) state "Equally important is to realize the length of time... for habitat to become optimal for most arboreal marsupials after major disturbance (clearfell, intense wildfire). Such a length of time has to be considered in the determination of the rotation length of a particular forest stand."

Loyn (1985) notes "The age which evenaged regrowth begins to support those species most sensitive to harvesting is not yet known." He considers that a rotation of 100 years or less would eventually exclude a small group of species from cutover areas, and a rotation of 150 years would be needed to maintain about a third of the forest in a condition suitable for these species.

Dunning and Smith (1986) consider that appropriate rotation and spatial organisation of logging coupes is useful for arboreal mammals with good dispersal capability dependent on particular successional stages after disturbance.

3.1.4 Logging at lower intensities

Dunning and Smith (1986) consider that conservation within logged compartments by modification of logging practice and reduction of logging intensity to maintain species and their essential resources at a lower but stable density is useful for disturbance tolerant species dependent on mature forest.

3.1.4.1 25% CANOPY RETENTION

Kavanagh and Webb (1989) note that their 25% canopy retention plot retained 57% of its canopy, 52% of its original basal area and 54% of trees > 80 cm. dbh. It can thus be considered to more accurately represent 50% canopy retention. There was no post logging burn.

Kavanagh (1985b) found that it was clearly apparent that few or no arboreal mammals were retained in logging areas outside of creekside reserves in the area logged to this prescription, with neither the Greater Glider or Yellow-bellied Glider persisting in logged areas.

3.1.4.2 33% CANOPY RETENTION

Dunning and Smith (1986) found that the numbers of Greater Gliders decreased by a half, Fawn-footed Melomys and Rufous Ringtail Possum declined by two thirds and Mountain Brushtail Possum and Brown Antechinus increased (the later apparently due

to juveniles and the former immigrations from more intensively logged areas). They also note that Challengers Skink declined significantly in numbers (even without a post logging burn).

3.1.4.3 50% CANOPY RETENTION

Kavanagh and Webb (1989) note that their 50% canopy retention plot retained 57% of its original canopy cover, 51% of its original basal area and 54% of trees > 80 cm dbh. The method utilized was a 'chessboard' method where alternate patches were clearfelled. There was no post logging burn.

Kavanagh (1985b) states "Surprisingly, Greater Gliders were not observed in the small (0.5 ha) retained patches in the 50% treatment." Prior to logging he recorded 19 Greater Gliders in the area subsequently subject to logging, after logging he recorded 7 in the same area (6 of which were in unlogged patches adjoining unlogged corridors). Kavanagh (1985a) notes that Yellow-bellied Gliders were observed on occasions feeding just inside the logged areas (< 30 m from logging boundary) "but these wide ranging animals were normally encountered only in creek reserves or on the unlogged plots."

Kavanagh and Webb (1989) note that "This pattern of logging approaches the 'Australian group-selection' logging system ... which, silviculturally and ecologically, is the more traditional and widely accepted form of logging elsewhere in Australia."

3.1.4.4 66% CANOPY RETENTION

Dunning and Smith (1986) found that the numbers of Rufous Ringtail Possum decreased by one half, Greater Gliders and Brown Antechinus by one third, and Fawn-footed Melomys by four fifths.

3.2 FIRE MANAGEMENT

McIlroy (1978) notes "As yet there has been little research on the effects of fire on wildlife, especially fires of different frequencies, intensities and seasons of Occurrence.", and "Studies of the effects of fire on wildlife in Australian forests have been limited to the first four years after the fires. ...Hence any conclusions made from the Australian studies to date must be regarded tentatively."

Recher, Allen and Gowing (1985) state "there is remarkably little information about the effects of fire on fauna or the long-term consequences of burning on forest ecosystems."

McIlroy (1978) states "Frequent low intensity fires (prescribed burning) also tend to produce a uniform habitat by gradually eliminating the shrub layer and allowing the monocotyledons and ferns to dominate the forest floor. As a consequence there is a gradual disappearance of animals dependent on the shrubs, litter or old logs for food and shelter."

Leigh and Holgate (1979) consider that "Possibly the current procedure of dropping aerial incendiaries on a grid basis as part of the burning programme in various areas especially for forestry and national park use may lead progressively to a substantial change in understorey structure and composition because of the localized selective grazing {by native species} of those small areas which have been burnt. ...it would lead most likely to a progressive increase in unpalatable plant species. This would alter, probably irreversibly the suitability of those areas for conservation of all parts of the flora and as a suitable habitat for the endemic fauna, both as shelter and feed."

Dunning and Smith (1986) found that post logging burning of moist hardwood forest was significantly deleterious for a variety of species and so advocated tractor clearing, rather than burning, to create disturbance for regeneration.

Mackowski (1987) found that "butt hollows" in the blackbutt forest he studied were lined with charcoal and "were probably 'excavated' by fire. He found that there was an average of 0.33 "butt hollows" in each tree 80 - 99.9 cm dbhob, 0.14 in trees 100 - 119.9 cm dbhob, 0.33 in trees 120 - 139.9 cm dbhob, 0.0 in trees 140 - 159.9 cm dbhob, and 1.17 in trees > 160 cm dbhob.

Mackowski (1987) notes "Interconnected hollows act as chimneys and, if connected through to the basal fire box, the result of even a moderately intense fire means either the burning down of the tree, the death of the standing tree, or, if it survives, the virtual sterilisation of the wildlife hollow complex of the tree mainstem and branches."

Mackowski (1987) notes that the frequent Occurrence of fire in 40 m site height blackbutt forest precludes a 100% chance of survival for habitat trees, as a proportion will be damaged, or weakened, or burnt down by each fire.

Bennett (1990) states "Fires, both natural and of human origin, can also create patches of differing successional stages within extensive natural areas, and so isolate faunal populations that may depend upon a particular seral stage."

3.2.1 BIRDS

Cowley (1971) notes "The birds most affected by fire are those which feed and nest close to the ground... Many other species which spend much of their time feeding at or near ground level but which nest in the higher levels of the forest would be affected to a lesser extent."

Cowley (1971) notes that the frequency with which fire burns an area can have a marked effect on the habitat by changing the plant species composition of the understorey and that this will in turn effect the bird species composition.

Rohan-Jones (1981) notes "the effects on birds of logging will be compounded by slash burning and the broad area hazard reduction

programme. These together will serve to maintain more of the forest in a relatively simplified structural condition and overall there will be more 'effectively dry' habitat conditions. As well as resulting in a much more open understorey condition with few hollow and over mature trees, soil moisture will also be significantly reduced. The resultant loss of invertebrate faunal prey and decreased humidity will make unsuitable conditions for a number of bird species that would otherwise be present."

Recher, Allen and Gowing (1985) found that "There was a significant effect of fire and logging on the number of birds. Burnt and logged plots had lower numbers and fewer species of birds than unburnt or unlogged plots. The combined effect of logging and fire was greater than either treatment alone."

Recher, Allen and Gowing (1985) note that "The species of bird affected by any given burn varies according to the intensity of the fire and amount and layers of vegetation burnt. It is probable that changes in the abundance of birds after a fire occur in response to changes in the structure of the vegetation. In most instances the impact will be greatest on birds which forage or nest in ground and shrub vegetation while those favouring more open vegetation may benefit. ...recolonization and an increase in the abundance of birds probably proceeds in parallel with the rate of post-fire revegetation."

3.2.2 MAMMALS

Shields and Kavanagh (1985 p.21) note that fire regimes "have been shown to have a greater effect on small mammal populations than logging, and current policy in some regions prescribe fuel reduction burning at very short intervals."

Fox and McKay (1981) found a replacement sequence in time for species of small ground mammals to reach their maximum abundance following a fire: New Holland Mouse and/or House Mouse -> Common Dunnart -> Brown Antechinus -> Bush Rat. They interpreted this as species occupying stages in the succession when their optimal habitat requirements were fulfilled, with New Holland Mouse and House Mouse populations peaking around one year post fire, Common Dunnart peaking at 4yr, Brown Antechinus reappearing after 2yr and peaking at 5yr and Bush Rat establishing populations after 3yr and plateauing at 8yr.

Wilson *et al.* (1990) studied small mammal succession following a wildfire, the impact of which few animals apparently survived. They found that "Populations of native small mammals at our burnt sites remained at extremely low levels for three years after the fire. They survived and recovered at a greater rate at partially burnt sites." They found that House Mouse populations peaked in the second to third years post fire on both the burnt and partially burnt sites. New Holland Mouse disappeared from one site after the fire and its population peaked 3 years after the fire at another site. Brown Antechinus populations peaked in burnt sites five years after the fire and continued to recolonise new sites up to the sixth year. Bush Rat achieved maximum abundance and colonization of sites in the fifth year. Swamp Rat was absent from a site it previously occupied for 3.5 years and was still increasing both in abundance and number of sites occupied in the sixth year. Southern Brown Bandicoot was present in low numbers until years 4 to 6 and was slow to colonise new sites.

Wilson *et al.* (1990) consider that Swamp Antechinus, Dusky Antechinus and Long-nosed Potoroo "may now have disappeared from the study area as they have not been captured for two to three years." They note that these species and New Holland Mouse "are vulnerable to the combined effects of disturbance factors due to their low population numbers and restricted distributions."

Fox and McKay (1981) cite reported greatly increased numbers of Yellow-footed Antechinus in forest unburnt for 40 years as opposed to stands unburnt for 30 years.

Dunning and Smith (1986) state that declines in numbers of Mountain Brushtail Possum and Fawn-footed Melomys "in the control plot accidently subject to burning suggests that the post logging burn commonly used in regenerating moist hardwood may be as disadvantageous as canopy removal to species that utilise the ground stratum."

Lunney, Cullis and Eby (1987) found that populations of Bush Rat, Brown Antechinus and Dusky Antechinus were drastically reduced following wildfire, with no Dusky Antechinus trapped for the three years sampled after the fire.

Moon (1990) states "For koalas, the effect of fires is to suppress eucalypt regeneration resulting in a simplified forest age structure, and to promote a dense ground stratum which inhibits koala movements." He recommends the formulation of alternative strategies to regular hazard reduction burning, to permit regeneration of koala food trees.

Wilson *et al.* (1990) state "Fuel reduction burning practices should be well planned and take into account ecological factors such as the frequency, area burnt, timing and intensity. It is recommended that 1) burning should not be at frequencies of less than four years, 2) patch burning be undertaken to produce a mosaic of successional ages within vegetation types, 3) burning not be carried out in spring when small mammals are breeding." For New Holland Mouse habitat they consider "It is essential that burning within these communities is not carried out on a large scale. It is recommended that burning be done in small patches (1-3 ha) within the preferred communities to maintain a variety of successional ages from 2-8 years."

3.2.3 REPTILES

Dunning and Smith (1986) found that post logging burning, "unlike logging, destroys litter and logs and increases the area of bare soil and rock. Since all three species of common reptiles were found to require logs and two were found to require litter, post

logging burning probably has a more detrimental long term effect than logging on reptile numbers." and "Normal logging had an immediate effect on population numbers resulting in a shift from dominance by [Murray's Skink and Challenger's Skink] to dominance by [Delicate Skink]." They conclude "results suggest that elimination of slash burning after logging may be sufficient to sustain the fallen log microhabitat requirements of [Murray's Skink and Challenger's Skink] in logged forests."

3.3 ROADING AND DISTURBANCE CORRIDORS

Bennett (1990) notes that streams and naturally burnt areas can act as natural barriers but is most concerned that disturbance corridors of human origin (highways, canals, pipelines, railway lines, transmission clearings) are imposing an ever-growing network of partial or complete barriers to animal movement throughout the landscape.

Andrews (1990) undertook a literature review which revealed a variety of harmful effects of roads; (i) habitat loss and modification with accompanying effect on populations, (ii) intrusion of the edge effect into the core of natural areas, (iii) subdivision and isolation of populations by acting as a barrier, (iv) a source of disturbance to wildlife, (v) increased roadkills, and (vi) increased human access with undesirable impacts on disturbed areas.

Richards and Tidemann (1988) in relation to tropical rainforests state "The process of selective logging requires the construction of access roads for large trucks and machinery, smaller tracks for bulldozers to extract logs, and large open areas for loading logs onto semi-trailers. When a tree is felled it leaves a large gap in the normally closed canopy. All this activity results in a network of connected clearings. Other disturbance or modification practices such as rainforest real estate developments produce the same result. These disturbed areas are unsuitable for most of the rainforest (specialist) bats to forage in, but are ideal for the open forest (opportunist) bats that invade within just a few weeks of their creation. There are, however, a few rainforest species (generalists) that seem to be unaffected."

Andrews (1990) cites a variety of overseas studies which have identified numbers of species which avoid roads, with specific species keeping particular distances away, some as far as 1.8-2.1 km away. In some instances breeding areas have been rendered unsuitable for a variety species by the construction of nearby roads. In others fragmentation by roads has significantly reduced suitable breeding areas.

Andrews (1990) notes that some species can be disturbed by roads so that they have less feeding and lying time, and expend more energy in flight. She also cites a study that established hearing loss in some species for weeks after less than 10 minutes exposure to a tape of a dune buggy, this caused inability to respond to recordings of predator sounds.

Andrews (1990) cites a variety of overseas studies that have found that roads (as narrow as 3 metres), powerline corridors, fences and even 10-15 metre wide mown grass strips, can act as total or partial barriers to the dispersal of a variety of vertebrates and invertebrates. She states "A barrier to dispersal of species can disrupt social organization. It can lead to local extinctions if an area is affected by fire or drought, can reduce the immigration of species to areas which may need replenishment, and also limit gene-flow, with subsequent 'bottle-neck' effects."

Barnett, How and Humphreys (1978) found "Road crossing by small mammals was inversely related to road width; roads severely restricted or stopped the movement of small mammals even when the road consisted of a long-unused and partly overgrown track."

Barnett, How and Humphreys (1978) cite overseas research that found that roads have impeded bird dispersal and small mammal dispersal, the most striking example being a population of *Rattus rattus diardi* (in Singapore) infested with the vector mites for scrub typhus which was contained within an area of 40ha. surrounded by roads; the adjacent populations across roads in all directions never carried the vector.

Andrews (1990) notes the most obvious effect of roads is the mortality caused by collisions with vehicles. She cites animals crossing roads, insects being attracted to shiny surfaces, birds alighting to feed on insects or collect grit, scavengers attracted to other road kills and animals attracted by grassy road verges as being contributing factors. She cites one estimation that one bird is lost every 13 km. and one mammal every 30km. In Australia in 1976 there were 866 000 km of roads.

Moon (1990) found vehicles to be the most significant cause of koala mortality (aside from habitat loss), in a single year at least six koalas were killed by vehicles in the Iluka area, leaving a population of some 20-25 animals.

Bennett (1990) notes that road systems "are a source of chemical and physical pollutants and they may introduce invasive plants and animals into environments that the road corridor passes through."

Bennett (1990) states "Lightly trafficked roads are commonly used by predatory mammals as a clear pathway for movement and hunting, unimpeded by vegetation and other obstructions... In south-western Tasmania, the marsupial predators Tiger Quoll, Eastern Quoll and Tasmanian Devil were recorded only along forest tracks despite a greater survey effort away from tracks... The introduced predators, Fox and Cat, also use roads extensively as movement pathways through forests. The proliferation of roads and tracks in forests facilitate their spread."

Andrews (1990) notes "Plants and feral animals are easily introduced into the core of an area along a road, partly because the edge effect favours species with generalized requirements.

Roads provide easy travelling conditions for animals, and are used by hunters such as foxes."

Gilmore (1990) notes "Many Australian predators exhibit a distinct bias to using tracks and roads through densely forested vegetation, suggesting that these areas may be subject to increased mortality of prey species."

Anon (1988) note that "Foxes tend to utilize established tracks and paths whenever possible while moving through bush areas".

Dunning and Smith (1986) state that Delicate Skink, "which is a widespread less habitat specific species, could survive along roadsides from where it could invade newly logged areas."

Andrews (1990) notes "Pollutants are emitted by vehicles, including oil residues and heavy metals such as lead, zinc, copper, nickel and chromium... Alongside heavily used roads the pollutants have potential biological significance if plants in which they concentrate form a large part of the diet of fauna, or if fauna living there breathe airborne pollutants. Pesticides and herbicides may be sprayed along roadsides and other utility corridors".

Andrews (1990) considers roads allow easy access to humans, which has been noted to lead to deliberate lighting of illegal fires and illegal hunting.

Andrews (1990) notes that "No Australian study documents the horrific injuries and mass mortalities documented in the USA" from powerlines, and cites American analyses which reveal that poor visibility, bad weather, mass migrations, dispersal by juveniles and the fragmentation by powerlines of the area flown between resting and feeding create the situations in which the greatest numbers of deaths occur.

Andrews (1990) notes that increases in traffic flow and/or speed lead to increases in road deaths of fauna. She notes that the speed of vehicles is not decreased by animal warning signs.

3.4 GRAZING

Bennett (1990) states "Grazing by domestic stock in remnant vegetation has marked effects on the composition and structure of wildlife habitats through selective browsing of plants, an overall decline in understorey biomass, trampling and soil compaction, and altered soil nutrient levels."

Andrews (1990) cites the detrimental effects of fences on wildlife including entanglement, the cutting off of important natural factors such as water supplies, prevention of movement into suitable habitat areas, disruption of seasonal movement, over-population through limitations on dispersal and increased human access through use of fence maintenance roads.

Yellow-bellied Gliders, Greater Gliders (pers. obs.) and Queensland Blossum-Bat (D. Milledge pers. comm.) have been noted to become inextricably entangled on barbed-wire fences.

3.5 CHEMICAL USAGE

3.5.1 PESTICIDES

Cowley (1971) considers "every species of land bird in Australia is a potential victim of chemical pesticides. Most of these species are at least partly insectivorous and could therefore be seriously affected by insecticides, birds which eat fruit or seed can fall victim to poisoned baits intended for mammal pests, and owls and hawks can receive toxic amounts of pesticides indirectly by preying on animals which have come into direct contact with pesticides."

Cowley (1971) cites an American example of the progressive concentration of chemical pesticides in a food chain which resulted in an overall 80,000 fold increase in concentration and widespread mortality of predaceous fish and birds; (i) apparently safe application of T.D.E. (trichloro-dichlorophenzlethane) applied to lake, (ii) 0.02ppm T.D.E. recorded in water, (iii) 5.3ppm in plankton, (iv) 10.0ppm in small fish, (v) 1700ppm in the predaceous fish, and (vi) 1600ppm in the predaceous birds.

Cowley (1971) considers that T.D.E. and other organo-chlorines act on the central-nervous system and sub-lethal amounts may affect an animal's behaviour in such a way that it becomes more susceptible to predation. He notes that in Australia there is circumstantial evidence that the application of pesticides is causing the unintentional death of many birds and lowering the reproductive capacity of other birds receiving sub-lethal doses. He also notes that significant quantities of dieldren and DDT have been found in birds eggs and the bodies of honeyeaters, kestrels, falcons and kookaburras.

Richards and Tidemann (1988) consider that the accumulation of insecticide toxins via the food chain is adversely impacting bats, stating "As insect pests become more and more tolerant to agricultural chemicals, and higher strengths are required for their demise, bats and other animals that eat sprayed insects are at an ever increasing risk. The annual cycle of most insectivorous bats ...is to store fat when prey is abundant which they can draw upon later. In areas where ground crops are grown and sprayed from the air, insect-eating bats that forage on crop pests gradually accumulate these poisons (microgram by microgram) into their fat reserves. At this stage the input dose of the chemicals isn't toxic, but is much higher when accumulated in their fat reserves and metabolised during winter hibernation."

3.5.2 1080 (SODIUM MONOFLUOROACETATE)

Allen *et al.* (1989) undertook trial baitings in southern Queensland (in areas where foxes were either absent or in very low numbers) with unpoisoned fresh meat baits and factory baits. Of the 412 (61% of total) fresh meat baits eaten 24% were eaten by 'dogs', 31% by birds, 2% by cats, 11% by reptiles, and the balance by ants, a fox and unknown (29%) species. Of the 123 (18% of total) factory baits eaten 44% were eaten by 'dogs', 17% by birds, 6% by reptiles, 4% by cattle, and the balance by a possum, a fox and unknown (28%) species. They note "Numerically, the two significant non-target consumers of both bait types were birds (28% of all baits consumed), dominated by crows (*Corvus* spp.), and reptiles (10% of all baits consumed), which, with only a few exceptions, were goannas (*Varanus* spp.). In the trials conducted in November and February reptiles removed more baits than did birds, but in the cooler March and May trials reptiles were poorly represented."

McIlroy *et al.* (1986) undertook two successive trail-baiting campaigns with fresh meat baits injected with 1080 in Kosiosko National Park. They found "During the first poisoning campaign foxes removed the greatest proportion of baits, followed by birds, dogs and pigs... The birds seen interfering with baits were pied currawongs *Strepera graculina*, Australian ravens *Corvus coronoides*, Australian magpies *Gymnorhina tibicen*, and wedge-tailed eagles *Aquila audax*." and, "During the second poisoning campaign birds removed most of the baits, followed by dogs, foxes, pigs and cats." During the first campaign 92% of baits were removed within 4 days and 99% within 21 days, though only 7% were removed by dogs. During the second campaign 99% of baits had disappeared after 18 days with only 10% being taken by dogs.

Allen *et al.* (1989) note "Generally, birds and reptiles are many times more tolerant of 1080 on a per kilogram body weight basis than are canines. Birds range from 1.3-18.51 mg 1080 kg^{-1} body weight... ; goannas, 43.6-119 mg 1080 kg^{-1} body weight... ; and dingoes/wild dogs, 0.1 mg 1080 kg^{-1} body weight, and cats, 0.2 mg 1080 kg^{-1} body weight".

McIlroy (1982) assessed the risk mammalian carnivores face from 1080 poisoning and found "Amongst the species studied, the Dingo faces the greatest risk followed in descending order by the smaller dasyurids, the feral Cat and the larger dasyurids and Long-nosed Bandicoot." In a field trial in southern NSW he compared areas baited with poisoned and unpoisoned baits and found "During the two months before the baiting there were no significant differences between the numbers of Brown Antechinus trapped in each area... Area A, the area to be poisoned, though, did contain 24-31% *more* antechinus than Area B. Two weeks later, however, after the poisoning, Area A contained 73% *less* antechinus than Area B, a significant difference." He considered that, in theory, Brown Antechinus and Dusky Antechinus could "eat sufficient bait containing 0.015 mg/g of commercial 1080 (a relatively low concentration advocated for some campaigns) during a poisoning campaign for them to face a 73-100% chance of being killed".

Calver *et al.* (1989) undertook labratory experiments on 20 native Western Australian mammals to determine the potential hazard of

1080 baiting by comparing their consumption of non-toxic baits with the appropriate lethal dose for each species. Twelve species were assessed to be potentially at risk from crackle (factory) baits and six species from fresh meat baits. The Northern Quoll "often ate all the food offered to them ... endangering their health through overeating.", had "high projected doses with meat baits... reflected the large amounts of meat baits eaten", and was "the species found to be at greatest potential risk". The two species tested which occur in NSW escarpment country, Common Planigale and Pale Field Rat, were both considered to be susceptible to crackle baits and the former to meat baits.

McIlroy (1982) notes that for mammals "Symptoms did not normally appear in poisoned individuals until 0.1-23 hours after ingestion of 1080. Typical symptoms, in approximate order of appearance, included depression or increasing sensitivity to stimuli, restlessness, rapid respiration, bouts of trembling, vomiting and convulsions. Most deaths occurred between 1.5-147 hours after ingestion of the poison while all survivors showed signs of recovery after 2-60 hours."

Calver *et al.* (1989) concluded that "more individuals of many species ate crackle bait compared with meat bait... The crackle baits also hold a much higher concentration of 1080 per gram of bait. Crackle baits are therefore potentially far more hazardous to non-target fauna than are meat baits, especially during periods of food shortage." They also recommended sun drying of meat baits prior to distribution to reduce their palatability to non-target species. Allen *et al.* (1989) found "Fresh meat baits laid on the surface were significantly more palatable to a broad range of non-target wildlife species than were factory baits. An important finding in this study was that factory baits, while less palatable to dogs, were significantly more target-specific than fresh meat laid on the surface."

Allen *et al.* (1989) undertook an assessment of the effectiveness of surface verses buried (2-5 cm) meat baits. Of the 114 (57% of total) surface-laid baits eaten 32% were eaten by 'dogs', 48% by birds, 5% by reptiles, 2% by cats, and the balance by ants and unknown (6%) species. Of the 38 (19% of total) buried baits eaten 89% were eaten by 'dogs' and the balance by ants, a bird and a cat. They concluded "Analysis of the data... shows no significant difference in palatability or attractiveness of meat to wild dogs between the two presentation techniques; 18.5% of surface-laid meat baits were removed by dogs compared with 17% of buried meat baits. However there was a significant difference in the non-target bait take between the two techniques."

McIlroy *et al.* (1986) undertook an assessment of the relative attractiveness of green dyed verses undyed fresh meat baits and found "During the first two campaigns birds pecked at 28 undyed baits compared with 4 dyed baits, and dragged 55 undyed baits, compared with 10 dyed baits, away from raked sites, giving the impression that they found undyed baits more attractive. However, although in the trial with unpoisoned baits they initially took more undyed than green-dyed baits..., analysis by means of 2 by 2 contingency tables revealed there was no significant difference between the numbers of either type removed by them or other animals".

McIlroy *et al.* (1986) concluded "Trapping, compared with poisoning, proved to be a more effective method of control during the present study. Fifteen (56%) of the 27 individual dogs known to be in the area during the study were trapped either initially for attachment of transmitters or later during efforts to recover the transmitters. In comparison, only three (11%) were known to have been poisoned and, in the unlikely event that all the individual dogs not seen after the baiting were killed, only 44% were poisoned. However, trapping requires a considerable amount of effort (e.g. 60 trap-nights per dog) and some expertise, and it can be an inhumane practice, especially if traps are not visited each day."

Jarman (1986) cites a number of examples where "Active suppression of dingoes in sheep-raising regions may have helped establishment of foxes." He notes "Although no Australian foxes live entirely within closed-canopy forest, if dingoes are absent foxes can penetrate dry forest..., wet eucalypt forest..., and even isolated patches of rainforest..."

Eason and Frampton (1991) found that at doses of 0.4 and 0.6 mg of 1080 per bait only one of six cats died, at a dose of 0.8 mg seven of 13 died, at 1.2 mg 6 of 8 died and at 1.4 and 1.6 mg all 10 cats died. They recommended a dose of 2 mg of 1080 per bait to kill all cats eating it within 24 hours.

Anon (1988) note when using 1080 Fox baits that the baits should be buried 10 cm deep along identified fox trails with the uneaten bait and dead foxes picked up and burnt or buried (at least 50 cm deep) after four nights.

Cowley (1971) states "Losses of birds and mammals have been recorded following the use of '1080' for rabbit control. In one incident over 75 brush-tail possums were killed and examination revealed large amounts of bait material in their stomachs. Possums form part of the diet of the powerful owl."

3.5.3 FERTILIZERS

Gilmore (1990) notes "Changes to water quality, associated with leaching of fertilizer from some soils has the potential to influence aquatic-dependent fauna downstream of a plantation. This has obvious implications for species such as the 'acid frogs' which are restricted to breeding in low pH waters, in the sandy coastal lowlands of subtropical Australia".

3.6 MINING

Wilson *et al.* (1990) found that the House Mouse was the only small mammal resident on revegetated mine areas up to five years after the revegetation. They note the adjacent unmined area supported populations of White-footed Dunnart, Swamp Rat and New Holland Mouse, stating "The study indicates that the vegetation on the regenerating mined areas had not developed to a suitable successional stage for permanent occupation by these native small mammals." They concluded that "The major factors contributing to this were sub-optimal rehabilitation procedures and the absence of suitable corridors for animal movements."

Wilson *et al.* (1990) for post-mining rehabilitation recommend techniques including "burning before clearing, reducing soil stockpiling and seed burial to optimize seed germination rates, using organic mulch and indigenous species. Mapping and maintenance of corridors for small mammals around the mine area should also be carried out."

Richards and Tidemann (1988) note that some old derelict mine tunnels have become vitally important sites for bats to raise young. They note that many of these old sites are now being reworked by open cut methods, particularly for gold, "consequently, several important bat colonies inhabiting abandoned mine tunnels are now under threat, and presumably others will follow."

3.7 FERAL ANIMALS

Main (1988) notes "Competitors and predators such as rabbits, foxes, cats, pigs, goats, cattle, donkeys, horses, camels and many invertebrates, of which the Portuguese millipede (*Ommatoiulus moreletti*) is notable, are among the many introductions made since European settlement. All have had an impact on the floral composition and structure of ecosystems. In the context of the theory of diversity advanced earlier, they all have acted as persisting perturbations beyond that to which ecosystems can respond with resilience. The predicted climatic changes are likely to favour all the introductions as an increase in rainfall is likely to lead to higher survival rates as drought-induced mortality is reduced."

3.7.1 Foxes

Jarman (1986) notes that "Foxes in Australia respond flexibly to availability of foods: large carcases are scavenged when they occur; the most abundant or easily caught mammals up to 3 kg in weight are most commonly hunted; and easily harvested invertebrates, fruits, and nest-contents of birds and reptiles are eaten seasonally. Yet some species are preferred, or are particularly vulnerable to hunting."

Jarman (1986) considers "where rabbits support numerous foxes, more vulnerable species such as rat-kangaroos or bandicoots may be subjected to insupportable predation. In north-eastern New South Wales rufous rat-kangaroos *Aepyprymnus rufescens* persist only where foxes and rabbits are scarce..." He cites similar situations with Woylies *Bettongia penicillata* and rabbits in

Western Australia, and Broad-toothed Rats *Mastacomys fuscus* and the common Bush Rat in alpine areas.

Jarman (1986) cites a number of examples where "Active suppression of dingoes in sheep-raising regions may have helped establishment of foxes." He notes "Although no Australian foxes live entirely within closed-canopy forest, if dingoes are absent foxes can penetrate dry forest..., wet eucalypt forest..., and even isolated patches of rainforest..."

Bennett (1990) notes "Foxes, efficient introduced predators in Australia, have been associated with the declining status of medium-sized marsupials (e.g. Brush-tailed Bettong, Parma Wallaby, rock wallabies)."

Kinnear (1987) studied the population dynamics of five remnant Black-footed Rock-wallaby populations in the central wheatbelt region of Western Australia. From 1979-82 the populations remained relatively stable or declined. Beginning in 1982 a Fox control programme using 1080 baiting was implemented on two sites and maintained for 4 years. He found that during a 31 month period 183 foxes were knowingly destroyed, which showed that poisoned foxes were rapidly being replaced by immigrant foxes. Despite this he concluded that the control programme was effective as on the two baited sites Black-footed Rock-wallaby populations increased by 138% and 223% while the unbaited sites recorded an increase of 29% and decreases of 14% and 86%.

Anon (1988) note that "Foxes tend to utilize established tracks and paths whenever possible while moving through bush areas".

Jarman (1986) notes "Foxes could also penetrate forests where they do not occur now if dingoes were eliminated, intensive logging, clear-felling or plantations introduced, or stock-grazing in the forests increased." and "Remnant communities of wildlife will become more vulnerable to foxes as suitable habitat becomes fragmented."

3.7.2 Cats

Eason and Frampton (1991) note that feral cats have altered ecosystems and depleted populations of indigenous lizards and birds on the mainland of both Australia and New Zealand and on numerous island habitats throughout the world.

Potter (1991) edited the proceedings of the Australian National Parks and Wildlife Service's workshop on the impact of cats on native wildlife which concluded:

> ".The unanimous conclusion of workshop participants is that cats represent a significant threat to wildlife in Australia.
>
> .Cats occupy most ecological habitats across mainland Australia and many offshore islands.

.Cats are known to kill and eat more than 100 native Australian species of birds, 50 reptiles, three frogs and numerous invertebrate animals. The list is growing rapidly as more knowledge comes to light through research.

.Cats kill prey up to their own body size; most of Australia's endangered and vulnerable mammals, birds and reptiles are in this size category.

.Cats prey significantly on endangered and vulnerable mammals including the Greater Bilby, Numbat, Rufous Hare Wallaby and Eastern Barred Bandicoot.

The impact of cats is threatening the success of recovery programs for these species. Cats killed all of the Rufous Hare-wallabies released in a recent recovery program. They are a major cause of death in the only remaining population of the Eastern Barred Bandicoot on the Australian mainland.

.There is evidence of cats causing the decline and extinction of native animals on islands.

.One in three Australian households keep domestic cats. These bring home five to ten birds on average each per year, with millions of birds being killed annually in large cities like Melbourne. This predation accounts for most of the young birds bred in suburban areas each year. Thousands of native mammals, such as Ring-tailed Possums, are also killed in suburban areas by domestic cats each year.

.Domestic cats provide a high density reservoir of breeding animals for feral populations.

.Cats are responsible for the carriage and transmission of infective diseased such as toxoplasmosis and sarcosporidiosis which can debilitate and kill native animals as well as affect livestock and humans.

.There has been little study of the broader biological impact of cats (eg competition with marsupial carnivores, interactions with other introduced species, impact of diseases) on the Australian environment.

Reduction of population size of otherwise common species by cats may have important ecosystem effects (eg reduction in numbers of honeyeaters reduces pollination rates and subsequent seed set of plants)."

3.7.3 Others

Anon (1988) consider the effects of competition of Brush-tailed Rock-wallabies "with Goats and European Rabbits for food are unknown but are likely to be detrimental and may be exacerbated in years where food is scarce. Unlike competition for food, where the effects are often subtle and difficult to detect, competition

for shelter has been directly observed... and may be an important factor in limiting the size and extent of Brush-tailed Rock-wallaby populations."

Recher, Rohan-Jones and Smith (1980) note that the introduced House Mouse and Black Rat "are known to respond to disturbance... and the intensive disturbance of large areas of forest through clearfelling could result in the development of permanent large populations of either species in the Eden District. The intrusion of these animals from logged forest could then have an adverse effect on native small mammals which survive in unlogged reserves."

Saunders (1990) notes that in his eight years observing the nests of Carnaby's Cockatoo nest hollows were taken over by swarming honey bees on three occasions while there were eggs or nestlings in them.

Moon (1990) notes that feral pigs "cause widespread ground disturbance, which may inhibit regeneration of vegetation, and they may inhibit koala movements."

3.8 Disease

Wilson *et al*. (1990) found that the presence of *Phytophthora cinnamomi* was "a major factor affecting small mammal abundance." They consider consequences of infection such as the reduction of plant species diversity, elimination of specific species, reduction in cover and a decrease in plant productivity would be expected to ultimately affect small mammals. They cite a study that found that the soil and litter fauna in infected areas is markedly reduced.

4.0 TARGET SPECIES

NOTE: * - denotes a species listed as threatened or rare and endangered on Schedule 12 of NPW Act as of March 1992.
H - denotes a species which utilises tree hollows.
L - denotes a species which utilises large logs.
P - denotes a species particularly vulnerable to predation by foxes and/or cats.
F - denotes a species particularly vulnerable to fire.
G - denotes a species particularly vulnerable to impacts of global warming.
R - denotes a species which utilizes rainforest, including where it is overtopped by eucalypts or Brush Box.

4.1 MAMMALS

*Spotted-tailed (Tiger) Quoll *Dasyurus maculatus* H
Mansergh (1984) notes that the Tiger Quoll is considered to have a patchy distribution and be common to uncommon in Tasmania, very rare or extinct in South Australia, to occupy about half its pre-European range and considered rare in Victoria, to have a limited disjunct range and be uncommon in Queensland and to be generally

uncommon (but more common in the north) in New South Wales. He cites the obtaining of only one locality record in a five year study of the Eden woodchipping region, where it was previously described as possibly endangered.

Mansergh (1984) notes infestations by the parasitic larvae of the native flea *Uropsylla tasmanica* may have a debilitative affect on Tiger Quolls and that feral cats and foxes may compete with them for food resources, but considers a combination of habitat destruction and the widespread trapping and poisoning in and around forest areas were probably responsible for the extinction of Tiger Quolls in many areas. He notes there is considerable concern over the impact of clearfelling practices, and while there has been no study of these impacts he cites concerns about adverse effects on potential food sources and reduced availability of breeding hollows.

***Eastern Quoll** *Dasyurus viverrinus*
While generally considered extinct in NSW there have been visual sightings in recent years by reputable wildlife researchers on the Petroi Plateau and Carrai Plateau in the head of the Macleay valley.

***Brush-tailed Phascogale** *Phascogale tapoatafa* H

Yellow-footed Antechinus *Antechinus flavipes* F
Fox and McKay (1981) cite reported greatly increased numbers of Yellow-footed Antechinus in forest unburnt for 40 years as opposed to stands unburnt for 30 years.

Dusky Antechinus *Antechinus swainsonii* F
Lunney, Cullis and Eby (1987) found that this species showed a negative relationship to canopy cover, significant preference for regenerating forest, dependence on a high percentage of ground cover and was absent from three successive post-fire censuses.

Common Planigale *Planigale maculata*

Narrow-nosed Planigale *Planigale tenuirostris*

***White-footed Dunnart** *Sminthopsis leucopus*

***Southern Brown Bandicoot** *Isoodon obesulus* F P
Wilson *et al.* (1990) found that following a wildfire Southern Brown Bandicoot was present in low numbers until years 4-6 and was slow to colonise new sites.

***Koala** *Phascolarctos cinereus* P
Kavanagh (1987a) notes that "no studies have been reported on the effects of logging, prescribed burning or other forest management practices on Koalas. Being an arboreal species and one dependent on eucalypt leaves for food, it could be predicted that below a certain threshold the intensity of logging would seriously affect Koala populations. This threshold level is unknown."

Kavanagh (1989a) reiterates these concerns following a Koala Summit (7-8 November 1988) by stating, "the lack of information which is of any use to forest managers on Koala habitats and their ecology in forests was one aspect highlighted by this summit. <u>The Commission should redress this situation by initiating a research programme</u> to address the questions: 1) What is good Koala habitat? 2) What are the movements and home ranges of Koalas in forest?" He considered that such research would help decide further questions: Are Koalas conserved by gully corridor reservation?; Do they require mature forest on ridges? and, To what extent do Koalas use regenerating forest?

Watts (1989) also advocates ongoing surveys and a specific research project on the Koala. He emphasises that in the short-term, in each area where Koalas are known to occur the preferred forest types/species should be noted and provision made for retention of undisturbed areas.

Moon (1990) notes that "the north coast has been identified as the remaining stronghold of koalas in NSW, these populations are known to be declining." In his study area he estimated that the koala population had been reduced to 20-25 animals and were still declining - "due mainly to an increased mortality caused by (in order of impact) habitat loss, road deaths, stress-related disease, dogs and fire." He considers "In the absence of action to redress the problems this population will cease to function as a breeding unit within a decade."

Fanning (1990) recommended adoption of an interim protocol to be applied when a Koala is found: immediate cessation of logging; record all relevant details and search area for other animals, and; initiate a research programme.

Greater Glider *Petaurus volans* H
Mackowski (1987) cites findings that the Greater Glider favours the use of two primary dens in each territory and use other hollows less frequently, and that their home ranges are 1.5 to 2.5 ha. Kavanagh (1985b) found the home range of Greater Gliders varied between about 0.75 and 2.0 ha (typically about 1.0 to 1.25 ha). Recher, Rohan-Jones and Smith (1980) found that Greater Gliders were recorded most often in large trees (91% of sightings being in trees over 60 cm dbh) and sightings were clumped with the greatest numbers associated with the large *E. obliqua*, high tree species diversity, and better quality soils.

Lindenmayer *et al.*(1991) found that in their study area Greater Gliders predominantly utilized branch hollows at a height of 40 m +/- 3 m.

Dunning and Smith (1986) found that the abundance of Greater Gliders "was positively associated with the number of trees >96 cm d.b.h., which is consistent with its apparent height preference of 30-36 m". They state that the Greater Gliders observed following normal logging "were on the borders with the 66% retention and the control II zones and it is assumed that their territories may have overlapped this area prior to logging. No animals were observed away from boundaries."

Kavanagh (1985a) found that all Greater Gliders were observed in unlogged patches of forest and nearly always in unlogged creek reserves in his study area.

Milledge, Palmer and Nelson (1991) found that the Greater Glider was more abundant in old-growth forest, which they considered "probably reflects the higher densities and more even distribution of the large, tall trees and stags it prefers for nest and den sites".

***Yellow-bellied Glider *Petaurus australis* H**

Mackowski (1984) found one of his study areas (logged 1920) had 57 Yellow-bellied Glider den trees/km^2 in Blackbutt forest (which averaged out to 12/km^2 when adjacent forest types were included). Kavanagh (1985b) considered that the Yellow-bellied Glider has an elongated range amounting to about 60 ha.

Loyn (1985) notes that Yellow-bellied Gliders regularly feed in the mid-slope region and move between ridges and gullies in a single night.

Recher, Rohan-Jones and Smith (1980) found the colony of Yellow-bellied Gliders they studied varied between 5 and 11 animals in an area of about 60 hectares. They note that Yellow-bellied Gliders mostly forage in tall mature canopy trees, den hollows are located in large live trees and up to three animals shared the one hollow.

Goldingay and Kavanagh (1990) in their study of Yellow-bellied Gliders in southern NSW found that they: had a social group structure consisting of an adult male, an adult female and subadult offspring; home ranges of glider groups were exclusive; mean group size was 2.6 +/- 0.3, though up to 6 were recorded; births occurred June-December; females apparently breed, and produce one offspring, in successive years with breeding failures in some years; subadults disperse from their natal home-range when 18-24 months old; females probably don't breed till they are two years old, and; individuals were still present when 6 years old.

Mackowski (1987) notes "Arboreal marsupials the size of yellow-bellied glider and larger appear to require hollows > 100 cm^2 entrance size, these hollows only occur in blackbutt > 100 cm dbhob and are most abundant in blackbutt > 140 cm dbhob".

Kavanagh (1987b) found "The foraging behaviour of the [Yellow-bellied] gliders also followed an annual pattern. Searching under loose bark for arthropods and honeydew, and licking the phloem sap from incisions made in the bark of eucalypts, were observed in all seasons of the year. Other foraging behaviours such as licking flowers to obtain nectar, licking foliage and small branches to obtain honeydew, chewing manna from small branchlets, and shredding fibrous bark to obtain beetle larvae, were confined to particular seasons." 50.7% of observations were of Yellow-bellied Gliders searching under loose bark for arthropods and honeydew, 24.5% of incising bark and licking sap, 12.1% of licking flowers for nectar and pollen, 12.1% biting and licking branches and foliage for manna and honeydew and 0.5% shredding fibrous bark for beetle larvae.

Kavanagh (1987b) found that Yellow-bellied Gliders primarily selected trees of certain species and secondarily trees of larger size for foraging, with 92% of trees used over 60 cm dbh and 58% over 80 cm dbh. He notes "The gliders in my study area selected the trees with the greatest number of flowers in which to forage for nectar; these would have been the older trees, because mature trees (c.200 years old) produce 2.2-15.5 times as many flowers as pole stage trees (c.25 years old)".

Mackowski (1988) located 248 trees of 22 species tapped for sap by Yellow-bellied Gliders in northern NSW. Northern Grey Gum (*Eucalyptus punctata didyma*) was most commonly utilised (110 records), followed by Scribbly Gum (*E. signata*)(24), Small-fruited Grey Gum (*E. propinqua*)(20), Spotted Gum (*E. maculata*) (19), Large-leaved Spotted Gum (*E. henryi*)(14) and Forest Red Gum (*E. tereticornis*)(12). The average dbhob was 65.6 cm and "Apart from a minimum dbhob of about 30 cm there was no consistent selection of a particular diameter class of tree for sap-tapping by *P. australis*." He also found that they prefer vigorous trees for sap-tapping.

Mackowski (1986) sent out questionnaires to all Forestry Commission and National Parks and Wildlife Service offices in north east N.S.W. to obtain records of trees tapped for sap by Yellow-bellied Gliders. Only 7 of the reported 131 sites were from south of the Bellinger River Valley, though he considered this to be an artefact of survey methodology it was also "interpreted as reflecting a greater than normal abundance of *P. australis* in the Clarence and Richmond River catchments."

Binns (1981) notes that the Yellow-bellied Glider is though to be very sensitive to disturbance, often apparently vacating a coupe when logging first begins. Kavanagh (1985a) found that Yellow-bellied Gliders were occasionally seen foraging just inside logged areas but were normally only encountered in creek reserves or unlogged areas. Kavanagh and Webb (1989) found that following logging they continued to use their den trees in the unlogged wildlife corridor but moved up to 1 km away to forage in unlogged forest. Recher, Rohan-Jones and Smith (1980) found that they moved into adjoining logged areas where taller trees had been left and that they could move through logged areas with scattered tall trees.

Kavanagh (1987b) concludes "These results suggest that mature forests which provide sufficient diversity of the favoured eucalypt species will be the habitats with the highest concentration of yellow-bellied gliders."

Milledge, Palmer and Nelson (1991) in their comparison of 50-80 year old regrowth (from wildfire) and 160-250+ year old-growth found that Yellow-bellied Gliders had a strong relationship with old-growth forest and made "little use of young forest even where stags or scattered old trees apparently suitable for nest and den sites were available.", with most records "clustered in and about old-growth stands with a core area greater than 1 km^2". They considered that Yellow-bellied Gliders are usually found in forests containing a high diversity of eucalypts which provide food sources at different times of the year, whereas as their study area sampled largely monotypic Mountain Ash stands the Yellow-bellied Glider's specialized foraging requirements may only be met only in old growth forest where the seasonal availability of resources such as anthropods sheltering in decorticating bark, as well as nectar and pollen and plant and animal exudates, are most abundant.

Mackowski (1986) notes "Using 250 home ranges of 60 ha each, an unfragmented area of 15,000 ha of suitable habitat should support a minimum effective population of *P. australis*."

***Squirrel Glider** *Petaurus norfolcensis* H

Eastern Pygmy-possum *Cercartetus nanus* H
Ward (1990) studied the Eastern Pygmy-possum at two sites in Victoria and found: diet includes nectar, pollen, insects and seeds; nest sites include knot-holes in trees, burrows, vacated birds' nests and accumulations of leaves and twigs caught between branches; individuals changed nests frequently; breeding can occur throughout the year depending on the availability of food resources, particularly banksia flowers; some females produce three litters a year with a mean of approximately 2.5 per year; the modal litter size is four, indicating females will produce about 10 young per year; young can mature from 4.5-10 months old, depending on season of birth; females are probably behaviourally dominant and may exclude males from areas of prime habitat, and; individuals can survive at least 4 years in the field and 8 years in captivity.

Rohan-Jones (1981) considers that from known habitat preferences Eastern Pygmy Possums will decline as the result of logging, primarily due to the reduction of suitable dense shrub patches by the practice of slash burning. Kavanagh and Webb (1989) note that the four Eastern Pygmy Possums they caught were all in unlogged forest. Dunning and Smith (1986) note that the Eastern Pygmy Possums they found "were only trapped in mature unlogged moist hardwood forest."

Feathertail Glider *Acrobates pygmaeus* H
Mackowski (1987) notes that Feathertail Glider nests, within hollows, contained 3 - 5 gliders when occupied.

Mackowski (1987) notes "Feathertail gliders were the most abundant arboreal wildlife found in blackbutt hollows... but they were not sensed by spotlight or aural means... This suggests that they are also common in other forests where they are not sensed."

He found that Feathertail Gliders occupied an average of 0.86 hollows in each tree 100 - 119.9 cm dbhob, 0.17 hollows in trees 120 - 139.9 cm dbhob, 1.00 hollows in trees 140 - 159.9 cm dbhob, and 1.17 hollows in trees > 160 cm dbhob.

Kavanagh (1985a) notes that no Feathertail Gliders were seen on plots after they were logged. Dunning and Smith (1986) note that most captures of Feathertail Gliders were in mature moist hardwood, though two were found two years after heavy logging.

***Long-footed Potoroo** *Potorous longipes* P R F
Claridge (1990) notes that prime Long-footed Potoroo habitat is warm-temperate rainforest and bordering wet sclerophyll eucalypt forest and that hypogeal fungi fruiting bodies comprise between 80-95% of their diet. He considers that logging and prescribed burning may be detrimental to the fungi and thus the potoroo.

Clark, Backhouse and Lacy (1991) note that only 32 individuals of this species have been trapped and it has been detected in 63 canid scats, with 23 scattered colonies detected. They note the main perceived threats to its survival are predation from introduced predators, and habitat disturbance from logging and unsuitable fire regimes.

***Long-nosed Potoroo** *Potorous tridactylus* P R F
Kavanagh (1982) notes that controlling the use of fire and reducing the number of foxes (and dingoes) is recommended in areas where the potoroo is known to occur. Wilson *et al* (1990) found Long-nosed Potoroo "may have disappeared" from their study area within a couple of years post fire, and considered it one of those species "vulnerable to the combined effects of disturbance factors due to their low population numbers and restricted distribution."

***Rufous Bettong** *Aepyprymnus rufescens* P
Kavanagh (1982) notes that management to favour Rufous Bettongs could best be achieved by controlling competitors (mainly rabbits), predators (foxes and dingoes) and beef cattle stocking rates,

***Red-legged Pademelon** *Thylogale stigmatica* P R F

***Brush-tailed Rock-wallaby** *Petrogale penicillata* P
Anon (1988) consider "Predation by Foxes is likely to have been an important factor in the disappearance of the Brush-tailed Rock-wallaby from the The Grampians, and the current low population levels (in Victoria) are possibly limited by Fox predation..." Kinnear (1987) found that populations of Black-footed Rock Wallaby increased by 138% and 223% over four years when a fox control programme was implemented.

Anon (1988) consider the effects of competition of Brush-tailed Rock-wallabies "with Goats and European Rabbits for food are unknown but are likely to be detrimental and may be exacerbated in years where food is scarce. Unlike competition for food, where the effects are often subtle and difficult to detect, competition for shelter has been directly observed... and may be an important factor in limiting the size and extent of Brush-tailed Rock-wallaby populations."

***Parma Wallaby** *Macropus parma* P R F
Read and Fox (1991) note that due to its restricted range and continuing pressures on its forest habitat the Parma Wallaby is a species that is especially vulnerable to extinction. They note that since European settlement its range has declined, though consider with the paucity of information about population size, distribution and ecology its status must be treated with some reservation until more data is available.

Read and Fox (1991) consider that optimum habitat for the Parma Wallaby appears to be wet sclerophyll forest (often with Sydney Blue Gum and Tallowwood present) with a moist or rainforest understorey. They found Parma Wallabies in areas subject to past logging disturbance and noted that Parma Wallaby occurred in 4.6% of Dingo scats collected in the Petroi-Five Day Creek area.

***Black-striped Wallaby** *Macropus dorsalis* P R F

***Black Flying-fox** *Pteropus alecto*

***Queensland Tube-nosed Bat** *Nyctimine robinsoni*

***Queensland Blossum Bat** *Syconycteris australis*

***Yellow-bellied Sheathtail-bat** *Saccolaimus flaviventris* H

***White-striped Mastiff-bat** *Nyctinomus australis* H

***Eastern Little Mastiff-bat** *Mormopterus norfolkensis* H

***Beccari's Mastiff-bat** *Mormopterus beccarii* H

***Queensland Long-eared Bat** *Nyctophilus bifax* H

***Common Bent-wing Bat** *Miniopterus schreibersii*

***Little Bent-wing Bat** *Miniopterus australis*

***Large Pied Bat** *Chalinolobus dwyeri*

***Hoary Bat** *Chalinolobus nigrogriseus* H

***Large-footed Mouse-eared Bat** *Myotis adversus*

***Golden-tipped (Dome-headed) Bat** *Phoniscus papuensis* H R

***Great Pipistrelle** *Falsistrellus tasmaniensis* H

******Eptesicus baverstocki*

******Eptesicus troughtoni*

Fawn-footed Melomys *Melomys cervinipes* R F
Dunning and Smith (1986) found "The abundance of [Fawn-footed Melomys] was positively correlated with the basal area of rainforest species in the overstorey and in the understorey and negatively associated with the basal area of overstorey eucalypts and Brush Box.", "The abundance of [Fawn-footed Melomys] on experimentally logged sites (33% and 66% canopy retention) declined in greater proportion than the amount of forest biomass removed (66% and 80% respectively)." and "this species appeared the most sensitive to logging disturbance." They found that Fawn-footed Melomys also declined on unlogged control sites, one area was attributed to the affect of an escaped post logging burn though in another area for no apparent reason "unless it was caused by the general disturbance created by logging of adjacent areas as [Fawn-footed Melomys] population numbers declined more than those of any other species in response to logging."

***Smoky Mouse** *Pseudomys fumeus*

***Hastings River Mouse** *Pseudomys oralis* F

New Holland Mouse *Pseudomys novaehollandiae* F
Wilson *et al.* (1990) found that New Holland Mouse disappeared from one site after a fire and its population peaked three years after a fire at another site. They considered it one of those species "vulnerable to the combined effects of disturbance factors due to their low population numbers and restricted distribution."

***Pilliga Mouse** *Pseudomys pilligaensis*

***Eastern Chestnut Mouse** *Pseudomys gracilicaudatus*

Broad-toothed Rat *Mastacomys fuscus* F

Pale Field Rat *Rattus tunneyi*

4.2 BIRDS

Pacific Baza (Crested Hawk) *Aviceda subcristata*

***Square-tailed Kite** *Lophoictinia isura*

***Red Goshawk** *Erythrotriorchis radiatus*

***Black-breasted Button-quail** *Turnix melanogaster* R

***Bush Hen** *Gallinula ventralis* R

***Bush (Stone Curlew) Thick-knee** *Burhinus magnirostris*

***Superb (Purple-crowned) Fruit-dove** *Ptilinopus superbus* R

Wompoo Fruit-dove *Ptilinopus magnificus* R

Yellow-tailed Black Cockatoo *Calyptorhynchus funereus* H

***Red-tailed Black Cockatoo** *Calyptorhynchus magnificus* H

***Glossy Black Cockatoo** *Calyptorhynchus lathami* H
Turner and Kavanagh (1990) consider that of the large cockatoos the Glossy Black Cockatoo is potentially the most threatened by logging. They note that this species "feeds exclusively on *Casuarina* fruits which although not scarce, appear to be selected from only certain trees. The effect of logging and prescribed burning on the availability of these preferred trees is unknown." They also note that the Glossy Black Cockatoo "appears to prefer the lower slopes of dry sclerophyll ridges, a habitat that is not usually protected by wildlife corridors."

***Coxen's Fig Parrot** *Psittaculirostris diophthalma coxenii* H R

***Superb Parrot** *Polytelis swainsonii* H

***Swift Parrot** *Lathamus discolor* H

Powerful Owl *Ninox strenua* H
Kavanagh (1989b) notes that "our knowledge of the ecology and habitat requirements of large owls, including the use, if any, of regenerating forest is largely unknown." He recommends that there is a need to determine the requirements and the reliance of the large owls for old growth forest as habitat.

Kavanagh and Webb (1989) note that intense predation by Powerful Owls significantly reduced arboreal mammals within unlogged forest in the vicinity of logged forest and that they were more frequently detected in the unlogged forest.

Kavanagh (1989b) recommends that for Powerful Owls the general locality (ie 2.5km radius or 2000ha) around each site where they were detected be well served by a network of reserved old growth forest along gullies as wildlife corridors (>100m width). He also recommends the employment of a specialist "nest finder".

Barking Owl *Ninox connivens*

***Sooty Owl** *Tyto tenebricosa* H R
Rohan-Jones (1981) notes that this owl is a predator of arboreal mammals together with which it forms a closely dependent subsystem, and recommends that where this combination is located should preferably be left unlogged.

Milledge, Palmer and Nelson (1991) found that the relative frequency of records of the Sooty Owl in different age classes suggests that its optimum habitat is large patches of old-growth forest. They note "The Sooty Owl was most abundant in old-growth forest, but often occurred in young stands... The proximity of some records in young stands to old-growth stands... suggested that some pairs of Sooty Owls include areas of both young and old-growth forest in their extensive home ranges... However, some findings in young forest removed from old-growth forest ...indicated that other pairs were able to occupy stands lacking high densities of old live trees.", and "Most records were clustered in and about old-growth stands with a core area greater than 1 km^2".

Kavanagh (1989b) recommends "that old growth forest be reserved in gullies in wide (>200m) corridors for distance of up to 1km in either direction at all locations where Sooty Owls were detected." He also notes the need for a specialist "nest finder".

Masked Owl *Tyto novaehollandiae* H
Kavanagh (1989b) recommends that for Masked Owls the general locality (ie 2.5km radius or 2000ha) around each site where they were detected be well served by a network of reserved old growth forest along gullies as wildlife corridors (>100m width). He also recommends the employment of a specialist "nest finder".

***Marbled Frogmouth** *Podargus ocellatus* R

***Albert's Lyrebird** *Menura alberti* R

***Rufous Scrub-bird** *Atrichornis rufescens* R

***Yellow-eyed Cuckoo-shrike** *Coracina lineata* R

***Northern Olive Whistler** *Pachycephala olivacea macphersoniana* R

White-eared Monarch *Monarcha leucotis* R

***Eastern Bristlebird** *Dasyornis brachypterus*

***Regent Honeyeater** *Xanthomyza phrygia*

***Painted Honeyeater** *Grantiella picta*

4.3 REPTILES

**Eulamprus leuraensis*

**Delma impar*

**Coeranoscincus reticulatus* L R

**Pseudemoia lichenigera*

Beech Skink *Cautula zia* L.R

Hemiergis maccoyi L
Hemiergis maccoyi is a burrowing skink found under rocks and fallen timber in southern NSW. Kavanagh and Webb (1989) found that there was a significant reduction in populations of *H. maccoyi* on three logged compartments compared with the employment unlogged control, with effects still significant three years after logging.

Lampropholis caligula

Challengers Skink *Lampropholis challengeri* L R
Dunning and Smith (1986) found that the highest densities of Challenger's Skink were associated with a closed forest canopy and abundant litter and logs in the ground cover. They found that numbers of Challenger's Skink declined significantly following logging in moist hardwood, even where there was 33% canopy retention and no post logging burn.

Leiolopisma coventryi L
McIlroy (1978) cites research that found that prescribed burning during winter destroyed the hibernation sites (logs and litter) of this species.

Murray's Skink *Sphenomorphus murrayi* L R
Dunning and Smith (1986) found that the highest densities of Murray's Skink were associated with a ground cover of abundant logs and litter. They found that its numbers decreased significantly following logging and burning.

***Southern Angle-headed (Rainforest) Dragon** *Hypsilurus spinipes* R

***Carpet and Diamond Python** *Morelia spilota*

Pale-headed Snake *Hoplocephalus bitorquatus*

***Broad-headed Snake** *Hoplocephalus bungaroides*

Stephen's Banded Snake *Hoplocephalus stephensi* R

4.4 AMPHIBIANS

***Green and Golden Bell Frog** *Litoria aurea*

***Green Thighed Frog** *Litoria brevipalmata*

**Litoria piperata*

**Litoria raniformis*

**Litoria spenceri*

**Litoria subglandulosa*

***Pouched Frog** *Assa darlingtoni* R

**Mixophyes fleayi*

***Giant Barred Frog** *Mixophes iteratus*

Philoria kundagungan W R G

***Loveridge's Frog** *Philoria loveridgei* W R G

***Sphagnum Frog** *Philoria sphagnicolus* W G

5.0 STATUTORY RESPONSIBILITY

The Forestry Act 1916 obliges the Forestry Commission to conserve native wildlife in State Forests, stating:

"8A (1) The objects of the commission shall be -
...
(e) consistent with the use of State Forests for the purposes of forestry and of flora reserves for the preservation of native flora thereon -
(i) to promote and encourage their use as recreation; and
(ii) to conserve the birds and animals thereon.

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

In practice timber production has achieved primacy over wildlife conservation (Dunning and Smith 1986, Mackowski 1987, Davey and Norton 1990). The Forestry Commission has consistently ignored research undertaken by their own personnel and other institutions on the impact of their operations on wildlife and failed to adopt adequate mitigation measures.

The Environmental Planning and Assessment Act 1979 gives the Department of Planning responsibility to protect and enhance the environment. They too have consistently failed their responsibility to ensure that developments or activities likely to have a significant impact on wildlife are controlled or adequate mitigation measures adopted, as evidenced by the large number of successful court challenges to E.I.S.'s which the Department has allowed. They also have responsibility for administration of the Heritage Act which contains mechanisms for the temporary and permanent protection of items of the State's natural and cultural heritage. There has been a political directive not to apply this Act to natural areas in recent years.

The Crown Lands Act requires that Crown land be managed so that the natural resources of the land, including flora and fauna, are conserved whenever possible. The Soil Conservation Act provides for the mapping and conservation of protected lands which can include land containing rare or endangered fauna. These acts are now administered by the Department of Conservation and Land Management, which is an amalgamation of the government departments who have historically had responsibility for these acts and similarly utterly failed their statutory duties to conserve fauna.

The National Parks and Wildlife Act 1974 gave the National Parks and Wildlife Service a clear statutory responsibility for the protection of protected and endangered fauna. This responsibility has only been partially applied for individual animals where direct methods of capture or killing were utilised, habitat destruction or indirect killing (e.g by felling of a tree) of protected fauna has been ignored.

The amendments to the National Parks and Wildlife Act 1974 and Environmental Planning and Assessment Act 1979 resulting from the Endangered Fauna (Interim Protection) Act 1991 specified in greater detail the National Parks and Wildlife Service's and Department of Planning's responsibilities to ensure the survival of protected fauna in N.S.W. These ammendments were further amended by the Timber Industry (Interim Protection) Act which substituted the word endangered for protected wherever it appeared in the E.P.A. Act. Most importantly the National Parks and Wildlife Service still has over-riding responsibility to ensure the protection of endangered fauna.

The other significant ammendments made by the Timber Industry (Interim Protection) Act are that for nominated management areas (which encompasses most of those on the north coast) the Forestry Commission can continue logging without complying with the requirements of the E.P.A. Act until they prepare E.I.S.'s in accordance with a schedule specified in the Act (though they are still required to comply with the N.P.W. Act), and that for those Management Areas the Minister for Planning is the determining authority.

Endangered fauna are protected fauna of a species named in Schedule 12 of the N.P.W. Act 1974 as threatened, as vulnerable and rare, or as a marine mammal.

The director of the N.P.W.S has the responsibility for licensing any activity which will take or kill endangered fauna. On the receipt of such a licence application the director must advertise the application in a statewide newspaper and invite public submissions for at least 28 days. In considering the application the director must take into account any fauna impact statement or environmental impact statement, submissions, the status of the species and proposed mitigation measures. The director must then notify the applicant and people who made submissions of the director's decision and reasons for it, and make all information concerning fauna supplied to the director in support of the application freely available to the public.

The applicant or people who made submissions may, within 28 days of notification of the director's decision, appeal to the Land and Environment Court if dissatisfied with the director's decision.

The amended Environmental Planning and Assessment Act 1979 requires that a Fauna Impact Statement is prepared if a proposed development (under part 4) or activity (under part 5) is likely to significantly affect the environment of endangered fauna:
"4A. ...in deciding whether there is likely to be a significant effect on the environment of endangered fauna the following factors shall be taken into account -

(a) the extent of modification or removal of habitat, in relation to the same habitat type in the locality and region;

(b) the sensitivity of the species of fauna to removal or modification of its habitat;

(c) the time required to regenerate critical habitat;

(d) the effect on the ability of the fauna population to recover including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development or activities;

(e) any proposal to ameliorate the impact;

(f) whether the land is currently being assessed for wilderness by the National Parks and Wildlife Service under the Wilderness Act 1987;

(g) any adverse effect on the survival of that species of endangered fauna or of populations of that fauna.

The amended National Parks and Wildlife Act 1974 states that a fauna impact statement is required to:

92D(1) "(c) include, to the fullest extent reasonably practical, the following:

(i) a full description of the fauna to be affected by the actions and the habitat used by the fauna;

(ii) an assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures upon them;

(iii) a description of the actions and how they will modify the environment and effect the essential behavioural patterns of the fauna in the short and long term where long term encompasses the time required to regenerate essential habitat components;

(iv) details of the measures to be taken to ameliorate the impacts;

(v) details of the qualifications and experience in biological science and fauna management of the person preparing the statement and of any other person who has conducted research or investigations relied upon."

The director is enabled to issue director's requirements for the preparation of Fauna Impact Statements which are legally binding.

The Minister for the Environment or the Director are able to issue stop work orders where they consider that an action is likely to significantly affect the environment of any protected fauna. Stop work orders last for 40 days and are able to be renewed.

6.0 GLOSSARY

dbh: diameter of a tree at breast height (1.3 m above ground), under bark - often used in general sense to include dbhob.

dbhob: diameter of a tree at breast height, measured over bark.

Cohort: a group of trees originating from the one regeneration event, often following a fire.

Endangered fauna: protected fauna of a species named in Schedule 12 of the N.P.W. Act 1974 as threatened, as vulnerable and rare, or as a marine mammal.

Habitat tree: trees containing hollows suitable for denning or nesting.

Indicator species: species that represents a particular use, ecosystem, or management concern.

Keystone species: a species, that if lost from a system, leads directly or indirectly to the disappearance of several other species.

Marginal habitat: habitat where a species can exist but not reproduce.

Minimum viable population: population size of a species that will ensure genetic viability over time.

Mobile link species: species which are important functional components of more than one food chain, plant-animal association, or ecosystem.

Optimum habitat: habitat that is of a quality that enables fecundity and/or population density of a species to be maximised.

Protected fauna: all fauna in N.S.W. not named in Schedule 11 of the N.P.W. Act 1974.

Sensitive species: species affected detrimentally by forest operations - logging, fire management, silvicultural treatments, grazing, roading and 1080 baiting.

Sub-optimal habitat: habitat of a lower quality than optimal habitat, but where a species can still reproduce.

Target species: species that are rare, endangered or sensitive to the effects of proposed activities and/or global warming.

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