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Biodiversity research for conservation in New Zealand: Lessons from Australia

An Australia New Zealand Foundation Fellowship Report 1996

by

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CONTENTS

Abstract

Priority research topics which relate to biodiversity are described based on interviews with Australian researchers while on an ANZAC Fellowship. Generic topics included: habitat fragmentation, biogeography, reserve complimentarity, rapid biodiversity assessment, mapping biodiversity and indicator taxa. Specific topics were earthworm fauna, cave invertebrates, indigenous knowledge and stag beetles. Topical issues in conservation science are also discussed: possums and 1080 poisoning, population dynamics of forest pest mammal species and modelling populations of rare species. Some observations on the organisation of Australian conservation science by comparison with New Zealand are related with recommendations for future organisation.

1. Introduction

1.1 PURPOSE OF THE FELLOWSHIP

The number of research proposals with "biodiversity" in the title presented for funding in New Zealand is increasing dramatically. Many of these necessarily have implications for the New Zealand Department of Conservation because most of the remaining native habitat is managed by it and this land harbours most of the native species (mostly invertebrates) surviving in New Zealand.

I believe to maximise efficiency DOC should consult and/or collaborate with the researchers undertaking biodiversity research, and ideally, initiate some of this research. Currently however, neither the research community as a whole, nor the Department, appear to have sufficient understanding of biodiversity research priorities, how that research should be conducted, or by whom. In Australia biodiversity research -especially on invertebrates and their habitats - is well underway. Thus the aim of the Fellowship was to visit researchers and learn as much as possible about which questions were being investigated, their methods and the scientific quality of biodiversity research.

For the purposes of this report, biodiversity is defined as the number of species harboured in a defined habitat and period. For some, biodiversity justifiably has cultural elements but for practical reasons I am confining myself to a strictly biological and scientific use of the term. The views expressed here do not necessarily reflect those of the Department of Conservation. The range of research topics is not comprehensive nor are the accounts of them exhaustive. For practical reasons I have restricted this report to relating only what was discussed with colleagues I could meet in the period of the Fellowship tour.

1.2 TOUR ITINERARY

Melbourne (29 January to 11 February)
Museum of Victoria, La Trobe University, Department of Conservation and Natural Resources.

Hobart (12 to 25 February)
Tasmanian National Parks and Wildlife Service, University of Tasmania, Queen Victoria Museum Launceston, Private consultant.

Perth (26 February to 3 March)
Western Australian Threatened Species and Communities Unit (Department of Conservation and Land Management), Curtin University, Edith Cowen University, Western Australia Museum.

Canberra (4 to 17 March)
Entomology Division Commonwealth Scientific and Industrial Research Organisation, Australian Nature Conservation Authority Threatened Species Unit, Biodiversity Unit Department of Environment Sport and Territories, Australian National University, Australian Capital Territory National Parks and Conservation Service.

Sydney (18 to 24 March)
New South Wales National Parks and Wildlife Service, Australian Museum, Macquarie University.

Brisbane (25 March to 12 April)
Queensland University of Technology, Queensland University, Queensland Museum, University.

2. Priority research topics in New Zealand

This section describes important research topics related to responsibilities shared by DOC and other agencies and particularly relevant to DOC's mission. Two categories of research are described: generic topics and specific projects. The research methods which could be used are described and limitations discussed. Key Australian researchers and institutions are noted where known who could potentially collaborate or advise. Some important references written by Australasians are cited.

2.1 HABITAT FRAGMENTATION AND RESERVE DESIGN

Native habitat is still being converted for agriculture or timber in New Zealand mainly on private land. Land acquisition for reserves or other protection (such as covenants) should continue as new priority habitat comes to the attention of the Department of Conservation. Further land acquisition should consider the size and shape of the proposed reserve and whether it is necessary to include "corridors" of native habitat which link one remnant to another. In Australia there has been some consideration of replanting forests to link existing remnant patches.

The topics encountered in Australia included: the effects of fragmentation on diversity, the use of corridors by fauna, re-invasion after fragmentation, reserve complementarity, and other biogeographic considerations in reserve design. These topics and two related case studies are described here.

2.1.1 Wog Wog fragmentation study

The effects of fragmentation on invertebrate diversity are being studied by Chris Margules (CSIRO Division of Wildlife and Ecology) and others at Wog Wog (see references). Many ecological questions are being addressed but the study has not finished. Diversity is being measured systematically in different sized patches of forest in a BACI (before, after, control, impact) style field experiment with replication. The control involves pseudo-patches, i.e. continuous forest with delineated areas of equal size to the treatment patches, which are remnant forest patches (same forest type) on cleared land replanted into pine forest. Thus the treatment is a dynamic situation where the surrounding habitat is changing during the years the study is being carried out.

The main result the Wog Wog study has illustrated to date is the importance of conducting experimental field studies with proper controls and replicates. In this study three groups of treatment patches of forest (each group comprising a 0.25 ha, 0.75 ha and c.3.5 ha patch) and two groups of control were created. A "patch" was forest shaped as a square. Treatment patches had the surrounding forest cleared and gradually replanted with pine over a year. The control plots remained unchanged, surrounded by original eucalypt forest.

Results show how completely different conclusions can be reached if only before/after data of the treatment blocks are analysed. This is because in the treatment blocks an increase in invertebrate numbers occurred and without examining the non-treatment or "control" blocks simultaneously one might be tempted to conclude that the treatment had no negative effect on biodiversity. However this upward change was more than matched in the control blocks. Thus there was a treatment effect even though there was an upward movement in both treatment and control. Examining individual pitfall traps showed how the data from pairs of pitfall traps could influence results. The pairs of traps were distributed thus: two near the edge of the patch, two near the centre, two on a contour and two on a flat or gully.

According to how the data were pooled and analysed, entirely different conclusions could result. If the data from a pair of traps near the edge of one of the patches were ignored it was generally found that the maximum diversity was preserved near the centre of an island of habitat -indicating again that fragmentation was having an effect. If only one set of data was selected from one replicate (various combinations of the individual from pairs of control/ treatment matched for size) then entirely different results can occur. Thus the general result so far from the Wog Wog study is to demonstrate the importance of including ecologically meaningful controls and replicates in these studies.

The Wog Wog study has the luxury (by New Zealand standards) of extremely high quality scientific input (Margules and others) into design, data collection and analysis, etc., huge scale funding, long duration and replication. Yet the data are highly variable and there are problems with design. I think this study is valuable for warning future researchers of the enormous problems of satisfying scientific design with field experiments, adequately measuring variability with sufficient replication, and the huge costs involved in conducting this sort of research properly.

2.1.2 Box-Iron Bark fragmentation study (Victoria Mallee)

This is a multi-disciplinary and co-operative study by the Museum of Victoria, Department of Conservation and Natural Resources and Deacon University. The aims are to identify the effect of fragmentation of box forest on biodiversity (mammals, birds, invertebrates) and the impacts of perturbations on fauna such as fire regimes, stocking, and introduced alien species. The first (survey) stage is in progress, which aims to identify those species still remaining in the fragments. These distribution patterns will be correlated at a later date with environmental variables.

The design revolves around ecologically discrete botanical communities, which have been pre-determined from survey. But limiting the units of study to these patches was deemed too restrictive. Instead, geographically based habitat criteria, which included the areas that linked up the truly box-iron bark habitats, may be used. Thus the intervening habitat between patches is now considered important in influencing the number of species remaining primarily in the native wooded habitat patches. These intervening areas include wetlands and other lower lying land which link up the more homogeneous areas of habitat.

Ralph from Deacon University (Melbourne) is investigating the effects of fragmentation *per se.* He selected remnant patches 10 ha, 20 ha and 40 ha and predicted which birds and reptiles would most likely be affected by fragmentation based on the known ecology of each species. The distribution, abundance, diversity and ecology of these pre-selected species in habitat patches are to be compared with the same species in "pseudo-patches" - equivalent areas in continuous forests. Problems included identifying true controls. Most of the control forest patches should be unmodified in contrast to the treatment areas (grazed, fired and forested to varying extents). However, finding unmodified forest to serve as controls has proved virtually impossible.

Early results show that the size or the isolation of the habitat fragments appear not to be significant in predicting the abundance and diversity of the invertebrate fauna. Rather the processes affecting habitat change *per se* have had a greater influence on the abundance and diversity of invertebrates. These processes include structural changes caused by stocking and fire for example.

One Australian researcher doing relevant work on fragmentation that I could not meet is Bob Pressey, from NSW National Parks and Wildlife Service, Armidale. Dr Pressey is studying reserve selection methodology, assessment techniques, effects of fragmentation, etc.

Another who has studied the affects of fragmentation on fauna is Dr Stephen Sarre, Dept Zoology, Auckland University. He has investigated the effects of habitat fragmentation on the genetic structure of populations of geckos in Australia. He has looked at the question of whether populations are discrete genetic entities or whether they exist as a meta-population. His PhD thesis gives a complete bibliography.

2.1.3 Biogeography

Relevant questions included determining the value of forest corridors between remnant patches: do invertebrate (or even vertebrate) species actually use corridors, will populations of species restock one another as local extinctions occur and can narrow strips (e.g. riparian strips) of original habitat sustain invertebrate populations? Bob Mesibov considered that colonisation by invertebrates occurred along "fronts" and at a slow rate. The implication for forestry practices in Tasmania and New South Wales are that the adequacy of coup forestry plans are unknown in terms of sustaining biodiversity (including botanical diversity) in the relatively short (in ecological terms) intervals involved in cropping rotations.

Reserve design and selection may need to take into account discontinuous patterns in the distribution of certain invertebrates. Dr Mesibov has found that the distribution of some quite taxonomically different species stops in the same line of demarcation, despite continuous forest. Thus a transect surveying species occurrence across these lines of demarcation will reveal relatively homogeneous distributions either side (but with different species compositions). It is important to realise that these distribution patterns are quite different from clinal variation. Theoretically protecting these lines demarcating species distribution is very important if an aim is to protect areas where speciation is likely to occur.

2.1.4 Reserve complementarity

Complementary reserve selection procedures involve protecting fragments of habitat collectively containing more diversity than a single area which might, by itself, have higher diversity than any single other habitat patch. The values of a patch may be assessed (by surveying perhaps using "indicator" recognisable taxonomic units – RTUs) objectively by using ordination procedures which identify patches (fragments) most dissimilar (and therefore most complementary) to each other. These patches would be priorities for inclusion in a reserve system. The concept is a departure from the usual approach of selecting and protecting the single area with the maximum diversity. Instead reserve selection is flexible -several areas are identified, any number of which can be selected for protection and still represent the total level of biodiversity occurring in the region.

The concept of reserve efficiency was discussed. That is measuring the ability of the reserve system to model the true level of biodiversity existing on the ground. These models include validation procedures to estimate efficiency (Margules and Redhead 1995).

2.1.5 Research brief

In the research brief on validating the Protected Natural Areas Survey Programme and reserve system described below the concepts of reserve complementarity and discontinuous species distributions need to be included. Hence Rapid Biodiversity Assessment and indicator species may be used in the validation exercise to identify single areas of high diversity but also to show areas of high complementarity and (related) discontinuous distributions.

2.1.6 Relevant projects/researchers/institutions

Fragmentation

Bob Pressey, NSW National Parks and Wildlife Service, PO Box 402, Armidale, NSW 2350. Email: Bpressey@ozemail.org.au
Alan Yen, Museum of Victoria Ralph Deacon University, Melbourne. Email:dacleo@silas.cc.monash.edu.au
Chris Margules, CSIRO, Division of Wildlife and Ecology

Biogeography

Bob Mesibov, Research Associate, Queen Victoria Museum, Launceston, Tasmania
Norm McKenzie, Information Division, Department of Conservation and Land Management, Perth, WA

Complementarity

Chris Margules, CSIRO Division of Wildlife and Ecology

2.2 BIODIVERSITY ASSESSMENT AND MAPPING

2.2.1 Rapid biodiversity assessment

There are many species of invertebrates undescribed and yet there is a high and urgent demand for quantitative information. Information on invertebrate diversity is required to identify important areas for protection and to monitor habitat under different environmental management regimes.

In New Zealand most of the network of protected natural areas was not created on the basis of systematic survey of biodiversity. It was created on the basis of scenic and botanical grounds. In order to identify remaining areas requiring protection on the basis of their biodiversity (by definition, invertebrate diversity) a superficially attractive method would be to use a rapid method of biodiversity assessment rather than the traditional inventory style survey where formal Linnaean binomials are finally assigned to every collected species.

Rapid biodiversity assessment uses morphospecies or recognisable taxonomic units in lieu of alpha taxonomy (Linnaean binomials) to describe collected animals from survey or monitoring studies. Voucher specimens are kept for a designated morphospecies or recognisable taxonomic unit, which are later verified as a unique species but not necessarily named using alpha taxonomy, thus reducing the work. If the original RTUs are found to actually involve more than one species, then the data involving these RTUs are removed from the analysis and if one or more RTUs are found to represent one species then these data are pooled. It has been found that the removal of these "duplicate" data involve few species and their removal makes little difference to the results.

Analyses using higher taxonomic units than "species", such as genera, can yield more sensitive information on changes in community condition than using species within one genera because the width of "ecological function" (trophic levels, habitats and natural histories) represented is wider. Dr Ian Oliver has tested the reliability of using technicians to recognise RTUs and found them to be highly accurate. Using technicians to identify too many genera involves too much expertise and the benefits of RTUs are lost (saving in time, money). Sorting time is greatly reduced with using selected RTUs.

Graphs of diversity of taxa with increasing trap effort show curves which are initially steep and progressively flatter with few extra taxa added with additional trap effort. Thus most diversity can be represented with minimal trapping effort. This minimal trap effort can be measured and used in subsequent research.

It is important that preliminary research is done on the scale of diversity which is likely to occur, i.e. using standard alpha taxonomy to assess the likely level of diversity which will be encountered. There may be some use (in terms of changing signal or alterations in diversity in response to changing environmental conditions) in using even ordinal classification or families (see references). This then precludes the necessity of using morpho species or recognisable taxonomic units.

Consideration needs to be given to the constitution of samples. Much of the diversity of a given sample includes animals that are single cases of a given taxonomic unit (species, genus, etc.). Because their occurrence in repeated samples is rare (many zeros) their presence (collectively) can be treated as a variable in itself.

The use of rapid biodiversity assessment methods is controversial. Not all scientists agree that they are valid because the process is based on defining a morpho-species or recognisable taxonomic unit often using amateur workers (hence its much touted advantage of being cheap and fast). These workers concentrate on small groups of taxa (say one genus) and become experts. The RTUs are given an arbitrary label. The problem (and objection of many) is that other researchers working on other studies cannot know the relationship of their RTUs to another's or to formally named taxa (Linnaean binomials).

For conservation purposes a taxa's endemicity is often important. If is important then the significance of an RTU may be impossible to calculate because there is no way of relating it to another taxa (i.e. the identity is arbitrary and not related to similar forms found in other locations). This problem is removed if the (RTU or morphospecies) is assigned a Latin binomial. This inherent problem with morphospecies is reversed somewhat if regional collection centres are established where the centre gives a label to the morphospecies which every other researcher conforms to and which ultimately is related to a Linnaean binomial.

2.2.2 Mapping biodiversity

Identifying areas of high biodiversity has been tackled by mapping techniques, which may involve highly sophisticated technology. These methods were discussed with Norm McKenzie (Western Australia Department of Conservation and Land Management) and Chris Margules (Division of Wildlife and Ecology, CSIRO). The latter is developing a method(s) of selecting priority areas for biodiversity conservation. For this he and others have developed the system (see references -others to be published in 1996 will include four user manuals). This system can incorporate any existing data base of various qualities and types. Dr Margules pointed out that the most robust database from which probabilistic statements can be made is one which includes presence and absence data but most databases do not do both. Thus with presence and absence data, statements about the probability of a given map selecting x% of the biodiversity can be made (usually a range of probability).

The mapping techniques allow identification of areas of high diversity on a large "bio-regional" scale and testing the adequacy (efficiency) of existing protected natural areas in actually protecting biodiversity *per se* (see references). This whole area is relevant to measuring biodiversity but is technically extremely complex -there was not enough time to investigate fully and it would be justifiable to learn about the methodology to see if there was some application suitable for New Zealand.

2.2.3 Research brief

The principal aim is to investigate whether the protected natural area system in New does in fact include habitat with the highest levels of biodiversity. Another is to identify areas outside the protected natural areas in New Zealand which harbour exceptionally high levels of diversity and are important for protection.

In identifying areas of high priority for protection it will be necessary to include the concept of reserve complementarity.

As a first step, two procedures need to be implemented in tandem: (1) assess the scientific validity and for application in New Zealand of rapid biodiversity assessment techniques and (2) using the results of the Protected Natural Areas Programme and other data bases, identify priority areas in New Zealand which need urgent survey. Determining which areas should be surveyed first can be achieved using a procedure which selects areas based on their meeting certain criteria. Relying on general of all remaining native habitat is not practical. Criteria which can be used to reduce the number of possibilities down to an acceptable number of choices include:

1. Land tenure -Land is not Crown owned or not already included in a protected natural area or, is Crown owned and is threatened by development or a pest species.
2. Location -In a region of New Zealand which has historically lost most of the representative habitat (such as lowlands, wetlands, grasslands etc), or is a category of habitat which is presently under a high level of threat.
3. Size - Habitat is small and fragmentary and, therefore, at higher risk from stochastic factors.
4. Biogeographic significance -The habitat occurs in a region of New Zealand which is recognised as having a high degree of endemism and/or diversity.

This selection process involves plotting on a map all areas which satisfy all criteria at once (hence a huge reductionist process) and then surveying using a rapid method.

It may be worthwhile incorporating a biogeographic mapping system into the methods for validating the Protected Natural Areas in New Zealand. However, expert advice should be taken before such a venture is undertaken. The software is complex and the quality standards of the data required for the databases are high. The New Zealand Department of Conservation has already embarked on a Geographic Inventory System and there may be some application using it with Biorap. But, again, extreme caution should be used to avoid an expense which may not deliver a readily product. This whole field was beyond the scope of this study tour but does warrant further investigation. There were clearly applications of biogeographic mapping techniques relevant management and this research brief.

2.2.4 Relevant projects/researchers/institutions

Centre for Biodiversity and Bioresources, Macquarie University, Sydney; Andrew Beattie, Ian Oliver, David Briscoe, Noel Tait.

Information Division, Western Australian Department of Conservation and Land Management; Norm Mckenzie.

CSIRO Division of Wildlife and Ecology, Canberra; Chris Margules (and co-workers).

Australian Museum, biodiversity research group; Gerry Cassis.

Co-operative Research Centre of Tropical Rainforest Studies, Griffith University, Nathan, Brisbane; Roger Kitching.

2.3 INDICATOR TAXA

An attractive alternative to monitoring or surveying every to estimate diversity or detect change due to some land management practice is to use taxa as surrogates for others. One assumes that recording the presence or absence or changes in these will faithfully reflect the same in other taxa. The validity of using indicator or surrogate taxa is highly controversial with many researchers opposed to their use yet most intuitively recognise their potential given the shortage of taxonomic knowledge and the practical impossibility of monitoring all species.

In New Zealand indicator species could be used to monitor the costs and benefits of pest mammal control or eradication and to survey new habitat for potential protection. Some of the considerations Australian researchers pointed out may be summarised under the following headings.

2.3.1 Problems

Researchers will need a good knowledge of the population demography, biology and ecology of the species involved to be able to properly interpret changes in density/abundance/species composition (including interactions between species) because natural variability may be extreme. Also a knowledge of habitat requirements of the species concerned is required to be able to prescribe sensibly the scale of the sampling unit. Time scale is also important - the interval between naturally occurring extreme fluctuations may be 10 to 15 years.

Some taxa may be too limited in their ecological tolerances to be useful as indicator species, e.g. collembolan are extremely sensitive to desiccation and therefore may be useful only for describing the effects of fire or other dramatic perturbations. Thus these taxa may not be useful for indicating changes which are more subtle such as removal of predators. Taxa with a more variable ecology (omnivores/predators/mixed habitat/overlapping generations, etc.) such as spiders, Carabidae, etc., (cf. presence/absence change) and not necessarily overall abundance. This change in composition will tell the ecologist more about the nature of the changes occurring. All researchers emphasised that the taxonomy of the indicator species needs to be well known before that taxa is selected for use. For example, the taxonomy of some invertebrates is complicated with the existence of nymphal stages which can be mistaken for more than one species. Hence it is important that the keys are available and/or the right (and willing) people for identification exist.

One of the logical steps in removing some of the problems of using indicator species (e.g. understanding the significance of variation) is to use an experimental design for the study. However, the practical constraints of affording enough replicates and the difficulty of selecting true controls in field experimental situations almost cancels any advantage. For example, controls may differ from treatments even before the "impact" (*sensu* "BACI" experimental design) has occurred.

Rarely has the connection between the indicator group and the perturbation that it is supposed to respond to been demonstrated in a cause-and-effect relationship. Thus much of the interpretation of the data stemming from studies using indicator species suffers from inferential conclusions.

2.3.2 Methods

Using set theory to compare sites may avoid some of the problems. Each site is given a domain and common species are illustrated by the degree of overlap with other domains. Another concept is to use changes in combinations of relative abundance between sites and/or points in time as a measure of perturbation. The idea is to take the relative abundance of species A (compared with all others combined) within one site and compare it with that from another year/site. However, there is still the risk of being confounded ignorance of naturally occurring changes.

Between-season and between-year variation could be minimised by year round pitfall trapping. Traps are set so that holes allow escape of all but the larger invertebrates such as carabids (or whatever the designated is). The traps are cleared periodically but are permanent, allowing the collection of absolute relative abundance data. There is inconsistency between workers on what constitutes a "sample" in pitfall trapping studies. Most agreed that data from groups of pitfall traps in a given treatment/control area should be pooled then analysed. Numerous configurations of pitfall traps are possible but the important consideration is to standardise methods and retain these at all costs. Once the methods are changed even slightly, comparability of data is lost. This has been proven with studies involving different configurations of pitfall traps with all other variables controlled for.

The use of ants as indicator species has illustrated how a speciose group can be used by grouping species into "ecologically functional" units. Stronger correlations are obtained and clearer patterns of biodiversity are observed compared with making the same comparisons using single species as defined by formal Linnaean taxonomy.

The quality of the taxa involved needs to be considered. If the task is simply to measure the diversity and abundance of a given group (e.g. ant species) in a given experiment without consideration as to WHICH species are involved then a false impression of the "health" of the community may be given. This is particularly true if the community included a species that was highly endemic or had unique ecological characteristics. From a conservation point of view it may be more important to conserve this species or association of species rather than a changed community which, in absolute terms, is more abundant and/or diverse with adventive colonisers after the perturbation compared with the original unique combination. From an ecological point of view it may be more important to consider the functional significance of species rather than diversity and abundance alone.

Some research has found that invertebrate communities are robust in withstanding the effects of fragmentation and other degradation -more so than generally believed. For example beetles survive degradation and fragmentation well. Hence there are doubts among some workers about the value of using indicator species in other than the simplest of communities.

Given the problems outlined above, using keystone species (ones on which others depend) is probably the most powerful type of indicator species to use. Monitoring these in effect means monitoring ecological relationships and processes, including threatening processes. However, again, interpreting the significance of any changes in keystone indicator species always needs a knowledge of the ecology of the species concerned, which in turn needs to be learned in advance of the use of the species as an indicator. If such species are relatively common and ubiquitous then it might be possible to consider the species/group population distributions (patches) as biologically linked meta-populations) thus giving even more power to any comparisons. If they are not, then conservation is forced into a population by population strategy.

2.3.3 Research brief

To develop a method for monitoring benefits and costs to the forest invertebrate community of long-term periodic pest mammal (browsers and rodents) control operations. The method would be standard, applied to a pre-determined group of invertebrates, and be one of a number of monitoring tasks for the forests destined for long-term pest mammal control in New Zealand.

The first requirement is to identify one or more species which are keystone species and are potentially suitable for monitoring. Ideally one or more of these taxa would be also prey for rodents and possibly possums so that a direct response to the control operation can be more quickly detected. Alternatively their habitat or food supply might be directly affected by possums and/or rodents through competition or being destroyed. These species need to be common and widespread to facilitate the uniform monitoring requirement among different areas in New Zealand. Thus the taxa may have to be restricted to only genus or sub-family. Their taxonomy needs to be well known and expert advice available. Once taxa have been selected research will be required on their so that relevant monitoring can be designed. This includes understanding their relationship with other species (e.g. predator-prey).

To achieve the above, a careful study of the invertebrate diet of rodents and possums is required in the forests which are to receive periodic mammal control by applying 1080 over the next 20 years. At the same time invertebrate survey of the same species that occur in their diet is required to investigate annual cycle, trapability and other information noted above. It will also be necessary to monitor rodents in a trial control of possums (and other browsers if they will be poisoned at the same time) and rodents before, during, and after poison operations to see if any monitored change in invertebrate numbers is related to the rodent diet. The study should take eviscerated body weight of rodents, sex, pregnancy state and sample year round. This study would be most applicable to a forest where there was to be an experimental knock-down of possums/ browsers and rodents. A study of the rodent and population is also required to determine the duration rodent and populations are reduced.

Once invertebrate taxa have been selected for monitoring, some forests should be used as experimental studies. Hence controls should be systematically set up (probably not practical for all situations) to check that any differences noted are real. Thus it should be possible to test whether the repeat period for possum/

browser control (four to five years) is too long because of the early re-establishment of rodent and populations preventing invertebrate population recovery. This in turn relates to the question of performance monitoring the 1080 operations: that is establishing *a priori* a standard which must be met at which point it is deemed the operation is successful. The standard(s) relate to levels of floral and invertebrate population recovery, not just to minimum levels of possum/browser population densities. This issue of performance standards in terms of improvements in environmental quality has not yet been tackled in New Zealand possum/browser control operations.

2.3.4 Relevant

Alan Yen and Rhonda Butcher, Museum of Victoria.

Robyn Coy, Forestry Research Centre, Department of Conservation and Natural Resources, Victoria.

Paul Horne, Institute of Horticultural Development, Victoria.

Rob Taylor, Forestry Commission, Tasmania.

Peter McQuillan and Carol Michaels, Department of Geography, University of Tasmania, Hobart.

Neil Burrows, Information Division, Western Australia Department of Conservation and Land Management, Perth.

Jonathan Majer, Department of Environmental Sciences, Curtin University of Technology, Perth.

Max Traun, Division of Wildlife and Ecology, CSIRO, Forrestfield, Perth.

Sarah Sharp, ACT Parks and Conservation Service, Canberra.

Jeff Clarke, Penny Greenslade, Peter Cranston, Matt Colloff, Entomology Division, CSIRO, Canberra.

2.4 THREATENED PLANT-INVERTEBRATE COMMUNITIES

In New Zealand the protection of remnant islands of native habitat has been a component of conservation philosophy for many years. But one of the problems is identifying important remnants that are not already protected and, of those that are, which ones need management of threats. No systematic collation of information on threatened plant-invertebrate communities has been done in New Zealand using existing information, expert advice or original survey. The closest set of surveys to do this are the Protected Natural Area Programme surveys. However, all but two of these paid no specific or systematic attention to invertebrates.

If DOC, as one of the implementing arms of Government is to meet its obligations under the Convention on Biological Diversity, then one of the most efficient ways it can do so is to identify and protect unique plant-invertebrate communities. In other words, scale up its traditional unit of protection from a species to a community. While it has been argued that it does this already, this protection has not been planned on the mainland with special consideration to unique plant-invertebrate associations. Rather the protected habitats have been singled out on the basis of supposed unique floral and/or vertebrate characteristics with the underlying (not declared) assumption that unique plant/invertebrate interests are being met at the same time. There is ample evidence from research of temperate forests in Australia which disproves this assumption. Thus it is important that DOC takes steps to identify and protect these areas if it wants to maximise its protection of biodiversity for a given dollar investment.

The Western Australian Department of Conservation and Land Management and the Australian Nature Conservation Agency have both invested in protecting threatened communities. Relevant publications and software describe in detail the database, criteria and management of a specialist group. There is also willingness from Australians to share and expert advice with New Zealand.

2.4.1 Research brief

The aim of such a unit in New Zealand would be to create a list of high priority proposals for habitat island protection based on a database of endangered native plant-invertebrate communities in New Zealand.

In particular, the research objectives should include determining protocols for registering a community, establishing relevant software, requesting access to existing databases, establishing networks within DOC conservancies (e.g. specialist invertebrate conservation officers) and Head Office Divisions (e.g., Forest Heritage Trust). Note that these can be modelled on the Western Australian Threatened Species and Communities Unit's mode of operation which has included customised software which they are prepared to share with DOC at minimal cost (contacts at Perth: John Blyth and Alan Burbidge).

A threatened plant-invertebrate community unit would need to employ a scientific validation committee to vet the communities identified as high priority for protection. Some field trips to ascertain ownership and status of priority communities and validate technical data would be necessary but the unit's primary function would be to use existing information. The principal product of the unit would be proposals for protection (covenant, land acquisition etc.). Hence the unit would be providing a service: ready-made proposals on which conservancies and head office staff can act upon.

The unit should focus on private land on the mainland and Chathams and offshore islands. Protected Natural Areas would be included where threatening processes were considered to be still compromising the community. In the first instance the unit's operation would involve canvassing existing databases (e.g. Protected Natural Areas Programme, Sites of Special Wildlife Interest, Wetland Environmental Resource Inventory, Biological sites of significance -Biosites) and DOC field staff, and undertake survey where appropriate. The unit's operation would include setting up, building and managing a database of invertebrate communities which, through meeting prescribed criteria (these can be modelled on the database), need urgent conservation (protection, management and research). The unit would also establish an independent validation expert committee (similar to those used to “check” the species included on DOC’s threatened species list) to review those communities to be finally listed as threatened.

2.4.2 Relevant projects/researchers/institutions

Allan Burbridge and John Blyth, Western Australia Threatened Species and Communities Unit, Wanneroo, Perth, Department of Conservation and Land Management.

Liz Dovey and Jamie Pook, Australian Nature Conservation Agency, Canberra.

3. Specific biodiversity research topics

3.1 EARTHWORM CONSERVATION

New Zealand and Australia have a common history of wide-scale loss of natural ecosystems. Native earthworms are often totally dependent on native and particular associated soil types. Loss of whole vegetation communities has probably included the loss of the native earthworm community, especially if that vegetation community was associated with a unique soil type. It is probable that whole earthworm communities have been lost which had unique combinations of species with restricted distributions. Given the extent of loss in New Zealand of its lowland forests and wetlands, this scenario almost certainly applies to New Zealand as much as it does to Australia.

At least two problems associated with earthworm conservation are evident from discussions with Australian colleagues. These are:

1. The biosystematics of the group are poorly known even compared with other invertebrate taxa and despite many species being large bodied. Morphological differences are often obscure and modern molecular genetic methods are required to distinguish among species. The outcome of this biosystematic problem is that conservation managers have insufficient knowledge about what they are trying to protect, the number of species at risk, or their status.

2. The behavioural ecology of the species creates practical difficulties for study. Some of the large species, such as the Gippsland giant earthworm, live in soils up to 1.5 m or even 6.0m deep. Making observations requires major excavation and hence destruction of habitat, thus potentially compromising the conservation of the species.

In Tasmania native earthworm fauna outside native vegetation has gone completely. With deforestation and fragmentation native earthworms have quite restricted distributions. Exotic earthworms have not invaded the vegetation except along road margins and clearings.

Despite the impact of deforestation and the fact that most native earthworm species inhabit the uppermost soil horizon, it is possible that some large deep soil species have survived burning and tillage. Hence survey of lowland areas in New Zealand is worthwhile -especially using modern molecular techniques for biosystematic comparisons and where remnant native vegetation persists. Minimising stock and feral ungulate numbers to reduce compaction, especially in fertile areas, will be important for the protection of native earthworm fauna as well as other native invertebrates.

3.1.1 Research brief

A biosystematic study using traditional and molecular genetic techniques is required which will corroborate Lee's (1959) taxonomy and plot the distribution of native species in privately owned land. The conservation status of species occurring in private land needs to be determined by comparing their distribution with those in protected natural areas and with historical records. Species needing special conservation investment need to be ranked perhaps using the Department of Conservation's species ranking system. If too little information is available an alternative method of ranking may need to be used.

3.1.2 Relevant projects/researchers/institutions

Dr Beverly van Praagh, Museum of Victoria, Melbourne.

Dr Tim Kingston, Queen Victoria Museum, Launceston, Tasmania

3.2 CAVE-DWELLING FAUNA

Many large cave systems in New Zealand occur on private land as well as on Crown land. Caves in New Zealand are known to have endemic fauna, some with distributions so restricted that these species are known from only one cave. Speleology and cave eco-tourism are growing pursuits in New Zealand and it is already well recognised that use of caves needs to be managed to preserve the geological features. While the same is recognised to be true for invertebrates, the relative importance of protecting caves on and off Crown land and managing them cannot be properly determined until more is known about the cave dependent fauna.

Research carried out by the Western Australian Museum on caves in the Kimberly Ranges has discovered entirely new taxa - even families. Their research suggests that there is poor agreement between morphological and genetic differentiation. Also the vegetation communities around the cave mouths are important buffers for any changes in the environment that might affect fauna inside the caves. Thus because the environments inside the caves are normally stable and in a state of delicate equilibrium, any perturbation (changes in watershed, cave exploration, etc.) can have quite dire consequences for the cave communities. These processes need to be understood as well as simply knowing which species are present.

3.2.1 Research brief

To identify high-risk cave systems in need of urgent protection and/or management. To do this, formal biosystematic survey of cave invertebrate fauna is needed and ecological study of the processes which maintain the integrity of these communities. If some reduction in the scope of the project is necessary, then the fauna survey could be limited to key taxa such as carabid beetles. Further limits could be preset by including only caves on private land or those known to be at some risk. However, other caves may need to be included to gain a perspective on the significance of those already surveyed.

Having completed a significant proportion of the fauna survey, research needs to he designed to learn about the processes which maintain the integrity of the cave communities. The study(ies) needs to focus in the first instance on those processes which are most likely to be subject to interruption by human influence (through land use and/or cave use).

3.2.2 Relevant projects/researchers/institutions

Bill Humphries, Western Australian Museum, Perth.
Note: Other researchers on Tasmanian and Australian interior cave fauna can be contacted through Dr Humphries.

3.3 INDIGENOUS KNOWLEDGE

At least two researchers in Australia are studying (recording) indigenous lore as it relates to invertebrates. The research is being done with the full co-operation of Aboriginal tribal elders and is a collaborative project with the appropriate tribe(s). It is important to note that the perception of biodiversity has a cultural dimension -western science's biosystematics may not correspond to the distinctions made by early Maori for example.

In New Zealand much has been recorded about Maori knowledge of natural history with respect to medicinal plants, plants generally, geology and birds but little on invertebrates. Some work on the names for insects in New Zealand has been done by Wendy Pond. Formally recording such information will have direct bearing on claims now and in future in front of the Waitangi Tribunal, regarding ownership of New Zealand's wildlife, and the Biosecurities Act.

3.3.1 Research brief

To document traditional Maori knowledge of invertebrates in New Zealand. This information would include matching traditional names with modern (western) scientific names and recording any knowledge regarding past distributions and life history. The project would require a survey of all relevant literature (especially historical) and verbal consultation with knowledgeable kaumatua. The latter process would have to be done with due recourse to procedure preferably the project should be a co-operative one with willing iwi.

3.3.2 Relevant projects/researchers/institutions

Alan Yen, Museum of Victoria, Melbourne

Biodiversity Unit, Department of Environment and Sport and Territories, Canberra (commissioned research not published at the time of writing).

3.4 RARE NEW ZEALAND STAG BEETLES (LUCANIDAE: *Geodorcus* spp.)

Research and management into the critically endangered New Zealand stag beetle *Geodorcus ithiganus* has been confounded recently when trying to decide future options. The species exists only as one tiny population on an island "stack" in the Mokohinau Island group east of Auckland. The habitat is probably far from ideal for the beetle: tiny (less than 0.5 ha), drought prone and at risk from fire, rodents, and damage from storms. Too few wild beetles are known for translocation and too little is known about their ecology to adequately identify suitable habitat elsewhere in the island group to receive transferees for reintroduction.

Ideally, one should harvest the wild population for breeding stock, produce eggs/larvae/pupae/adults, then introduce these to new habitat. However, captive breeding stagbeetles has seemed a technical impossibility because of our ignorance of their ecological requirements and the fact that with larvae, pupae and adults one is dealing with effectively three "species" each with their different requirements. The same situation (with the added one of needing more distributional information) exists for some of the mainland rare species: *G. auriculatus* and *G.* n.sp. (Mt Moehau).

Miscellaneous biological information gathered on luncanids included a diagnostic method for differentiating between lucanid larvae and other Scarabaedoidea found in the same type of location. Lucanid larvae all have vertical anal slits -the others are horizontal. Most large flightless species of Lucanid larvae undergo 4 instars. Typically one instar is completed every year. The pupal stage would probably take a matter of weeks -the pupa forming a cell out of mucus and frass. Geoff Montieth (Queensland Museum) has successfully kept larvae in captivity in jars (with breather holes) of woody detritus (as collected from under the logs they use). These survive well as long as they are not disturbed. Pupal cocoons are made against the wall of the jar which serve as reliable indicators of the success of the rearing. Adults have been kept in captivity and have laid. They have been fed using inverted pieces of fruit - the adults burrow up from the underside and suck juices from them.

3.4.1 Research brief

Discussions with Australian colleagues have revealed that luncanids occurring there have been successfully (successive generations) reared and suggested that captive rearing is a feasible option for New stagbeetles. Before this is undertaken, a study should be made on the techniques of captive breeding of New Zealand stagbeetles using a common giant species such as *G. helmsi*. After this has been successfully completed a captive breeding programme using *G. ithiganus* could be started by which time relevant research into its habitat requirements might be finished so that transfer sites in the Mokohinau Islands could be identified.

Practical trials of management methods on Stack H (Mokohinau Islands) should be carried out before translocations including: (1) extending the current test of supplying refuges such as concrete paving stones (larger numbers, layered, partially buried, litter/no litter etc.), and (2) creating larval and pupal habitat by digging 250 mm square pits about 200m deep, in-filling with litter and capping with paving stones.

3.4.2 Relevant projects/researchers/institutions

Dr Barry Moore, research associate Entomology Division CSIRO, Canberra (contacts in Australia with experience captive rearing lucanids, also works on cave-dwelling carabids).

Dr Geoff Montieth, Queensland Museum, Brisbane (contacts with captive rearing experience and reared luncanids himself).

Jack Hasenpusch, the Australian Insect Farm, PO Box 26 Innisfail Qld 4860; Tony Hiller, Mt Glorious Biological Centre, Main Road, Mt Glorious, Qld 4520 (rears luncanids).

4. Conservation issues

4.1 BRUSHTAIL POSSUMS AND BIOLOGICAL CONTROL

4.1.1 Female possum immune response against male sperm

The general issue of possum control in New Zealand was discussed in detail a number of times with scientists and policy makers of sister organisations to the New Zealand Department of Conservation. Some Australian colleagues expressed serious reservations about the desirability of a biocontrol method which could present a risk to Australian brushtail and ringtail possums. They feared the risks of the virus escaping from the New Zealand brushtail population and establishing in Australia. They thought there would be serious public and professional opposition to the virus ever being introduced.

In Australia there has been some public debate over the risks of such a biological control technique and the risks to fox populations in the United Kingdom. However, it seems that the issue of risks to non-target possum populations has not yet been adequately tackled in public debate in New Zealand and Australia. It must be asked: should the research investment continue if opposition to using the biocontrol method is going to prevent its use after its development? If the answer is 'yes" then it seems that some intensive advocacy work will be required.

Further opposition to the technique was voiced centring around the technical problems of finding a reliable vector for a virus in wild populations of possums in New Zealand. The complex ecological interactions of at least three biological agents (virus, vector and possum) present huge technical difficulties - especially given that two are not as yet established in New Zealand. The question of mutation was raised: that of the virus and of the possum's immune system. In the latter the issue is not only one of evolution, but also of catering for the inherent variation which may occur in such a large population as exists in New Zealand.

4.1.2 Monitoring tasks during possum control operations

Although there is a huge effort to monitor the effectiveness of a possum control operation (nowadays usually measured in terms of the percentage change in trapping indices), two problems were identified as still remaining essentially unsolved. The first relates to "performance assessment" -determining what level of improvement in a given environmental variable is required in order to state the control operation(s) have met operational standards (set *a priori*). For example a performance standard with respect to vegetation recovery is not simply measured in some arbitrary but detectable increase in foliage of species fed on by possums. Rather a quantitative figure on the amount of increase in the biomass of these species would be set prior to the operation(s). This figure then is one of the performance assessment criteria measuring the "success" of the operation(s). Other criteria would relate to predetermined levels of bovine tuberculosis found in pasture, forest invertebrate abundance and diversity, etc.

While there may be technical difficulties in measuring (and meeting) these "benchmarks", it has yet to be done in New Zealand and should be. If performance criteria are not preset, then New Zealand runs the risk of outlaying enormous expense on possum control without ever knowing if the investment was worthwhile or should be continued. In order to meet these increased technical requirements research will be required on how to measure beneficiary flora and fauna species.

The second problem relating to monitoring involves calibrating changes in trapping indices to actual possum density (possums per unit area). Possum densities are likely to vary enormously in time and in different habitat types. Hence arbitrarily setting percentage decreases might not have any ecological significance. This obviously relates to the above point about setting proper performance criteria, i.e. answering what density of possums is required to produce a given level of environmental improvement.

4.1.3 Alternative biological control options for possums

An alternative (or at least additional) course of research is to investigate the 15 or so species of possums which occur in New Guinea (all of which belong to the same family as *Trichosurus vulpecula* (F. Phalangeridae)) with the aim of identifying possible naturally occurring pathogens and parasites which could be manipulated and introduced into New Zealand. The latter could be used as vectors for any virus developed for the immune response to male sperm project (assuming baits are not going to be used for spreading the virus). The conclusion from a discussion on confamilials of *T. vulpecula* was that not enough lateral thinking had been done into the possibilities of research into existing biocontrol agents in other species of possums.

4.2 POPULATION DYNAMICS OF FOREST PEST MAMMAL SPECIES

The plan to control possum populations periodically in key forests around New Zealand carries with it the risk of creating an unstable dynamic interaction between the pest species which are related as predators and prey. In particular the predator species (mustelids and cats) could be periodically deprived of a key prey species (rodents) and may switch to native species as prey. Further, the removal of rodents incidentally during possum control may ultimately cause the decline in densities which may in turn allow the return of rodent populations to levels higher than occurred at the outset of control operations. These higher levels of rodents may increase their impact on native species. However, in discussions with colleagues modelling pest mammal species, it seems that the period when rodent densities are likely to be significantly reduced seems too short to interfere with predator-prey dynamics. Thus it is thought that the rodents will re-establish in a very quick time with the possibility that mustelids may diet switch only temporarily. However, it was agreed that the questions raised in this debate are testable and should be investigated.

4.3 MODELLING POPULATIONS OF RARE SPECIES

4.3.1 Case study of Placostylus giant land snails (Gastropoda: Bulimulidae)

A long-term (over 50 years) approach for the management of rare species is required. But is the size of the large enough to survive stochastic processes over a long period? Population viability analysis and other forms of modelling are logical options to pursue - especially if one is to develop minimum levels of management (such as poisoning rodents) over long periods. However, the practical problems gathering essential demographic and breeding data in the field often prevent useful models being developed.

In discussions with modellers in Australia it was decided that modelling generally was still useful for conceptually identifying areas where more information is needed but that modelling was unlikely to yield more explicit information depending on the species concerned. However, where there is a pest species involved in the management of the rare native species, there is scope for modelling - especially the density dependent effects of poisoning on the pest species.

5. Biodiversity conservation research - some comments

5.1 COLLABORATIVE RESEARCH

The most obvious difference I saw between Australian and New Zealand conservation researchers was the higher level of co-operative and collaborative research occurring in Australia. Privatisation in New Zealand seems to have made co-operative research harder to organise. Australia, on the other hand, has almost every conceivable combination operating of co-operation and collaboration between public organisations. Co-operation and collaboration seems more the rule than the exception. In the field of research described in this report, the situation is more the reverse in New Zealand.

Yet for the New Zealand Department of Conservation to support its declared policy of underpinning its conservation management on sound science, the department will need to maintain a scientific capability to retain credibility in the public's eye. "Scientific capability" means employing practising scientists because scientific credibility can only be maintained with the publication of original research. DOC has acknowledged the need for in-house scientific capability (for liaising with other research institutions, organising research and disseminating research findings). Its own scientists cannot, however, meet the increasing demand for science from conservation managers. At the same time the research capability of Crown Owned Research Institutes in New Zealand in areas of responsibility to have increased. Two outcomes are obvious to me from this scenario: (1) must retain practising research scientists and (2) it must collaborate with non-Department researchers. By collaborating and co-operating with other research institutions DOC will be able to take full advantage of their growing expertise.

Most of the large scale research projects relevant to the Department and not funded by it are funded by the Public Good Science Fund administered by the Foundation of Research Science and Technology Clearly there are ad-vantages in Science and Research Division collaborating with other researchers using these funds as paying partners (salary, overheads and operating costs met by the Department). On the other hand, the department must be careful not to blur the boundary between research properly financed by the Public Good Science Fund and operational research, which is its responsibility. The experience of some to date has been that the Foundation has refused bids with Departmental collaboration, on the basis that these research projects should be entirely funded by the Department if they are considered important. Thus it is crucial that senior executive liaison occurs between the Foundation and the Department to clear away this impasse. This situation is changing under current policy direction.

A practical solution is to get FORST’s agreement that specified objectives in a collaborative proposal are DOC’s priority and will be funded by it. Thus obligations to this "operational research" which would not normally fund, is clearly identified and provided for.

5.2 RESTRUCTURING CONSERVATION SCIENCE RESEARCH

Corporatising the Science and Research Division of the Department of Conservation has been mooted many times in New Zealand - especially during the planning stages for the establishment of the DOC. The equivalent is underway in Victoria with the creation of a State Owned Enterprise for research. Lengthy discussions took place between myself and Department of Conservation and Natural Resources, Museum of Victoria and university academic staff on this concept. Most researchers agreed that the change was detrimental to the objectives of conservation.

The most serious problems identified were :

1. An incompatibility of long-term ecological research and short term funding based on annual budgeting.
2. Removing scientific staff from direct involvement with field staff, policy mak-ers and conservation managers was inefficient in terms of providing day to day expert advice to Departmental staff. Thus placing scientific staff into a State Owned Enterprise or similar effectively divorced scientific staff from freely and speedily interacting with the key users of their expertise.
3. The chances of agencies paying for priority conservation research was small. Thus forcing a conservation research organisation to find funds itself was placing it in jeopardy of redundancy. Even if ment funds are available the projects these organisations are willing to pay for are unlikely to match priorities, nor are they likely to fund long-term research.
4. Experience of New Zealand researchers employed in Crown (owned) Research Institutes (all of whom contest for research funding) is that the time spent in making applications and administering projects funded "externally" amounts to a huge amount of effort and time which dramatically reduces scientific productivity.

These and other considerations (such as job satisfaction, staff retention) need to be considered if privatisation of conservation research should occur.

5.3 CO-OPERATION BETWEEN AUSTRALIAN AND NEW ZEALAND RESEARCHERS

I was very impressed by the fact that Australian researchers would so readily give up their time to a relative stranger and discuss their research, especially since I was probably the main beneficiary. Yet the mutual benefits of Tasman links are obvious. As respective conservation organisations in both countries try to expand their knowledge and skills to meet their obligations to protecting biodiversity, mutual exchange of practising conservationists must continue. I believe that New Zealand will never match Australia's diversity of skills, knowledge, and scale of research needed to cope with the challenge protecting our biodiversity. Therefore it is in the interests of the New Zealand Department of Conservation for its scientists and managers involved with biodiversity conservation to visit Australia in the future, and share the expertise of our neighbour.

6. Conclusions

1. I conclude it will be to the advantage of future biodiversity research to:

   - Action the following priority invertebrate research projects as described
   - earlier in the report :
   - Habitat fragmentation and reserve design.
   - Evaluate rapid biodiversity assessment.
   - Indicator species in environmental assessment.
   - Threatened plant-invertebrate communities.
   - Earthworm conservation.
   - Cave-dwelling fauna and their ecology.
   - Indigenous knowledge of invertebrates in New Zealand.
   - Conservation of rare stag beetles in New Zealand

2. Further investigate the use of biodiversity mapping techniques for use in New Zealand.

3. Collaborative and co-operative research with Crown-owned Research Institutes, universities and museums. Urgently set up meetings between senior Department of Conservation and Foundation of Research Science and Technology officials to gain agreement that DOC researchers may collaborate on a self-paying basis with funded researchers without prejudice to the Foundation's funding that project. Investigate ways of creating links with more than one Science and Research Division scientist with the same funded research project; set up management within Science and Research Division to facilitate such co-operative research. Hence create co-operative research projects within the Division.

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Appendix 1

Research topics currently funded or recently funded by the Biodiversity Unit, DEST,Canberra

1. Economics of biodiversity -answering questions like how can economic incentives be created for landowners and industry to help conserve biodiversity, what is the cost of recovering incremental proportions of biodiversity (5%, 10%, etc.) in New South Wales by outright purchase and discontinuing logging to voluntary protection. These questions have been tackled by Mike Young and economist at Wildlife and Ecology at CSIRO, Canberra.
2. Chris Margules (CSIRO Wildlife and Ecology Div.) has studied the efficiency of mapping techniques in identifying areas of various levels of biodiversity.
3. Determining the efficiency of using surrogates for biodiversity. This research determines how much of the total biodiversity is protected if one uses only forests, forests and wetlands, etc. This work is being done by Simon of New South Wales National Parks and Wildlife Service and will be forwarded when finished.
4. Modelling which processes are responsible for the decline in biodiversity - which, how much impact and where these operate.
5. Indigenous biodiversity knowledge -research is being conducted to record what is known and how much is being lost. Related is the issue of the ownership of genetic material: Commonwealth, State, local indigenous people, international interests.