ECOLOGICAL THEORY AND BIOLOGICAL MANAGEMENT OF ECOSYSTEMS

Edited by

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Erratum

p15 end of INTRODUCTION: add
"theoretical questions and at the same time be of use to managers."

p77. column one, third line from bottom of page: insert hyphen between research and management.

p81. column one, fifteenth line from bottom : insert "management" in place of mamagement".

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INTRODUCTION

This publication is the report of a workshop on the theme "Ecological Theory and Biological Management of Ecosystems" held on 23-24 March 1987. The workshop was the result of an approach made by the Division of Wildlife and Rangelands Research, CSIRO to the Department of Conservation and Land Management (CALM) to explore some of the issues seen by managers as problems associated with the management of ecosystems. To make the most of the time a residential location was chosen. This set a limit of 24 people and the composition was evenly divided between those regarded as research workers and those involved in management and planning. Within these groupings were people studying and managing nature conservation areas as well as those studying and managing production forestry. The workshop was structured to provide for interactive discussion groups to explore each of the set topics. The first morning was devoted to 3 prepared lectures to set the scene for the subsequent discussion topics; Andrew Burbidge introducing the theme with Richard Hobbs and Roger Underwood presenting the research and manager's viewpoints respectively. The remaining day and a half was devoted to the nominated discussion topics. The participants were divided into two groups of 12 with a balance of management/planning and research represented in each. The discussion leaders had been contacted 6 weeks before the workshop and asked if they would lead a discussion on the nominated topic. This involved preparing a set of briefing notes and devoting 10 minutes or so at the start of the discussion period to introduce the topic. The total discussion period was one and half hours for each topic and there were 2 groups discussing each topic. A "scribe" took notes during the discussion and these were used by the discussion leader to prepare a five minute summary for the plenary session and to write up the results of the discussion for this bulletin.

All papers and reports published here have been refereed by participants. In the case of the workshop reports they were refereed by at least two of the people who took part in that particular discussion group and then returned to the discussion leaders for redrafting if necessary.

We would like to thank Richard Hobbs and Peter Kimber, who were the other members of the organizing committee, and the participants who worked so hard to make the workshop the success it undoubtedly was. We would also like to thank Rob Hopkins and the staff at the Manjimup Research Centre for help with logistic problems associated with our use of the Perup Field Ecology Centre. This Centre proved to be ideal for such a workshop. We would also like to thank Jill Pryde of CALM's Wildlife Research Centre for typing this publication.

Denis Saunders

Andrew Burbidge

PROGRAM

23 March 1987

1. The why and how of managing biological resources.

   Andrew Burbidge

2. What is ecological theory and is it of any use to managers?

   Richard Hobbs

3. Management, research and ecological theory: the vision and the reality.

   Roger Underwood

Discussion Topic 1. The initiation of research and carrying it through to management. Discussion Leaders: Allan Walker and Geoff Mercer.

Discussion Topic 2. Biogeography and its use for setting of priorities for management. Discussion Leaders: Norman McKenzie and Ian Abbott.

24 March 1987

Discussion Topic 3. Management in uncertainty; using the opportunity to adopt an experimental approach to management. Discussion Leaders: Tony Start and George Peet.

Discussion Topic 4. Monitoring; is it of use in integration of research and management? Discussion Leaders: Angas Hopkins and Graham Arnold.

Discussion Topic 5. Planning/Communication. Discussion Leaders: Susan Moore and Chris Muller.

Discussion Topic 6. Priorities of research and management and the setting of objectives. Discussion Leaders: Barry Wilson and Ken Wallace.

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THE WHY AND HOW OF MANAGING BIOLOGICAL RESOURCES

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WHY MANAGE BIOLOGICAL RESOURCES

This question is basic to the allocation of public finance by society, and becomes even more important in times of economic difficulty when people's and especially politicians' thinking tends to become even more concerned with short-term goals.

The question can be reduced to its most basic parts.

1.Are endangered species worth saving, especially if they are of no economic benefit to humans?

2.Why manage for sustainable utilization when we can produce more in the short-term and leave the solution of problems to later generations who may have more knowledge and better technology?

3.Can management produce cost-effective results?

Endangered Species. Extinction is a natural evolutionary process. Charles Darwin (1859) in his "Origin of Species" said "...as new forms are continually and slowly being produced, unless we believe that the number of specific forms goes on perpetually and almost indefinitely increasing, numbers must inevitably become extinct."

Before Darwin, extinction was a shocking thought to people who believed that species had been created once and for all. Now we have almost come a full circle with some people using Darwin's name to justify man-caused extinctions. These people argue that rare species are headed for extinction anyway, and, therefore, it is a waste of money to try and save them.

The most obvious difference between natural evolutionary extinctions and those induced by humans is the rate. Australia unfortunately provides too many striking examples of this increased rate of extinction since the arrival of Europeans.

In Western Australia, in only 150 years, 17 (12.4%) of the 137 species of terrestrial mammals have become extinct on the mainland and a further 24 species (17.5%) have declined to a small fraction of their former abundance and range. A further 8 species of Australian mainland mammals that did not occur in W.A. at the time of European settlement, plus the Thylacine, are extinct and a further 8 have declined. Fortunately, eight of the 25 species that are extinct on the mainland still occur on continental islands, meaning that 18 species or 7% of Australian mammals are extinct.

Similarly, 104 species (about 1.4%) of plants are presumed extinct in W.A., the overwhelming majority having occurred in areas cleared for cereal growing in the south west of the State (S. Patrick & S.D. Hopper pers. comm.). The exact number will never be known, since it is more than likely that many species were wiped out before they came to the attention of botanists. The W.A. figure of ca 1.4% of the total flora compares unfavourably with only 27 extinct plant species in the whole of Europe (ca 0.2% of the total flora), 39 in southern Africa (0.2%) and 74 in all continental U.S.A. (0.4%) (Leigh et al. 1982).

There are four main arguments for the preservation of species (see Main 1982, Ehrlich & Ehrlich 1983 for a detailed discussion of this topic).

The first is that simple compassion demands their preservation. Compassion develops from a view that other products of evolution also have a right to exist; the needs and desires of humans are not the only basis for ethical decisions. It is fairly easy for most of us to feel compassion for the beautiful and large living things around us (so long as they are not dangerous!) but few feel compassion for invertebrates or micro-organisms, even though vertebrate animals and vascular plants cannot exist without them.

The second argument is based on aesthetics: other species should be preserved because of their beauty, symbolic value or intrinsic interest. Kangaroos, numbats, wildflowers of striking beauty and butterflies of iridescent hue seem automatically to appeal to most members of our society, and we feel a loss if they are not around. However, most of the vital links in the food webs of ecosystems are not obvious to most people and even if they are drawn to people's attention they do not appeal because they are small and insignificant.

The third argument is based on economics: the unique Australian fauna and flora attracts tourists; plants and animals provide all our food; plants, animals and micro-organisms provide medicines and drugs; plants provide perpetually renewable sources of fuel, wood for building and many other products. Any examination of the history of human utilization of wild animals and plants will show that so far we have utilized a minute proportion of the potential that exists in nature. Many biological resources may assume a value in the future. Sometimes something that has been considered "useless" suddenly becomes "useful", e.g. timber from marri (*Eucalyptus calophylla*). Clearly, extinctions reduce our future options. Unfortunately, such arguments often seem to hold little value when weighed up against the often short-term economic benefits of a major development project.

Another difficulty with economic arguments is that they are often impossible to quantify to economists who usually view 10 years as being the maximum period for economic planning.

The final argument, probably the most important, is also the most difficult to sell to the general public because it involves indirect benefits to mankind; it is that other species are vital components of ecosystems that provide humanity with indispensable free services: the life-support systems of our planet. Life-support services provided include the oxygen we breathe, the maintenance of the quality of the atmosphere, the control and amelioration of climate, the regulation of freshwater supplies, the generation and maintenance of soils, the disposal of wastes and cycling of nutrients, the control of pests and diseases, the pollination of crop plants, the direct supply of food and the maintenance of a genetic store from which we can benefit in the future.

Do the rarer components of ecosystems make a significant contribution to the provision of life-support systems? Rarity is a function of species diversity. The usual situation is that, at a given locality, a few species are common and most species are rare. The few common species that perform most of the ecosystem functions are often termed "keystone species". Some biologists argue that conservation action should be aimed at keystone species rather than at rare species; however, rare species may play important ecosystem roles too, which are difficult to detect until a species disappears (e.g. pollination).

A review of whether rare species are worth conserving from a life-support services - ecosystem function point of view needs to examine why some species are rare (Main 1982). Rarity is caused by a variety of "limiting factors" - physical factors like climate, soil or nutrient availability or biological factors like predation, parasitism, food availability, fecundity, etc. What if limiting factors change? Clearly, relative abundance of species in an ecosystem may change also and other limiting factors then become important. A local example of this is provided by the studies of fox predation on rock-wallabies by Kinnear et al. (1988). When predation pressure was removed rock-wallaby populations increased rapidly until other limiting factors such as food availability controlled overall population numbers.

In time, limiting factors affecting species abundance in ecosystems change, either naturally or because of human interference. If ecosystems are to adapt and evolve then rare species must be protected since some of them may be the keystone species of the future. Change in the near future may be rapid because of the climatic changes that will probably result from increasing levels of carbon dioxide and other pollutants in the atmosphere.

Managing for Sustainable Utilization. The concept of sustainable yield is easy to understand when applied to species of considerable economic value, whether they be jarrah or karri trees for timber, tuna or western rock-lobsters for food or ducks for hunters. It simply means harvesting the species at a rate that is sustainable, rather than allowing overharvesting with a resultant loss of the resource.

Sustainable utilization is a concept that applies to ecosystems and the biosphere as a whole. The principle is the same but the control of over-utilization is more difficult; many different sectors of society impact on ecosystems and the biosphere. There is also the problem of knowing how much disturbance ecosystems or the biosphere will absorb before they change irrepairably. Managing for sustainable utilization requires the cooperation of whole societies and, ultimately, the whole world.

Arguing that future generations will be able to fix our mistakes is akin to the proverbial ostrich with its head in the sand. (They actually flatten their long necks on the ground when nesting to try and avoid detection by predators; evolution is not that silly!) Attempts today to rehabilitate degraded environments have a low success rate and are very costly. There is no reason why attempts in the future should be any different and future societies will have even greater problems than ours, partly because of our mistakes, e.g. climatic change and rising sea levels due to atmospheric CO_2 buildup, and partly because of a greater human population.

The effectiveness of management. There are many cases where research into and management of biological resources have proved effective. One of the best known local examples of an endangered species being saved by the application of research results is the Noisy Scrub-bird (*Atrichornis clamosus*), which has increased from one population of around 100 when the species was rediscovered in 1961 to four populations totalling over 450 today (Burbidge et al. 1986). There are many similar examples that could be quoted. As to whether these success stories are cost-effective depends on what value is placed on endangered species.

Endangered species programs often get the limelight, but programs that prevent ecosystems getting out of balance and species becoming endangered are just as, if not more, important and are usually much cheaper in the long run. A good local example is West Australian Petroleum's achievement in preventing exotic animals establishing on Barrow Island during the operation of their oil field (Butler 1987). Barrow Island is the largest land mass in the world that is free from exotic rodents. Its nature conservation values are very high and the environmental costs resulting from establishment of exotics would also be high. The economic costs of eradication of exotics once they became established are likely to be enormous.

HOW DO WE MANAGE BIOLOGICAL RESOURCES?

Although some of us may appear to spend much of our time managing paper and people, our profession actually is the management of biological systems. How good are we at managing? What can science provide to help us?

The Complexity of Biological Systems. It has been estimated that there are about 30 million species in the world, of which only 1.7 million are named. I do not know of any estimate of the number of species in Western Australia, but there are likely to be several hundreds of thousands. These multitudinous species exist in complex interacting ecosystems about which we understand some general principles but know little of the detail. Any analysis of our current knowledge must conclude that we often can not comprehend the whole system we are trying to manage and we usually can not predict the changes that will take place after perturbations. The current state of our science allows us to look only at parts of a system.

Humans have tended to regard the environment as limitless and for 99% of our history that view was correct. Today, however, we can assault the environment in ways that it cannot sustain. Technology has captured our imagination to the extent that many are coming to believe in the "hi-tech solution" - a belief that it does not matter how big a mess we make, someone will invent something that will solve the problem. This almost religious belief overlooks two facts; that new technology is creating environmental problems much faster than it is solving them and that there is no such thing as a foolproof technology, as Chernobyl and Challenger testify.

Clearly, we are grappling with complex problems at a superficial level. The best approach is to understand and remember that fact and act accordingly - we should be conservative as well as conservationist in our approach. We should monitor for and seek any unexpected effects of our actions and modify our procedures accordingly.

General Principles. One set of guidelines we can follow is contained in the three conservation strategies: The World Conservation Strategy (WCS) of 1980, the National Conservation Strategy for Australia (NCSA) of 1983 and the

State Conservation Strategy for Western Australia (SCSWA) of 1987.

The objectives of the WCS are:

1.To maintain essential ecological processes and life-support systems

2. To preserve genetic diversity

3.To ensure the sustainable utilization of species and ecosystems

Within the SCSWA are several key Strategy Directions that are particularly relevant to our workshop. These are presented below in the same order as listed in the Strategy with some comments about our role as researchers and managers.

1.IMPROVING THE CAPACITY TO MANAGE

"Foster an environmental ethic throughout all sectors of the community."

"*This is the most important aspect of the State Strategy... Inherent in achieving this ethic is to develop*:

(i)"a sense of stewardship for our environment and natural resources as a whole, not just those within conservation areas;... and

(ii)a wider exposure to and understanding of the concept of sustainability;..."

Clearly we must be able to demonstrate that we apply these principles to our own work if we are to influence others. We should commit a proportion of our resources to fostering an environmental ethic in the public and ensure that all our educational and interpretative material promotes development of an environmental ethic. For example, we should ensure that our Departmental journal "Landscope" promotes the development of an environmental ethic, and presents nothing that promotes the opposite view. Our commitment to public participation in planning and other facets of our work, such as setting research priorities, will also help foster the development of an environmental ethic. This does not mean we should react to every pressure group, but it does mean that we should react to broad public views as much as possible. We should also be involved in shaping public views through education.

"Emphasize the contribution of the environment to our way of life"

We should commit a proportion of our time to educating people about the dangers of extinction and environmental degradation, particularly in relation to the role of living things in providing life-support systems. Many environmental scientists and managers are committing themselves to the principle of an "ecological tithe", i.e. committing at least 10% of their time to environmental education. Educating people about the plants, animals and environments in Parks, Reserves and State Forests is an important first step to helping them gain an understanding of wider environmental problems. In my view, recreational guides like "Beating About the Bush" should present more educational material. We should also emphasize the contributions reserved lands make to our way of life, e.g. the water catchment functions of State Forest.

"Develop a conserver approach in the use of resources"

Here, too, the best approach is to set an example and promote relevant education in order to convince others. Management Plans are an important method of promoting a conserver approach.

"Recognize the affinity of the Aboriginal culture with the natural environment"

We have made a start to developing cooperative management programs for land that has both nature conservation and Aboriginal significance. Much more needs to be done. Such programs will be of enormous benefit if we are to manage most of our remote reserves.

"Plan to meet the consequences of changes to climate"

"*Continued rises in levels of atmospheric carbon dioxide and other gases which trap heat are predicted to begin affecting our climate increasingly over the next few decades. Early planning, especially for the coastal zone as sea level rises, will mitigate the economic and environmental costs.*"

As far as biological resources are concerned the predicted rise in sea level is far less important than the possible climatic effects, which are predicted to include increasing aridity in the south west. One possible way of planning to mitigate climatic effects on flora and fauna is to define those areas that are likely to be refugia and ensure that they are reserved and managed.

"Integrate land use management and monitoring on a regional basis"

Monitoring of ecosystems, both in relation to natural fluctuations in abundance and in relation to the effects of management practices, is in its infancy in W.A. CALM is developing a strategy and will work out ways of implementing it in the near future.

"Develop and regularly update inventories of natural resources and processes, required for regional planning and management"

Natural resource inventories and knowledge about environmental processes are of value for things other than regional planning and management, having considerable local value as well. Preparing inventories and studying processes are a major function of research in both CALM and CSIRO. The challenge is to commit a sufficient proportion of our resources to it and to set priorities correctly.

2.MANAGING FOR SUSTAINABLE YIELD WHILE PROTECTING LIFE SUPPORT SYSTEMS

"Prevent further decline in species and genetic diversity in Western Australia

"In view of our commitment under the WCS and NSCA to preserve genetic diversity, the continuing decline of species and genetic diversity in Western Australia is of great concern.... Even an expansion of well-managed National Parks and Nature Reserves will not prevent further loss of species and genetic diversity."

This strategy is a major function of CALM. While a continued expansion of National Parks and Nature Reserves will not prevent a further loss of genetic diversity it will certainly reduce the loss enormously and we should continue to press for further reserves even if we cannot manage them at this time. Do we commit enough resources to documenting and managing genetic diversity? I submit we do not. Can we formulate better ways of conserving habitats and species on lands and waters outside conservation reserves? Not an easy task, but its importance indicates that it should continue to have a high priority in research programs.

"Adequately protect and manage representative areas"

In Western Australia we have already done more than some other states and/or countries to reserve areas of nature conservation significance. However, it is clear that many more areas should be reserved and that more needs to be done to adequately protect conservation reserves from interference and degradation. Too few of our existing conservation reserves are Class A and mining remains a threat to the protection of some areas and the reservation of others. As we all know, many conservation reserves receive no management at present, so it is a long way from "adequate".

"Implement a conserver approach in the use of resources"

"As part of a conserver approach, consideration should be given to:

- lowering per capita consumption by reducing waste;
- substituting alternative resources where applicable;
- maximizing yield per unit of resource;
- production of higher value goods, thus achieving the same economic benefit while conserving the rate of resource use; and
- further attention to recycling/re-use."

We, above all other sectors of society, should maintain and improve a conserver approach to the use of resources entrusted to our Department and we are doing a lot in this regard. No doubt, there is still much room for improvement.

"Modify inappropriate management practices to conserve natural resources"

Some people in society believe that some CALM management practices are inappropriate. We know we do not monitor the results of our management practices sufficiently; perhaps much of the heat would be removed from some of these arguments if we did.

"Rehabilitate degraded lands, waters and ecosystems"

While we have made major commitments to rehabilitate some lands under our control, other land, such as the rabbit-degraded areas of Nullarbor Plain reserves and cattle-degraded parts of Kimberley reserves, have received no attention.

"Avoid disturbing sensitive environmental areas where viable alternatives are available

"Development options in biologically productive areas, such as wetlands and islands, should be subject to detailed environmental impact assessment."

This strategy sounds too much like a meaningless compromise to me. CALM manages the majority of W.A.'s islands and many of its wetlands, as well as other biologically productive areas. We should argue against degradation of these environments under any circumstance.

"Review regularly the state of the environment in W.A. and progress toward the objectives of the Strategy

"Agencies responsible for managing sections of the Western Australian environment should report regularly on the condition of each facet. These reports should be integrated by a lead agency and the findings reported to the community."

Clearly, this strategy relates to CALM and associated research agencies. We need to work out an efficient way of reporting the state of that part of the environment entrusted to our care.

THE FUTURE

The group of people at this workshop represents a cross-section of the scientists and managers associated with the natural biological resources of Western Australia. I believe that the challenge for us is to ensure that we and our colleagues develop and maintain a strong biological background and a commitment to nature conservation. Otherwise, the management of biological resources will be superficial, concerning itself too much with people-issues like hazard reduction for the protection of adjacent property, rather than dealing with important but complex issues like the management of ecosystems. Protection of adjacent lands is important, since conservation is unlikely to succeed if there is local opposition to it; the challenge is to convince local communities that they benefit from biological resource management and to develop joint arrangements that protect all interests.

Perhaps one way of measuring the state of the environment in relation to our capacity to manage biological resources is to work out what proportion of CALM's resources are actually spent on effective research and biological management and then see if the proportion increases with time.

REFERENCES

ANON. (1984). A National Conservation Strategy for Australia. Australian Government Publishing Service, Canberra.

BUTLER, W.H. (1987). Management of disturbance in an arid remnant: the Barrow Island experience. In: "Nature conservation: the role of remnants of native vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.). Surrey Beatty and Sons, Sydney.

BURBIDGE, A.A., FOLLEY, G.L. and SMITH, G.T. (1986). The Noisy Scrub-bird. Western Australian Wildlife Management Program No. 2. Department of Conservation and Land Management, Perth.

DARWIN, Charles (1859). "The Origin of Species". John Murray, London.

EHRLICH, P.R. and EHRLICH, A.H. (1983). "Extinction: the causes and consequences of the disappearance of species." Ballentine Books, New York.

INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE AND NATURAL RESOURCES (1980). World Conservation Strategy: Living Resource Conservation for Sustainable Development. IUCN, Switzerland.

KINNEAR, J.E., ONUS, M.L. and BROMILOW, R.N. (1988). Fox control and rock wallaby population dynamics. Aust. Wild. Res. **15**.

LEIGH, J.H., BRIGGS, J.D. and HARTLEY, W. (1982). The conservation status of Australian plants. In : "Species at risk: research in Australia" (ed. Groves, R.H. and Ride, W.D.L.) Australian Academy of Science, Canberra.

MAIN, A.R. (1982). Rare species : precious or dross?. In: "Species at risk: research in Australia" (ed. Groves, R.H. and Ride, W.D.L.). Australian Academy of Science, Canberra.

STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA CONSULTATIVE COMMITTEE (1987). A State Conservation Strategy for Western Australia. Bulletin 270, Department of Conservation and Environment, Perth.

WHAT IS ECOLOGICAL THEORY AND IS IT OF ANY USE TO MANAGERS?

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INTRODUCTION

A criticism often levelled at much ecological research is that it bears little relevance to real-world problems associated with the management of biological resources (e.g. McKellar 1987; Fig. 1). There appears often to be an unbridgeable gulf between the theoretical constructs of ecology and their actual application. Even within the science of ecology, researchers are seen as being divided into those who deal primarily with mathematical models based on theoretical premises and those who collect field data and attempt to answer "real" problems. Indeed, it has been the case that many field ecologists have little training in mathematics and many theoretical ecologists make little effort to get into the field. However, the distinction between theory and practice is not as clear cut as some would make out.

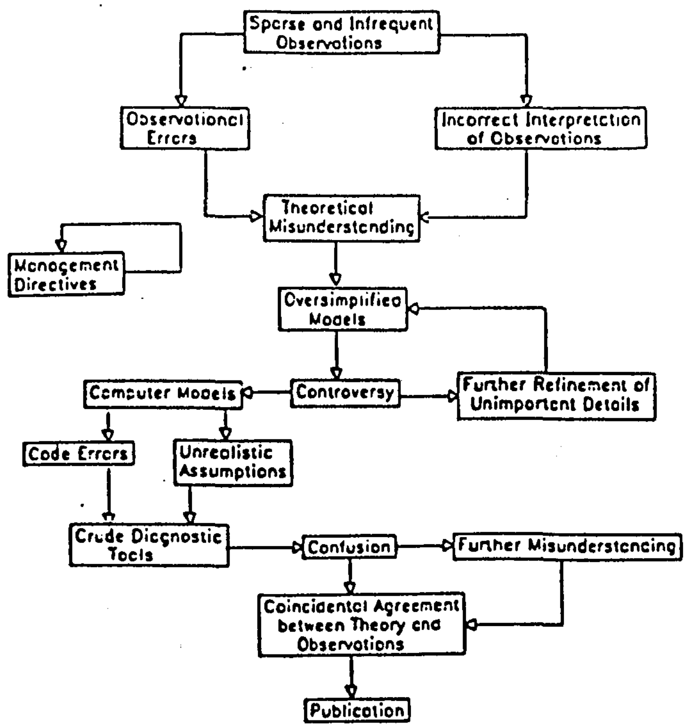
In this paper I want to illustrate that ecological theory is essential to both field ecologists and managers since it underpins everything that they do,. I use "theory" in its broadest sense here, which can be described as a "systematic statement of principles and methods" (Levin 1981), which serves to organize our thoughts and perceptions and aids us in designing our research to be more effective. Thus ecological theory is not simply a collection of mathematical formulae and is not practiced only by theoreticians. Much current ecological theory has been developed from careful field observations by people who are primarily field ecologists. Managers also use ecological theory in almost every management decision they take, even if they do not explicitly recognize that they are doing so. In that respect some aspects of theory have become "second nature" and no longer recognized as theory. It is thus impossible to separate theory and management at this broad level. There is, however, a difference between the broad theoretical basis of ecology and the application of individual ecological theories. In this paper, I will first outline the basic theoretical framework of ecology, and then go on to look at problems associated with particular past and current theoretical arguments. I will then discuss how ecological theory impinges on management questions and how theoretical approaches can be of use to managers. Finally I discuss how research can be designed to address important

THE THEORETICAL FRAMEWORK OF ECOLOGY

Ecology is still a relatively young science and as such does not have a rigid formalized set of theories (e.g. McIntosh 1980). Lawton (1974) commented that "Ecology suffers from a surfeit of fascinating but apparently unrelated observations, superimposed on an acute shortage of general theories". The search for general theories has often been fruitless, and a reason for this lies in the vastness of the subject matter of ecology. Ecology deals with everything from genes to global processes, from arctic tundra to tropical rain forests and from microbes to blue whales. The very diversity of life that ecology sets out to study and explain conspires to thwart any generalities that are put forward. A theory that works in a desert probably will not help much in the intertidal zone.

The level of prediction possible in ecology is also low compared to other sciences. In chemistry it is possible to say with certainty that if you add compound X to compound Y you get a predictable reaction which produces compound Z. The exact rate of the reaction may vary with temperature, but the result is always the same,

Fig. 1. The way in which managers might sometimes conclude that ecological research is carried out (original by S. Briggs).



and the laws governing the process are well understood. In ecology such a level of predictability is not possible because of interacting species or system components, environmental variability and the general level of complexity confronting the ecologist. Ecologists have spent a long time searching for a theoretical basis for making such predictions, but it may be that more limited theories relevant to particular systems or subsystems will be more productive (e.g. Oster 1981; May 1986).

Ecology has however developed a broad theoretical framework which helps to put some order into the apparent chaos. This relies on a hierarchical arrangement of levels of organization, ranging from the individual organism through populations, communities and ecosystems to landscapes and finally the entire biosphere (Table 1). These different levels of organization have distinct sets of processes which operate mostly at a certain level, and theoretical concepts have been derived for each level. Thus, for instance, at the community level ecologists have developed the concepts of niches and food webs to formalize the interrelations between species in any given assemblage, while the concepts of stability, resilience and succession deal with community change and response to disturbance. These general concepts can be widely applied; niches and food webs can be studied equally well in the desert or intertidal zone. Concepts such as population growth and regulation, succession and hydrologic cycles are also central to management decisions. It is impossible to manage a species without some consideration of its population processes.

A potential problem involved in the transferring of ecological concepts to management is that ecological and managerial units do not always coincide, especially at larger scales (Table 1). It may be relatively easy to define an individual population and treat it as a management unit. However, nature reserve boundaries seldom follow natural community or ecosystem boundaries (e.g. Newmark 1985; Schonewald-Cox & Bayless 1986) and landscape and regional units are often the responsibility of several different authorities. There is an increasing awareness of the need to

Table 1. Ecology: A Theoretical Framework

Organisational level	Key concepts and processes	Corresponding management level
Individual	Energy balance Physiological and behavioural responses	? Species reintroduction
Population	Population growth and regulation. Density dependence/ independence. Species interactions. Coevolution Population genetics	Species-oriented management
Community	Environmental gradients, ecotones. Niche theory Diversity, food webs Stability & resilience Succession	Reserve Management
Ecosystem	Energy flow Trophic levels Biogeochemical cycles	Reserve management
Landscape	Geomorphologic processes Hydrologic cycles Connectivity Island Biogeography	Catchment, Regional, Multi-authority Management
Regional	climatic patterns	
Global	Biomes Greenhouse effect Acid rain Global climate etc.	National/ international

manage natural systems as ecological units which may cut across several legal and political boundaries (e.g. the Murray Catchment in eastern Australia). The idea of landscape level "networks" is also gaining support (e.g. Forman & Baudry 1984; Noss & Harris 1986). This involves the integration of smaller land-use units (e.g. reserves, farmland, road verges, etc.) into a larger integrated unit. The application of such ideas often requires cooperation between several management authorities.

CAN THEORY HELP MANAGEMENT?

The theoretical framework of ecology given in Table 1 is imbedded in all aspects of research and management of natural systems. However, some more detailed theoretical aspects may apparently be of little day-to-day use to managers. In this section I outline some of the areas where particular ecological theories have been applied successfully to management situations.

Perhaps the most successful application of theory has been in harvesting situations. The concept of maximum sustainable yield has been applied widely, especially in forestry and fisheries. Forestry, in fact, embodies many aspects of ecological theory and some of plant ecology's most robust concepts have come from forestry (e.g. the -3/2 law for self-thinning; Westoby 1984). Theory has helped explain the dramatic drop in fish stocks which has often occurred following increased fishing pressure. The concept of multiple stable states for populations (e.g. May 1977) predicts that increases in harvesting rates can lead to a sudden switch from a relatively high stable population size to a much lower level. This

Fig. 2. Figure from Shimwell (1971) illustrating hydroseral succession. The succession is inferred from the vegetation zonation. The pollen profile on the left is hypothetical - actual analyses by Walker (1970) indicated that the supposed sequence was incorrect.

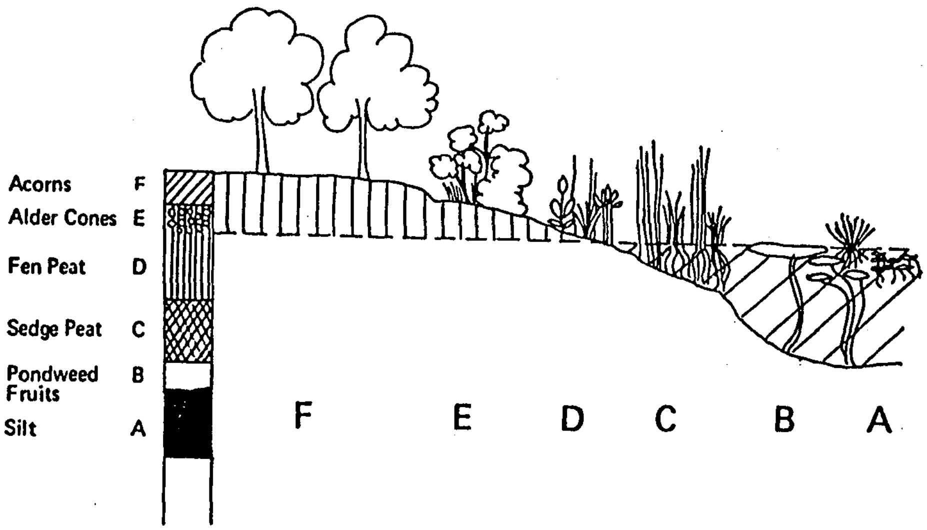


Figure 34. Hydroseral succession and the zonation around a lake. A, zone of floating aquatics; B, rooted acquatics; C, reedswamp; D, sedgemarsh; E, fen-carr; F, mixed mesophytic woodland.

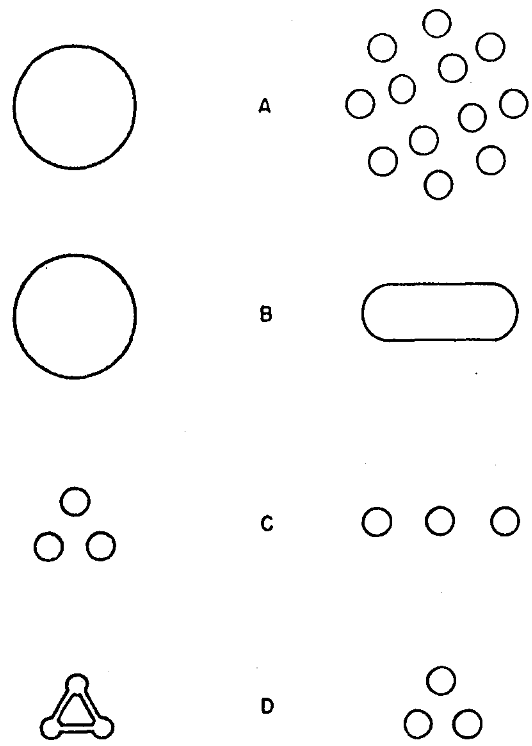
concept is now implicit in the development of more rational fishing policies. The concept of multiple stable states has also been used to explain periodic outbreaks of pests such as spruce budworm in Canada (e.g. May 1977; Moss et al. 1982), and to develop more rational use of herbicides.

A theoretical analysis of the Antarctic ocean ecosystem is also leading to an understanding of changes brought about by whaling and is central to the development of an ecologically sound policy on krill harvesting (May et al. 1979; Laws 1985). The history of whaling has been one of a total rejection of the maximum sustainable yield idea in favour of "mining" for maximum immediate profit (Cherfas 1986) with the result that the bigger whales suffered dramatic population declines. An analysis of the Antarctic food web indicates that the decline in krill consumption due to reduced numbers of large whales has been compensated for by an increase in consumption by smaller whales, seals and birds. An argument for krill harvesting by humans has been that it would simply mop up the surplus not utilized by the larger whales, but it seems likely that this surplus is largely illusory. Any increase in harvesting may therefore affect the rate of population growth of the now rare larger whales. Without an understanding of food-web interactions such problems could go unnoticed - it should be noted, however, that a huge amount of empirical data was also needed to reach these conclusions.

PROBLEMS IN ECOLOGICAL THEORY

Although the theoretical framework in Table 1 can be applied widely and the previous section has indicated that theoretical considerations can be helpful in management, there is still much debate over many more detailed ecological concepts and the relative value of different theoretical approaches. This debate makes the application of theory difficult: how can a manager take theoretical aspects into account when the theorists are bickering amongst themselves about which theories are correct? Discussion in science is, of course, healthy and necessary, but much of the theoretical discussion in ecology often has little obvious relevance outside the seminar room. Johnson & Bossert (1980) suggest that managers find theoretical approaches "faddish, speculative

Fig. 3. "The geometrical rules of design of natural preserves, based on current biogeographic theory", from Wilson & Willis (1975). The configurations on the left are assumed to be superior to those on the right.



and lacking in sustance; in other words not practical" and also "cannot use methods which are new and consequently potentially controversial".

Theory is often developed with little or no data, leading to what Slobodkin (1974) has termed "ecological nonsense with mathematical certainty". A further problem is that "Theoretical ecology has only too often developed models without sufficient regard for the basic natural history of the organisms being studied" (Wangersky 1970). Such theory is the happy hunting ground of much pointless ecological debate. In other cases, theory is developed from a particular system and extrapolated to all other situations, where it is of dubious relevance. Many arguments in ecology are between researchers who study totally different organisms. It should not come as too much of a surprise to find that the population or community processes of copepods and birds are different in some respects. Further confusion arises from concepts which are proposed and become enshrined in the ecological literature and textbooks without being rigorously tested.

An example of this is the classical "hydrosere" first proposed by Clements (1928). Observed zonations of plant communities around in-filling lakes or ponds were interpreted as representing a successional sequence; i.e. starting from open water and developing through reedswamp to fen-carr and finally oak woodland (Fig. 2). This developmental sequence has been used in many textbooks as a classic example of succession (e.g. Shimwell 1971). It is now a classic example of the pitfalls of inferring temporal sequences from spatial patterns. Walker (1970) carried out detailed pollen analytical work and was able to show that vegetation development in in-filling lakes was not unidirectional and that the end point of the hydrosere was likely to be bog, not woodland. Although adjacent, the oak woodland was never part of the same successional sequence. It should be noted, however, that there are other excellent studies of succession which have stood the test of time much better (e.g. vegetation development behind retreating glaciers; Crocker & Major 1955).

The whole conceptual framework for succession has also undergone radical change in the past 20 years, with a move away from the original ideas of the community as a "superorganism" and of climatic climaxes (Clements 1928; see Miles 1979). However, old ideas die hard, and it is difficult to find a modern textbook which does not include major sections on Clements' ideas. The persistence of Clementsian ideas had a significant effect on how research was carried out. M.B. Davis suggested that in the United States, "We do not know what the virgin vegetation of the pioneer days was like because all the ecologists were so busy looking for non-existing climax that they forgot to record what was actually growing there" (quoted in Colinvaux 1973). Later ideas have also stayed beyond their usefulness. For example, Odum (1969) produced a list of 24 trends in ecosystem properties that could be expected in the course of succession. This list is still widely quoted despite the fact that many of the expected trends are now known to be wrong or at least not general.

Theoretical misconceptions, or theories put forward without adequate supporting data can present problems for managers. Further, the relative youth of ecology as a science means that its theoretical framework is still evolving and the emphasis of debate is constantly changing. Factors not considered important (or not considered at all) 20 years ago now occupy a central place in much research. An example of this with important management implications can be found in the Australian arid zone. Ross (1969) put forward an outline for an "integrated ecology of arid Australia" and listed the major components of the system. Nowhere in the paper was fire mentioned, and yet now fire is considered one of the major influences in the arid zone (e.g. Saxon 1984; Griffin & Freidel 1985).

This example is symptomatic of a more general change in the way natural systems are viewed. Traditional concepts are often based on the assumption of equilibrium, and in fact many current models still contain this assumption, if only because it makes the mathematics easier. But is is becoming clear that real systems often have non-equilibrium dynamics, and this dramatically alters the management approach required (e.g. White & Bratton 1980; Mooney 1984; Lewin 1986).

ISLAND BIOGEOGRAPHY AND CONSERVATION

Few areas of ecology openly admit to having a "theory", but island biogeography is one, and island biogeographic theory has been applied to the problems of nature reserve design and selection. It is worthwhile exploring this in some detail, especially since this is an area of great potential interchange between theory and practice.

Wilson & Willis (1975) produced a series of "geometric rules of design of natural preserves, based on current biogeographic theory" (Fig 3) in which they suggested that certain sizes, shapes and configurations of reserves would result in lower extinction rates. It should be noted that the authors provided no data on which their rules were based, and in fact their hypotheses had been previously rejected for publication in both Science and Bioscience (Willis 1984). The book in which their work was published was later criticized as "a most frustrating volume in its lack of data and supporting evidence for hypotheses presented" (Peet 1976). Despite the rather shaky foundations for the ideas, Wilson & Willis (1975) put them forward as recommendations to planners and managers of natural parks and other natural preserves, and these recommendations were subsequently adopted by IUCN (1980) as guidelines for reserve selection. Considerable debate has followed on the use of island biogeographic theory in conservation (reviewed by Soule' & Simberloff 1986; Boecklen 1986), but its incorporation into the World Conservation Strategy led Simberloff & Abele (1984) to conclude that "a theory, even a partially discredited one, can impress non-experts".

Details of Wilson & Willis' scheme have also been adopted elsewhere. For instance, the Conservation Strategy for Western Australia states that "Conservation corridors are important for the maintenance of representative systems of flora and fauna, especially in regard to migratory fauna" (SCSWA). This certainly represents a useful guiding principle, but it is only really a working hypothesis and the actual database on which it rests is very small (e.g. Forman & Baudry 1984; Dendy 1987). Many authors have suggested that corridors must be important for wildlife (e.g. Saunders 1986; Bridgewater 1987), and they certainly have a useful function in other ways such as providing windbreaks. Current research in the W.A. wheatbelt by D.A. Saunders and co-workers is now producing the first good evidence that vegetation corridors are used by wildlife to move between reserves. Much more work needs to be carried out on how animals perceive and utilise corridors before we can assess whether management strategies are being successful.

Recent debate has centred on the so-called SLOSS problem (single large or several small?), which deals with the contention that a single large reserve is generally preferable to groups of small ones. The general assumption is that this should be so if all else is equal, but clearly all else rarely is equal and there are many factors which can confound the area effect (Soule' & Simberloff 1986). The SLOSS debate has generated a lot of heat in the ecological literature and is apparently far from being resolved (e.g. Murphy & Wilcox 1986; Lahti & Ranta 1986).

Recent attempts to use island biogeographic theory in conservation management have found it of less use than basic ecological information (e.g. Kitchener et al. 1980; Lahti & Ranta 1985; Zimmerman & Bierragaard 1986). The latter authors are particularly scathing about the application of island biogeographic theory to conservation; "Our results ... lead us to conclude that calculation of reserve sizes based solely on species-area data can never be more than uninspired guessing. Intuitive guessing about characteristics of a faunal reserve made by the field biologists involved would probably achieve better conservation results. If the impressive brainpower and effort used in repeated vain attempts to extract conservation strategy from biogeographic theory were instead devoted to autecological research, how much better would conservation be served?". It is interesting to note a recent paper on the selection of a conservation reserve network in SW Queensland (Purdie et al. 1986). This subject would appear to be a prime candidate for the application of island biogeographic theory, but it is not referred to once in the paper. Reserve selection was instead carried out on the basis of field assessment of conservation value.

The case of island biogeographic theory has all the ingredients which tend to make managers suspicious of ecological theory, i.e. wide acceptance of a theory based on assumption rather than data, continued argument as to its validity, and the diversion of resources from more directly "useful" research. Nevertheless, the proposition that island biogeography can be applied to conservation has generated a lot of research and useful debate on the important characteristics of nature reserves. It has provided a hypothesis to be tested and modified, on the basis that you have to start somewhere. It can thus be regarded as providing useful guiding principles until the ideas are refined on the basis of further data. This highlights the need for researchers to make sure that they point out the limitations of current theory, and for managers to be kept informed of recent developments.

RELEVANCE TO MANAGEMENT

The foregoing discussion of problems involved with ecological theory serves to indicate that the transfer of theoretical considerations to management problems is not easy. I now go on to consider how ecological theory and research can be more effectively applied to management problems.

To the ecologist everything is possible, within the constraints of the natural system. The biological world presents limitless scope for research, and researchers can spend their entire lives flitting about in this sea of research questions, constantly coming up with new problems and new research directions. The manager's view of the world is, of necessity, more restricted because factors other than the biological system have to be involved (Fig. 4). In the terminology of decision analysis (Norton & Walker 1985; Fig 5) the managers' perceptions of ecological problems are different from the researchers because they are constrained by more factors. The options available to managers are restricted by practical feasibility, environmental acceptability, economic desirability and, in many cases, political advantage. These different factors may only have a small area of overlap or may not overlap at all, in which case conflicts arise. Successful co-operation between managers and researchers requires that the researcher recognises these additional constraints and that the managers point out the most appropriate options. This does not mean, however, that all research should be concentrated on the small overlap area since advances in technology can alter the practical and economic feasibility and changing attitudes can alter environmental and/or political acceptability. A function of research therefore is to indicate possible expansion of the range of options open to managers.

Note that, in this context, research is assumed to be problem-orientated, and this is taken as a pre-

Fig. 4. Differences in perceptions of options available between researchers and managers.

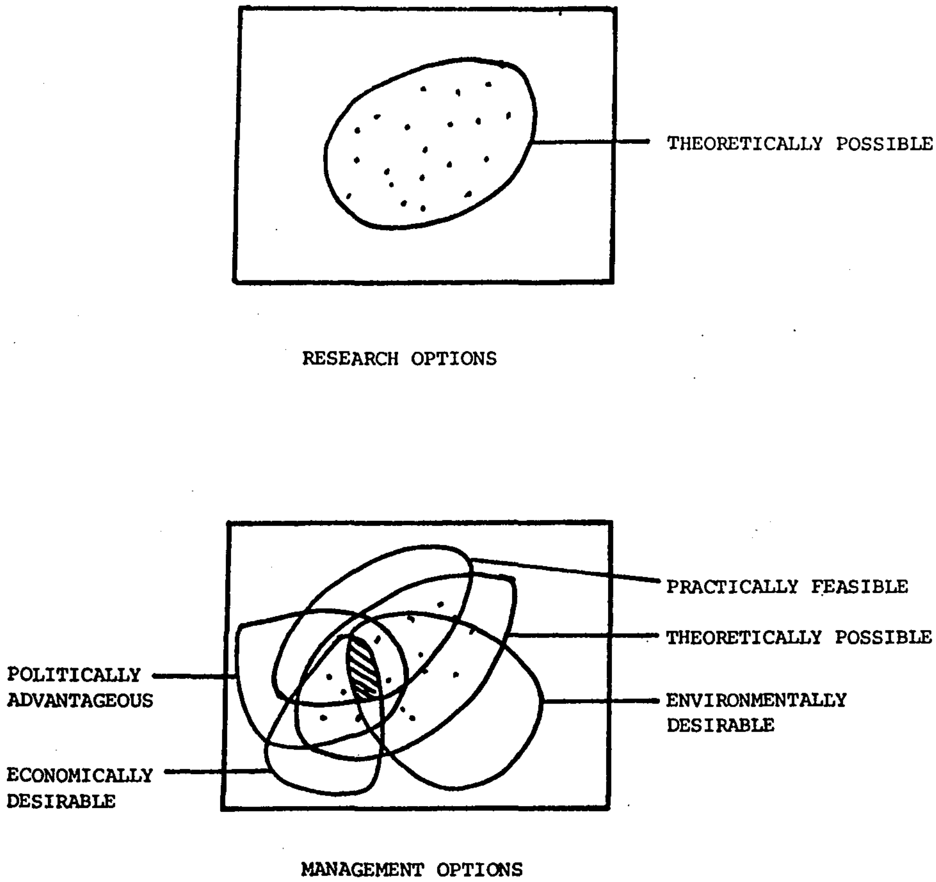
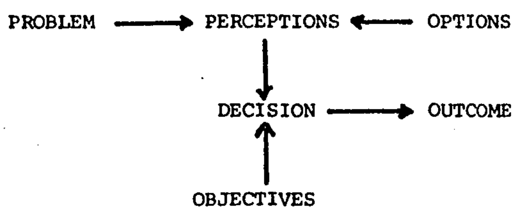


Fig. 5. A decision analysis approach illustrates the relationships between perceptions, options and the decision making process.



requisite for relevance to management. While this approach is valid where management does involve dealing with specific "problems" (e.g. pest control), problem definition becomes harder in more general conservation management. Problems to be dealt with range from fairly specific topics such as the maintenance of particular species or populations through to the maintenance of biotic/genetic diversity. Relevant research problems thus include a wide range of questions which fall into three main categories:

1. What's there?
2. What's it doing?
3. How do we manage it?

These three questions can be thought of as an idealised sequence for a research program - i.e. a series of surveys and sampling programs followed by more detailed population, community or ecosystem studies which lead to management prescriptions. Questions 1 and 2 could be thought of as non-applied compared with question 3, but in reality the distinction is not so clear, simply because you need some knowledge of 1 and 2 before you can answer 3.

This can be illustrated by a hypothetical problem concerned with managing a hypothetical animal (Fig 6). To establish the requirement and/or priority for management, surveys are conducted to determine the animal's current range and status. More detailed studies are then required to determine its life history characteristics, population dynamics and habitat requirements. These in turn require some information on interactions with competing species and predators, the population dynamics of its food organisms and the dynamics of its habitat. This then requires information on the vegetation dynamics of its habitat and processes such as succession, nutrient cycling and so on. Management decisions can, and usually have to, be made at any stage in this investigative hierarchy, but decisions can be made with more confidence as more information becomes available. Note that the theoretical concepts discussed earlier (Table 1) are prominent amongst the information required for management. Note also that the information required concerns processes rather than entities - i.e. the processes of predation, competition, succession, nutrient dynamics have to be quantified, and it is through manipulation of these processes that the management of the organism will proceed. Thus although the organism itself was the initial object of management, it is the manipulation of basic ecological processes which has to be achieved. This has been argued previously by Main (1981), and must underlie any management decisions. The dynamic nature of natural systems must also be recognised - natural change has to be recognised and dealt with (e.g. White & Bratton 1980; Lewin 1986). Vegetation succession, changes in animal population sizes and the impacts of infrequent events such as storms or floods are examples of factors which have to be considered in management - natural systems are rarely static entities.

STRATEGIC VERSUS OPERATIONAL RESEARCH

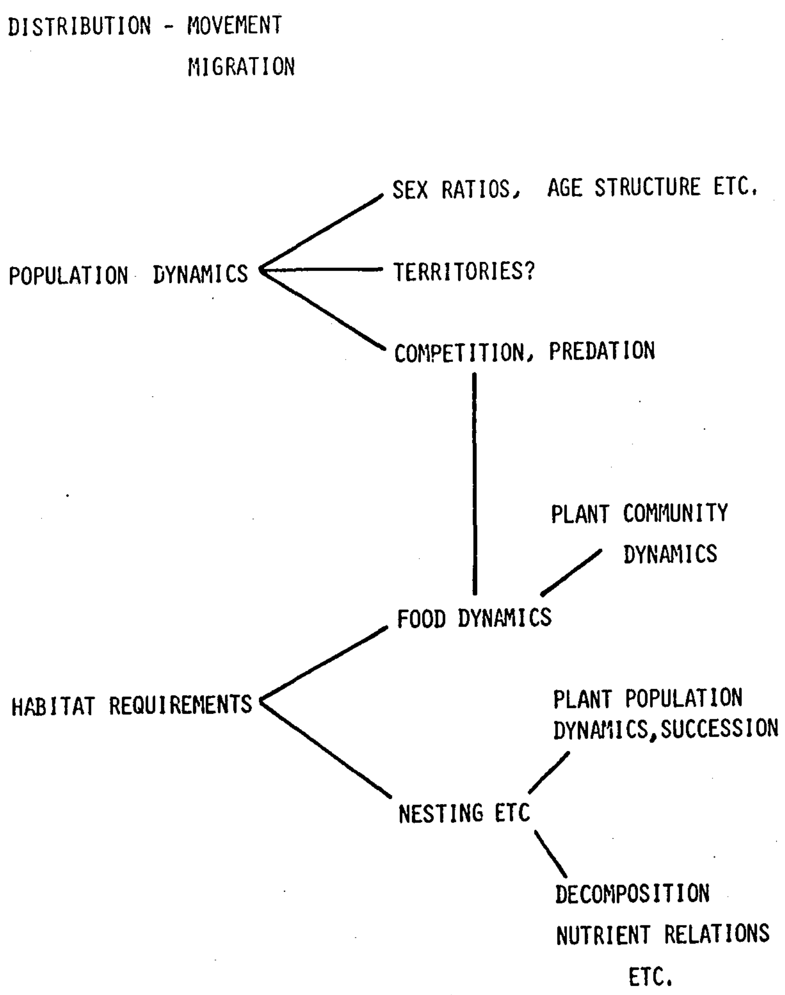
A distinction must be made between research which aims at improving the actual management process itself (i.e. operational research) and research which aims to provide more general guidelines for management (strategic research). Although the first type can be considered more directly and immediately applicable, the second type is of equal importance since it can help channel management operations in the best direction. Strategic research should lead to a better understanding of the basic ecological processes which have to be manipulated to achieve the desired management goals.

An example of this comes from recent work on road verges in the wheatbelt (Arnold et al. 1986). In this study we looked at the status of road verges and their usage by wildlife. A finding of the study was that numbers of small insectiverous birds in the road verge vegetation increased with an increase in the area of native vegetation nearby. Although this study provides no information on the management of road verges per se (i.e. how to control weeds, regenerate trees, etc - "operational"), it does indicate that management effort should perhaps be concentrated on relatively short verges connecting large area of bush, compared with longer, more isolated verges.

THEORY AND MANAGEMENT - WHERE TO NEXT?

In this paper I have tried to outline both the necessity to consider ecological theory in management and also the problems involved in doing so. There is a basic requirement to deal with fundamental ecological processes if conservation management is to succeed. This requirement has to be viewed in the light of other constraints, but failure to meet it will result in the subsequent

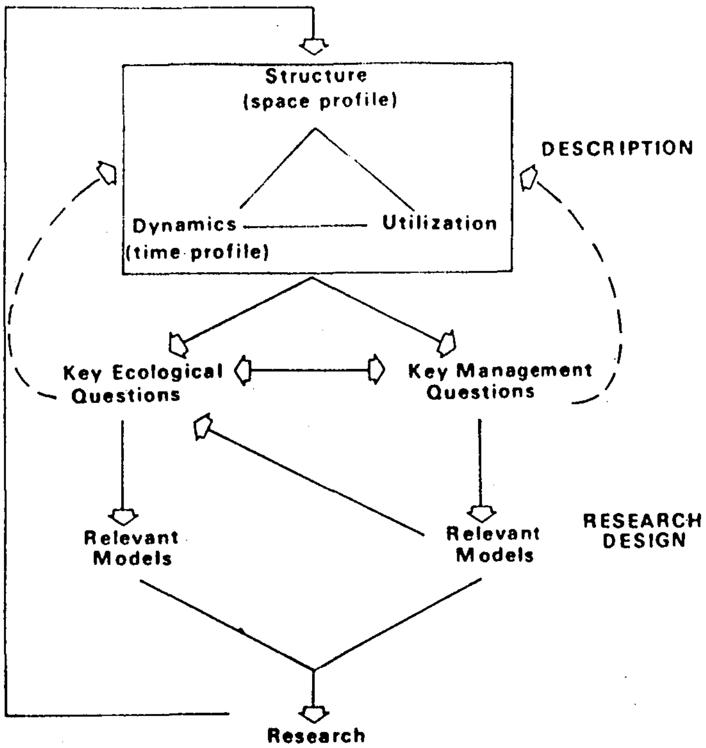
Fig. 6. Information required for adequate management of a target species.



failure to meet the goals of conservation. Thus ecological concepts such as succession, nutrient dynamics and so on should have a central place in management decision. Most management decisions are based on ecological theory, even if the manager does not realise it because the principles are so deeply ingrained. However, managers must also realise that current theoretical development may have major impacts on their activities. The relevance of detailed ecological theory may be difficult for the manager to assess. I suggest that ecologists need to point out clearly the empirical base on which their ideas are founded. A major problem at the moment is that it is very difficult for the non-expert to assess the status of a "theory" - i.e. is it just a good idea or has it been rigorously checked against the real world? In general it seems that there is no substitute for good empirical data for the formulation of either theory or management decisions.

There is a need for greater cooperation between researchers and managers so that theoretical developments can go hand in hand with practical requirements (e.g. Hopkins & Saunders 1987). Walker et al. (1978) suggested an approach in which key ecological questions and key management questions are formulated in parallel so that research can be designed accordingly (Fig. 7). They also suggest that "Research effort would be carried out simultaneously at a fundamental research and management-oriented level. The two are interconnected and the development of each

Fig. 7. Suggested procedure for an ecosystem study (from Walker *et al.* 1978).



should influence the other". This therefore represents an extremely interactive process, with theoreticians, field ecologists and managers all having an input to the formulation of research programs. To complete the picture, Figure 7 should be extended to include further arrows from research through to management and monitoring, with a feed back loop leading to further questions and models. There are problems associated with this scheme; for instance, the timescale of fundamental research is often much greater than that for applied research. Applied research is also often much more productive if some of the basic work has already been done. However, we now rarely have the luxury of separating basic and applied research completely, and they should at least be considered in an integrated framework. Researchers should also be able to take advantage of management operations for the provision of ready-made experiments, while cooperation from managers could allow the design of large scale experiments which would otherwise be impossible (e.g. the Wog Wog experiment; Margules 1985). This then leads to the development of research programs which collect empirical data which is useful to managers and at the same time aids in the development or testing of ecological theory. Closer contact between researchers and managers should improve communication and make for easier transfer of information and ideas. Such active cooperation between researchers and managers should lead to increased awareness of each other's problems and proccupations and should ensure more effective research and more successful application of ecological theory.

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REFERENCES

Arnold, G.W., Algar, D. and Hobbs R.J. (1986). A survey of the flora and fauna in road verges in the Kellerberrin district. Report to the W.A. Roadside Verges Conservation Committee.

Boecklen, W.J. (1986). Optimal design of nature reserves: consequences of genetic drift. Biol Conserv. 38: 323-338.

Bridgewater, P. (1987). Connectivity: an Australian perspective. In : "Nature Conservation: the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.) pp. 195-200. Surrey Beatty, Sydney.

Cherfas, J. (1986). What price whales? New Scientist 110 : 36-40.

Clements, F.E. (1928). "Plant Succession and Indicators." Wilson, New York.

Colinvaux, P. (1973). "Introduction to Ecology". Wiley, New York.

Dendy, T. (1987). The value of corridors (and design features of same) and small patches of habitat. In : "Nature Conservation: the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.) pp. 357-359. Surrey Beatty, Sydney.

Formann, R.T.T. and Baudry, J. (1984). Hedgerows and hedgerow networks in landscape ecology. Environ. Manag. 6 : 495-510.

Griffin, G.F. and Freidel, M.H. (1985). Discontinuous change in central Australia: some implications of major ecological change for land management. J. Arid Env. 9 : 63-80.

Hopkins, A.J.M. and Saunders, D.A. (1987). Ecological studies as the basis for management. In : "Nature Conservation : the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.) pp. 15-28. Surrey Beatty, Sydney.

IUCN (1980). World Conservation Strategy. Gland, IUCN, UNEP. WWF.

Johnson, E.A. and Bossart, A.K. (1980). Problem solving in ecology. Ecology 61 : 1262-1263.

Kitchener, D.J., Chapman, A., Dell, J., Muir, B.G. and Palmer, M. (1980). Lizard assemblage and reserve size and structure in the Western Australian wheatbelt - some implications for conservation. Biol. Conserv. 17 : 25-62.

Lahti, T. and Ranta, E. (1985). The SLOSS principle and conservation practice: an example. Oikos 44 : 369-370.

Lahti, T. and Ranta, E. (1986). Island biogeography and conservation: a reply to Murphy and Wilcox. Oikos 47 : 388-389.

Laws, R.M. (1985). The ecology of the southern ocean. Am. Sci. 73 : 26-40.

Lawton, J.H. (1974). Review of J.M. Smith's "Models in Ecology". Nature 284 : 537.

Levin, S.A. (1981). The role of theoretical ecology in the description and understanding of populations in heterogeneous environments. Amer. Zool. 21 : 865-875.

Lewin, R. (1986). In ecology, change brings stability. Science 234 : 1071-1073.

McKellar, R. (1987). Relevance, accountability and efficiency of research for management. In : "Nature Conservation : the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W. Burbidge, A.A. and Hopkins, A.J.M.) pp. 345-346. Surrey Beatty, Sydney.

McIntosh, R.P. (1980). The background and some current problems of theoretical ecology. Synthese 43 : 195-255.

Main, A.R. (1981). Ecosystem theory and management. J. Roy. Soc. W.A. 41 : 1-4.

Margules, C.R. (1985). The Wog Wog habitat patch experiment : background, objectives, experimental design and sample strategy. Tech. Mem. 85/18, CSIRO, Div. Water and Land Resources, Canberra.

May, R.M. (1977). Thresholds and breakpoints in ecosystems with a multiplicity of stable states. Nature 269 : 471-477.

May R.M., (1986). The search for patterns in the balance of nature : advances and retreats. Ecology 67 : 1115-1126.

May R.M., Beddington, J.R., Clark, C.W., Holt, S.J. and Laws, R.M. (1979). Management of ,multispecies fisheries. Science 205 : 267-277.

Miles, J. (1979). "Vegetation Dynamics". Chapman & Hall, London.

Mooney, H.A. (1984). Applied and basic research in Mediterranean-climate ecosystems. In : "Dynamics and management of Mediterranean-type ecosystems" (ed. Conrad, C.E. and Oechel, W.C.). pp 8-12. Gen. Tech. Rep. PSW-58, Berkeley.

Moss, R., Watson, A. and Ollason, J. (1982). "Animal Population Dynamics". Chapman and Hall, London.

Murphy, D.D. and Wilcox, B.A. (1986). On island biogeography and conservation. Oikos 47 : 385-387.

Newmark, W.D. (1985). Legal and biotic boundaries of Western North American national parks : a problem of congruence. Biol. Conserv. 33 : 197-208.

Norton, G.A. and Walker, B.H. (1985). A decision analysis approach to savanna management. J. Environ. Mgmt. 21 : 15-21.

Noss, R.F. and Harris, L.D. (1986). Nodes, networks and MUMs: preserving diversity at all scales. Environ. Manag. 10 : 299-309.

Odum, E.P. (1969). The strategy of ecostystem development. Science 164 : 262-270.

Oster, G. (1981). Predicting populations. Amer. Zool. 21 : 831-844.

Peet, R.K. (1976). The legacy of MacArthur. Ecology 57 : 613-614.

Purdie, R.W., Blick, R. and Bolton, M.P. (1986). Selection of a conservation reserve network in the mulga biogeographic region of south-western Queensland, Australia. Biol. Conserv. 38 : 369-384,

Ross, M.A. (1969). An integrated approach to the ecology of arid Australia. Proc. Ecol. Soc. Aust. 4 : 67-81.

Saunders, D.A. (1986). Breeding season, nesting success and nestling growth in Carnaby's cockatoo, Calyptorhyncus funereus latirostris, over 16 years at Coomallo Creek, and a method for assessing the viability of populations in other areas. Aust. Wildl. Res. 13 : 261-273.

Saxon, E.C. (1984). "Anticipating and inevitable: a patchburn strategy for fire management at Uluru (Ayers Rock - Mt Olga) National Park". CSIRO, Melbourne.

Schonewald-Cox, C.M. and Bayless, J.W. (1986). The boundary model: a geographical analysis of design and conservation of nature reserves. Biol. Conserv. 38 : 305-322.

Shimwell, D.W. (1971). "Description and Classification of Vegetation". Sidgwick and Jackson, London.

Simberloff, D. and Abele, L.G. (1984). Conservation and obfuscation: subdivision of reserves. Oikos 42 : 399-401.

Slobodkin, L.B. (1974). Comments from a biologist to a mathematician. In "Ecosystem Analysis and Prediction" (ed. Levin, S.A.) pp. 318-329. Proc. SIAM-SIMS Conf, Atla, Utah.

Soule', M.E. and Simberloff, D. (1986). What do genetics and ecology tell us about the design of nature reserves? Biol. Conserv. 35 : 19-40.

State Conservation Strategy for Western Australia Consultative Committee (1987). A State Conservation Strategy for Western Australia. Bulletin 270. Department of Conservation and Environment, Perth.

Walker, B.H., Norton, G.A., Conway, G.R. Comins, H.N. and Birley, M. (1978). A procedure for multidisciplinary ecosystem research: with reference to the South African savanna ecosystem project. J. Appl. Ecol. 15 : 481-502.

Walker, D. (1970). Direction and rate in some British post-glacial hydroseres. In : "Studies on the vegetation history of the British Isles" (ed. Walker, D. and West, R.G.). pp. 117-139. Cambridge University Press, Cambridge.

Wangersky, P.J. (1970). An ecology of probability. Ecology 51 : 940.

Westoby, M. (1974). The self-thinning rule. Adv. Ecol. Res. 14 : 167-225.

White, P.S. and Bratton, P.S. (1980). After preservation : philosophical and practical problems of change. Biol. Conserv. 18 241-255.

Willis, E.O. (1984). Conservation, subdivision of reserves and the anti-dismemberment hypothesis. Oikos 42 : 396-398.

Wilson, E.O. and Willis, E.O. (1975). Applied biogeography. In : "Ecology and evolution of communities" (ed. Cody, M.L. and Diamond, J.M.) pp. 523-534. Belknap, Cambridge, MA.

Zimmerman, B.L. and Bierragaard, R.O. (1986). Relevance of the equilibrium theory of island biogeography and species-area relations to conservation with a case from Amazonia, J. Biogeog. 13 : 133-143.

MANAGEMENT, RESEARCH AND ECOLOGICAL THEORY: THE VISION AND THE REALITY

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I would like to make two points at the outset of this paper. Firstly, I do not intend it to be a scholarly or scientific work. Rather, I will put forward my views on the problems we face and suggest approaches which can be taken in overcoming them. Secondly, I will be concentrating on the Western Australian scene, and on issues pertinent to the Department of Conservation and Land Management (CALM), rather than taking a national or international perspective. I am sorry if this leads to a presentation which is parochial, however it reflects my background and my preoccupation. It also does what I hope all CALM managers and scientists do: focuses on the most important problems at hand.

I also wish to say at the outset how much I approve of the concept and the format of this workshop. It is unusual for policy makers, research scientists and district managers to sit down together for a "jam session" on philosophical issues and their relationship to the real-world demands of ecosystem management. Too often each group convenes its own get-together (the policy meeting, the research working groups or the managers meetings) and this physical separation entrenches philosophical differences, and in turn leads to the adoption of the familiar and ridiculous stereotypes about researchers, managers and those at Head Office. Anyone who has experienced the intellectual stimulation and the joy of learning which can arise in multi-disciplinary groups, quickly becomes bored and irritated by contrived research-versus-management arguments.

Land management and wildlife conservation in Western Australia is going through difficult times at the moment because there is an expanding task, rising public expectations, constant critical and unforgiving attention from environmental groups, all at a time of diminishing resources. We are subject to pressure from competing bureaucracies in Government, all after a maximum slice of the resource cake and we are increasingly imposing upon ourselves higher and higher standards of excellence. This stems partly from professional pride, but is also a result of the intense personal commitment to conservation which runs right through our Department.

At any time, but especially in tough times, it is imperative that a conservation and land management agency meets the following three requirements.

1.It must ensure that its policies and practices are firmly based on the best available scientific information about the ecosystems it is managing.

2.It must make the best possible use of its collective intelligence and energies.

3.It must develop a positive vision, ie, the clearest possible idea of where it wants to be, so that it can bridge the gap between the real world of today and the ideal one of tomorrow.

I see these imperatives as fundamental to ecological (ie, conservation and land) management everywhere and; in the remainder of this paper I will try to look at how each might best be tackled in the Western Australian context.

THE SCIENTIFIC BASIS FOR MANAGEMENT

Everyone agrees that the management of natural ecosystems, whether for nature conservation, for recreation, resource production or simply for the protection of particular human values, should be firmly based on scientific principles, ie, "ecological theory". Setting aside for the moment the problem that few people actually understand what is meant by the term "ecological theory", there is a fundamental dilemma in this thesis. On the one hand, the ecosystems we manage are enormously variable and impossibly complex and the amount of our scientific knowledge is scanty, while on the other hand, we cannot stop the clock! On all sides, society is intervening in natural processes, harvesting native plants and animals, and altering landscapes. We cannot simply order all this to stop, on the grounds that we do not know enough. In any case, even a "do nothing" policy can represent an artificial intervention. Most difficult of all is the question of scale of resolution - there is always a level of uncertainty to which research has not yet penetrated - and no matter how much we seem to learn, there is always more we do not know. I can think of few cheaper targets than the adequacy of our scientific research, and therefore the basis of our management. There have been recent attacks on this score from such points on the critical spectrum as the Southwest Forest Defence Foundation (Anon 1986) and the Chief of the Division of Forest Research in CSIRO (Landsberg and Parsons 1984).

The fact is, of course, that we can never know "everything". We may never even know "enough" in some situations, such as the massive perturbations associated with mineral sand mining in kwongan, or bauxite mining in the jarrah (*Eucalyptus marginata*) forest. Nevertheless, we are not helpless, nor should we be professionally intimidated in this situation. There are six steps we can take to maximise the scientific validity of our management, and to minimise ecological mishaps.

1.We must continue to maintain a strong research effort in conservation and land management. That is critical to our survival. We must also support the research efforts of others in relevant fields.

2.We must focus research effort onto the most serious problems. These are where the basic elements of the ecosystem (air, water, soil) are being degraded, where species or communities are threatened with extinction, where we need to ensure the sustainability of harvested natural resources, and where there is an opportunity for economic benefit.

3.We must have effective mechanisms for constant review and updating of the four basic elements of our management system. These are:

i)reserve location and adequacy;
ii)policy statements;
iii)management plans; and
iv)operational prescriptions.

These elements should be reviewed and revised on the basis of the latest research findings, and the results of systematic performance and ecosystem monitoring.

4.We must continue to seek to oppose (or defer) interventions in ecosystems where the outcome is uncertain, and to encourage research effort by the proponents.

5.Wherever possible, "control areas" must be set aside, characterised, and looked after.

6.Wherever there is uncertainty, the "experimental management" approach, involving the setting up and testing of working hypotheses, must be adopted.

This approach may not satisfy the sternest critics of our research inadequacies. It will probably not prevent an occasional mishap, but it is a professional and positive approach to the dilemma of having to manage with a permanently deficient data base, and provides constant opportunity for improvement and refinement of operations.

Before leaving this subject, there are four important points I would like to add.

1.There can be a world of difference between scientific theory and scientific fact. Like any manager, I am wary of theories which have not been thoroughly tested or which do not appear to gel with what I actually see on the ground. A good example of this was the theory of the hot fires-legumes-dieback interaction in the jarrah forest (Anon 1976). Despite the fact that it was rapidly superseded by the impeded subsoil drainage theory, the "hot burns cure dieback" story became a popular fad, and still turns up to haunt me, in scientific publications (Raison et al. 1984), in letters to the editors of newspapers and even in my daughter's high school biology class notes.

As Richard Hobbs has pointed out (this publication) the field of ecology is huge and the science is inexact. Both researchers and managers must therefore be constantly on the alert as to what is fact and what is idea. Substantial changes to policies, management plans or prescriptions based on the latter may not be progressive.

Moreover, in the distinction between fact and hypothesis, managers are dependent on their scientific colleagues. This dependency imposes a considerable responsibility on research ecologists and research managers.

2.We must remember that even prescriptions for management based on well designed research and careful analysis can have unpredictable side effects. A good example of this is the change to the fecundity of fox populations predated upon by CALM research scientists (Kinnear pers. comm.). As I will discuss below, the principle of the unexpected consequence underlines the necessity for all research to be scaled up to trials, before it is adopted as an operational procedure.

3.Ecological requirements cannot always take priority over everything else. For example, whilst it might satisfy ecological theory to allow karri (*E. diversicolor*) forest national parks to be "cooked" by an occasional high intensity wildfire, this ignores the aesthetic value of these beautiful forests, ie, the principal reason for which they were reserved. By the same token, present day aesthetics may have to be sacrificed for the long-term conservation of the ecosystem.

4.Useful research information does not derive exclusively from research scientists performing statistically valid experiments. Managers can set up creative leader trials, can make revealing observations, and can select and set aside control areas. Furthermore, they can constantly alert research scientists to planned operations or unplanned events where simple surveys and plots can be established and provide important data. There are certain rules for management staff carrying out research trials (see Table 1), but given compliance with these, extremely useful information can be produced.

INTEGRATION OF RESEARCH AND MANAGEMENT

I have written previously on the different orientation, values and preoccupations of research scientists and managers (Underwood 1983, 1984). Unless these are understood, and effectively dealt with, they can lead to an unhealthy organisation, the symptoms of which are irrelevant research, frustrated staff and a lack of creativity and progress in management. But worst of all, a lack of effective integration of research and operations staff will prevent the most efficient application of our collective intelligence and energy to conservation and land management.

Three courses of action can be taken to maximise integration of research and operations; the use of multidisciplinary teams, efficiently managed research extension, and the development of a positive approach to liaison.

Multidisciplinary teams. When research and management staff unite to tackle a land management or wildlife conservation problem, they get to know each other and the scientist can provide the results of his/her work, or his/her knowledge of the work of colleagues. The manager can outline the constraints under which he/she operates. In addition, the gaps in research knowledge become glaringly obvious, as do the limitations of the manager's influence and capabilities. As a consequence, a joint commitment to improving the whole system emerges.

This is a very important process, and on the whole I have found that it works very well, irrespective of whether the task is to draft a policy or a job prescription. It can fail, when a team member is "playing" to another constituency, or when the problem is too "dirty" (Mason and Mitroff 1981), and these are potential difficulties to which a manager must be alert when setting up multidisciplinary teams.

Management of research extension. Having studied this problem in some detail as a research worker and a manager, I have concluded that the onus for effective research extension falls very squarely on the shoulders of the research scientist and his/her director. If they manage it properly it will happen; if they don't, it will not. Most managers (particularly in large, complex regions) simply do not have the time to scan the scientific literature and to integrate research findings.

In my view, five essential steps must always be taken to ensure successful integration of research findings into management.

1.Research findings must first be presented to research colleagues. This is to confirm the validity of the work in terms of design, analysis and conclusions, but more importantly to make sure scientific staff agree amongst themselves upon the implications to management and what is actually to be presented.

2.Research findings must then be written up in non-scientific language and presented to operations staff in the form of new, or revised policy or prescription. This must be accompanied by a description of the expected benefits and likely costs of the innovation proposed.

3.In most cases, work must then be scaled up to field level demonstration trials. These are best organised as collaborative projects between research and operations staff. They are designed to ensure proposals can be properly evaluated for cost, practicality and safety, and unexpected consequences.

4.Research scientists must participate in the initial training of operators and in early implementation. This ensures their rapid attention to teething problems and avoids serious misinterpretation. It also highlights the areas where research is incomplete. It is a responsibility of research directors to plan for each scientist spending part of his/her time on this work, even though it will be at the expense of more research.

5.Research scientists must contribute to subsequent reviews of procedures and prescriptions. This ensures the incorporation of their most recent findings and allows researchers to experience first-hand the problems and concerns of managers.

Unless these steps are systematically followed, research findings will languish, or worse, be misapplied.

Clearly, such an approach is generally more applicable within an agency like CALM than it is, for instance between a researcher in CSIRO and a manager in CALM, but, this is not always true and depends on the problem and the approach.

Research-operations liaison. This must be faced positively and must be actively managed if it is to occur properly. The mechanisms are familiar (seminars, field days, newsletters, workshops, publications, technical demonstrations, policy meetings) but the will to make the time and effort is often lacking. Unless there is a determination to have effective liaison, it can lapse. This may mean producing a forum for such interaction to occur, or at least be initiated and this workshop is an example of this approach.

I also emphasise the importance of social interaction and of sharing the fun of the job. Friendship is a very powerful positive influence, but again, it is something which does not just happen, it must be worked at.

In this section I have talked about how best to integrate research and operations, because not only will this improve the standards of ecological management, but will ensure best use of scarce human resources

I now want to turn to my final point. Without a vision, ie, a clear and positive idea of where we want to go in the field of ecological management, progress can only be slow and haphazard.

THE VISION

Andrew Burbidge (this publication) presented the case for nature conservation and suggested how our management must comply with the noble precepts of the World Conservation Strategy. I agree with him and I share these ideals. However, for goals to be meaningful at the level of park, reserve, and district management, they need to be scaled down from the international scene, and they need to be given priorities, in the same way that priorities need to be set at the higher levels, eg state, national and international. The resultant statement of ranked objectives can then form the fundamental basis for the structure of the research program and for the allocation of resources for management on the ground.

This is the ideal. In fact, it is probably the greatest weakness in conservation and land management in W.A. at the moment. While a comprehensive statement of objectives is emerging in the Corporate and Regional Management Plans, no system for allocating priorities has been developed. There is a major imbalance of resources (for important historical reasons) and great social and economic barriers to change. Current research priorities have largely been inherited from the agencies that amalgamated to form CALM each of whom had a more narrow charter than CALM. Research priorities can only be changed at a serious cost in terms of lost investments. In many areas of the State we do not have the staff or the funds to practice even the most elementary and scientifically valid ecological management (eg, control of feral animals, or management of fire). Despite these difficulties, I remain optimistic. Conservation and land management in W.A. has two wonderful advantages over that in many other parts of the world. Our population is still comparatively small, and community attitudes towards the environment in general are improving.

It is also my view that a vision does exist, but is not yet explicit, and that a system of determining priorities can be developed and implemented, even though it will be a gradual process. Until both these things are done our capacity to properly plan for the conservation of the biological and physical resources for which we are responsible, will be deficient. Our capacity to implement management plans on the other hand, is a matter of community and political priorities, and is outside the scope of this workshop.

CONCLUSION

In this paper I have tried to look at ecosystem management from the viewpoint of an agency charged with the task of conservation and land management in a State as huge and diverse as Western Australia. I accept that conservation management must be based on ecological principles, but I acknowledge that there are serious limitations in our data base and our resources. Nevertheless, I believe that we can meet our scientific, and our moral obligations to conservation if we observe four key principles.

1.Maintain an effective research effort.

2.Constantly review and update of management policies, plans and procedures, on the basis of current research findings, and monitoring programs.

3.Adopt a positive approach to maximising the effectiveness of collective intelligence and energy of all scientific and management staff.

4.Establish clear goals and priorities.

This approach will not immediately satisfy our critics, but must generally move us in the direction of better management, and therefore more effective land and wildlife conservation in W.A.

REFERENCES

Anon. (1976). Understanding fire in the forest. Ecos 77, 3-12.

Anon (1986). Biological and ecological research in the karri forest - what needs to be done. South-West Forests Defence Foundation, Nedlands.

Landsberg, J.J. and Parsons, W. (1984) Eds. Research for forest management. CSIRO Division of Forest Research, Canberra.

Mason, R.O. and Mitroff, I.I. (1981). Challenging strategic planning assumptions : theory, cases, and techniques.

Raison, R.J., Woods, P.V. and Khanna, P.K. (1984). Dynamics of fine fuels in recurrently burnt eucalypt forests. CSIRO Division of Forest Research.

Underwood, R.J. Research for forest fire operations in Australia. Dept. Cons.. & Land Mang. West. Aust. pp 269-282.

Table 1. Rules for Research Trials by Management Staff

1. Studies should be relatively short-term. (They nearly always lapse when the originator is transferred.)

2. Experimental design should be checked out with an experienced research scientist. (Information collected which cannot be analysed is often useless.)

3. A "Research Proposal" (or Research Working Plan) must be written and filed. In particular this must contain an objective and enough survey data to enable relocation on the ground.

4. Results and conclusions must be reported, especially to the local senior manager and to the appropriate research scientist.

5. If there is an appropriate outlet, the work should be published.

THE INITIATION OF RESEARCH AND CARRYING IT THROUGH TO MANAGEMENT

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INTRODUCTION

This Workshop session was dealt with in two parts: the initiation of research; and carrying research through to management.

It is clear that each of these questions is closely related to the aims and objectives of the Agency conducting the research and to the nature of the resources being managed.

A model was constructed to represent how research might be initiated. Then a number of steps to facilitate the transfer of information from research to manager were discussed.

DISCUSSION

Initiation of Research. Research questions and problems come from a number of levels within an Agency and they should also be solicited from an informed public. These questions and problems must then be screened and put into priority order, bearing in mind that this screening process and setting of priorities must be relevant to the strategic objectives of the Agency. It is implicit therefore that the Agency must have well defined and updated aims and objectives. Without these stated objectives it is almost impossible for an Agency to conduct its work (including research) and allocate its resources with relevance.

Some criteria which would assist screening and priority setting for research were proposed and these are listed below.

1.Are any species or communities threatened with extinction?

2.Will there be degradation of ecosystems (air, soil, water)?

3.Will the understanding of ecosystem processes be enhanced?

4.What are the costs and benefits of conducting this research?

5.What is the potential for this research to be useful to management?

6.Does the research have valid scientific merit?

7.What is the urgency for the research results to be used by management?

A model for the process of initiation of research using these criteria is shown in Figure 1.

Integration between policy makers, researchers and managers in an organization is necessary to ensure that the correct research questions are addressed and that resources are allocated accordingly.

Carrying Research through to Management
This step is often neglected, but will only be successful if there is an effective transfer of information from research to manager. The responsibility for this task is that of the individual research worker and he/she should take cognizance of the following.

1.Research workers must communicate effectively with each other.

2.Research workers need to communicate widely inside and outside of their agency. Seminars, videos, field days are all appropriate in this context but simple language should be used when dealing with non-agency personnel.

3.Research work should be scaled up to field trials as part of the process of incorporating research results into management activities.

4.Research workers should participate in the early implementation of the results within manage-

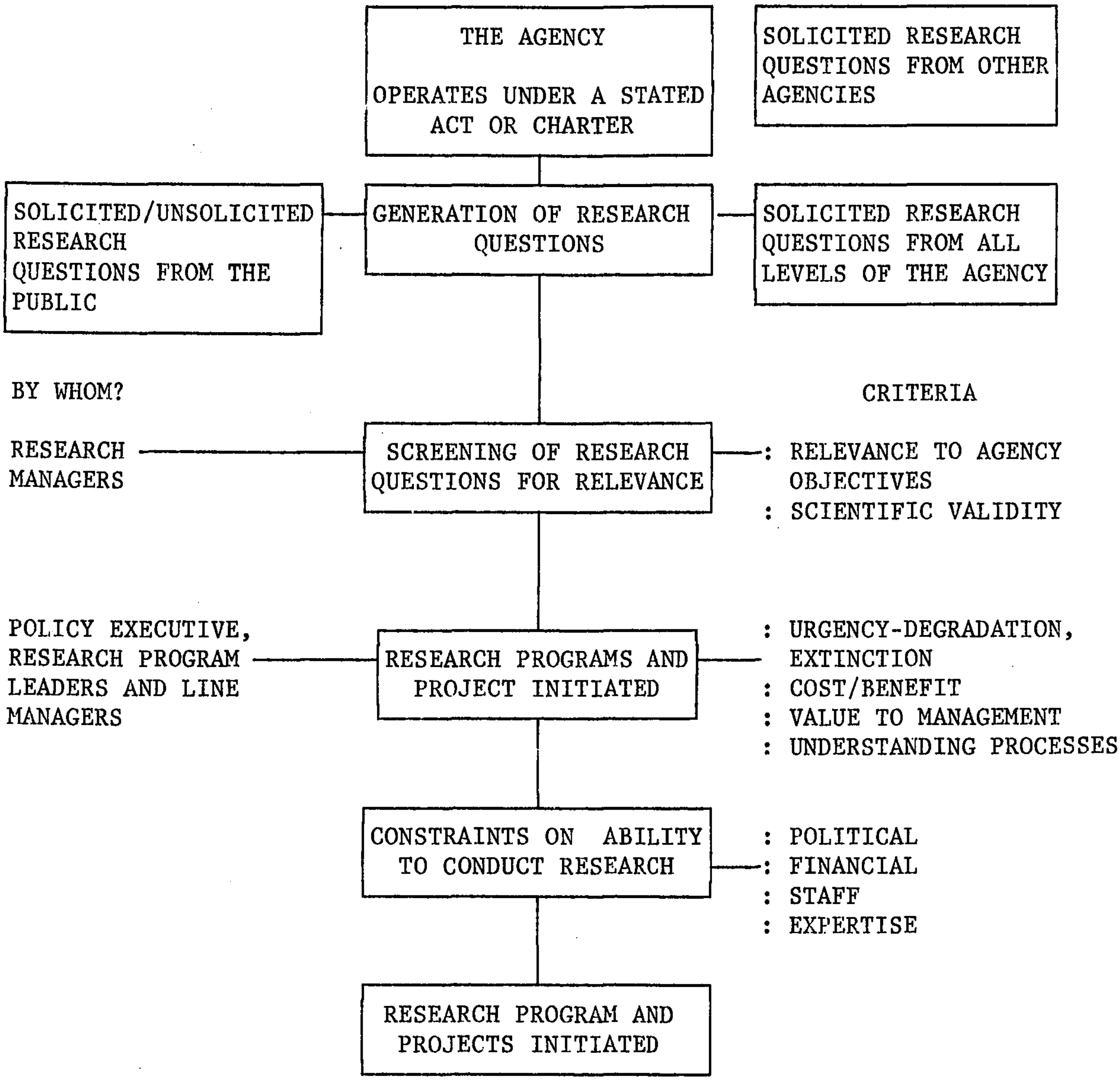

Fig. 1. A model for the process of initiation of research

ment activities and should monitor the results of this management.

5.Publication is essential.

The handover of information from research workers to managers is an area of concern. Research workers should always be involved in the formulation of management prescriptions and in the consequent monitoring and review of these prescriptions. This active collaboration of research workers and managers in the implementation of research findings should result in more effective resource management.

THE INITIATION OF RESEARCH AND CARRYING IT THROUGH TO MANAGEMENT

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INTRODUCTION

This workshop examined two questions:

1.What initiates and determines the direction or emphasis of a research program? and

2.how are the results of this research communicated most effectively to management levels of an organization charged with the management of land and its associated biological resources?

While the conduct of research is not exclusive to an organization involved with managing biological resources, the effective communication of research findings to the operational or management arm of such an organization is essential if it is to manage efficiently. The integration of results from the various disciplines or studies is usually carried out at the management level, but when management plans are being prepared the interdisciplinary integration occurs within the planning team. In some research into the management of individual species, the integrated approach is not always appropriate and the work should stand alone. This is particularly so in the management of endangered species.

DISCUSSION

Factors affecting initiation of research projects

It is important to have research frameworks that are adequate to handle the problems which arise. It is necessary to employ competent staff and to have sufficient funds to ensure that research direction is responsive to unforeseen management problems and which includes both short term problem oriented research and longer term studies. Efficient research needs an administrative structure that can assess priorities and reallocate resources accordingly. It also needs a process that can integrate multi-disciplinary studies so that they may be applied to management.

In order to initiate research, it is first necessary to identify problems and then place them in priorities.

A list of potential projects compiled by resource managers is one method for identifying research areas. Such lists need to be comprehensive and detailed enough to allow proper evaluation. This approach can involve bodies external to the managing organization as well as the organization's staff. This may act as a stimulus for outside research workers to focus on problems that the resource managing organization is interested in solving.

Regular consultation between manager and researcher is necessary during all stages of a research program and this is the hallmark of well targeted research programs.

The opportunity frequently exists for managers to gather, in an ordered way, long term data that provide an extremely useful background for a research study. The existence of such data will sometimes influence a research worker to choose a particular project.

Although some of the finest research comes from work carried out on a very limited budget, the provision or non-provision of funds is probably the most seductive agent in determining the course of research proposals. An often neglected factor in this matter of funding, and one which is very pertinent of the Department of Conservation and Land Management (CALM), is the capacity of some organizations to provide facilities and other assistance. Although such assistance may not be financial it often influences outside agencies deciding on a particular study.

Communication of research results to managers

This subject was discussed at length but did not generate any definite conclusion, rather a series of approaches were suggested. In an organization like CALM, with large areas of land to manage and these scattered over a large state, decentralizing research activities is essential. The benefits of decentralization were seen to be the creative impetus brought about through exposure of researchers to regional problems. Decentralization can result in isolation and it is necessary to ensure that research is subject to the critical review process normally associated with good research and that publication is part of the product of the research. This approach is essential to ensure that the scientific competence of the research staff is monitored and is seen to be monitored.

Departments of Agriculture use extension officers to provide liaison between their research workers and the farmers who use the results of the research. This approach is one which an organization like CALM could follow. The validity of this approach within CALM is evident in the way that the Silviculture and Environmental Protection branches provide information to managers. As a counter to this point of view, the "single mission" character of the activities of the Silviculture and Environmental Protection functions was highlighted and the breadth of scope of research activities underlined. A practical answer was seen to be a liaison function for the program leaders in the Research Division who would be conversant with activity in their respective areas. Managers should use the program leaders as sounding boards for management actions and also assist in identifying potential research needs.

The process of development of a management plan for a natural resource area or for a particular species was seen to be the most definitive process by which research results could be carried through to management. Good planning is a vehicle of singular importance in the communication process because it provides the stage where there is a conscious step of drawing out the management implications from any number of research studies. Planning is the integration of sometimes conflicting information into a set of coherent guidelines for management.

Communications between research workers, management and the public are often hindered by the use of jargon and simple English is preferable.

CONCLUSION

The main difficulty associated with the initiation of research and carrying it through to management arose through the separation of the research role from the management role. The action of exploring a problem should be a joint exercise by both parties and in CALM there is already extensive co-operation in defining the matter to be researched and assistance in collecting data. Joint studies involving workers and managers would lead to procedures and solutions that are realistic and could be implemented. If compromises are necessary in the face of operational realities, the research worker should be involved with the manager in making such compromises.

BIOGEOGRAPHY AND ITS USE FOR SETTING PRIORITIES FOR MANAGEMENT

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INTRODUCTION

The session began with an introductory description of differences between biogeography (including descriptive ecology) and experimental ecology. Its purpose was to provide common ground for the ensuing discussion on the implications and limitations of biogeographic studies for management. To emphasise the local context I have tried to use Western Australian studies to illustrate both the introduction and the points raised during the discussion.

Biogeographic studies describe the present and/or past patterns in the geographic distribution of organisms over periods ranging from decades to millions of years and / or usually over areas as least as large as a natural district. For the purposes of this discussion the term "descriptive ecology" will be used to distinguish non-experimental studies confined to relatively small study areas such as a single reserve, or along a corridor between reserves.

Most studies of field ecology in Western Australia include elements belonging to the "descriptive ecology-biogeography" continuum, because they contribute to our knowledge of: (1) patterns in the distributions of species or in the composition and diversity (eg. species richness) of communities; (2) the status (eg. rarity, endemism, commonness, relictualism) of species and communities; (3) the geographic and temporal scales at which various species operate; or (4) the influence that physical and biological factors have on ecological boundaries, the relative abundance (eg. presence or absence) of species, and the complexity and dynamic nature of communities, at various localities at various times. Examples include: disturbers (fire, exotic species), environmental gradients (scalars such as substrates, altitude, climates), barriers to dispersal, and connections with other organisms (food chains, competition for resources).

A large, and ever increasing, body of such data has been provided for Western Australia by biologists of the W.A. Museum, W.A. Herbarium, various CALM and CSIRO research centres, universities, mining companies, private organizations (eg RAOU) and individuals.

As our knowledge of the biota has become more detailed, there has been a realization of the problems confronting native species, the limited research and management resources available to conservation organizations, and the fragmented nature of our data-base. The W.A. Biological Surveys Committee was convened in 1977 to coordinatate biological research. Its aim is to improve the coverage of the available data in terms of both the biological diversity and the geographic extent of the State.

Biogeographic studies in W.A. (see McKenzie 1984) have moved away from comparisons of land-unit or regional species lists (e.g. McKenzie 1981) and the provision of biotic maps based only on the distributions of individual species or of a few attributes such as structurally dominant plant species and superficial geology (see Beard 1980). Instead, recent investigations of biogeographic pattern (the "what and where") have emphasised quantitative analyses that attempt to explain the observed patterns in terms of environmental factors. For example, certain recent studies of the biogeography of individual species have sought explanations through correlations with climatic (Nix & Gilleson 1985) attributes.

Similarly, studies of the biogeography of communities (Hnatiuk & Hopkins 1981, Biological Survey Committee 1984, McKenzie & Robinson 1987) have adopted sampling designs that provide quantitative assemblage data because such data-sets retain spatial discrimination and are amenable to the same analytical techniques as descriptive ecological data-sets. The last two of the studies just cited, aim at reasonably exhaustive species composition data for a wide array of organisms (so that a variety of different parts of ecological networks are represented), at a large number of quadrats (quadrat sampling designs acknowledge connectance between species in an assemblage) positioned to represent the geographic extent of study areas more than 250 000 square kilometres in area. Such data-bases provide data of the "what and where" sort, at broad geographic scales, that better represents entire ecological networks. They also yield insights into "how and why" similar to those provided by descriptive ecology, but at regional scales. The latter is gained through the identification of physical scalars such as substrate, climatic or altitude gradients (Austin et al. 1984) that are strongly correlated with biotic patterns, and by resampling the quadrats at various points in time to monitor changes in species composition across the entire district. Members of the discussion group had indicated concern that the value of biogeographic data was limited because it had no value in elucidating the ecological processes (the "how and why") needed to manage the biota effectively.

Sometimes biogeographic patterns have been used as a basis for testing ecological theories such as species interactions (e.g. competition and community structure), density-dependent habitat selection, r - K strategies, minimum viable population sizes, equilibrium theory of island biogeography, and species richness versus area in relation to habitat patch-size or habitat heterogeneity. Examples include Hopper (1979), Kitchener (1982), Hopkins & Hnatiuk (1983), McKenzie & Rolfe (1986) and Moran & Hopper (1987), as well as the recent interest in species richness-area relationships (Kitchener et al. 1980) although, in the context of designing representative nature reserve systems, SLOSS (single small or several large) relationships have proved too superficial (Zimmerman & Bierregaard 1986, Shafer & Sanson 1986).

On the other hand, it has been difficult to do experimental biogeography; that is, to manipulate biological and/or physical parameters across large enough areas, or for long enough, to be termed biogeography rather than ecology. As a result, attempts to test hypotheses concerning the processes of ecological patterning at these larger geographic or temporal scales have relied on "natural experiments" (descriptive data) that correlate patterns in species composition, richness, etc. with gradients in biophysical scalars or disturbers imposed on the region's biota (discussed above). The problem of identifying causation from "natural" experiments in ecology has been discussed by Diamond (1983) and is aggravated for biogeographers. At biogeographic scales it is especially difficult to set up and maintain valid "control" quadrats, yet these are needed to untangle (isolate) the variety of disturbers, scalars, and ongoing biotic processes present in natural systems across study areas as big as regions. The discussion group took the view that causes were most likely to be identified through autecological studies.

Thus, while biogeography has been able to provide insights into "how and why" over large study areas (from correlations and other circumstantial evidence), the actual causes have rarely been isolated. Nevertheless, when setting priorities between management programs it is essential to have the regional "what and where" context and only broad-scale studies can provide these insights in an objective manner; for instance, such data allow planners to distinguish localised events from regional trends that affect the persistence of native species. Elton (1966) summed this up as follows; "it is one of the tasks of ecological survey to provide the strategic setting for population studies".

DISCUSSION

There was no dispute among members of the discussion group that this "what and where" (the regional context) is fundamental to setting priorities for the management of wildlife, although it was pointed out that perhaps biogeographic survey effort should be directed to areas where resources were available to incorporate the findings into management activities. Managers of large areas with limited resources disagreed as they find themselves being asked to predict conservation values for areas of land about which there was little or no data. More biogeographic data are necessary to help them make such decisions.

A model of biogeographic survey (Fig. 1) currently being researched by the Western Australian Department of Conservation and Land Management, was presented to stimulate discussion on the opportunities quantitative

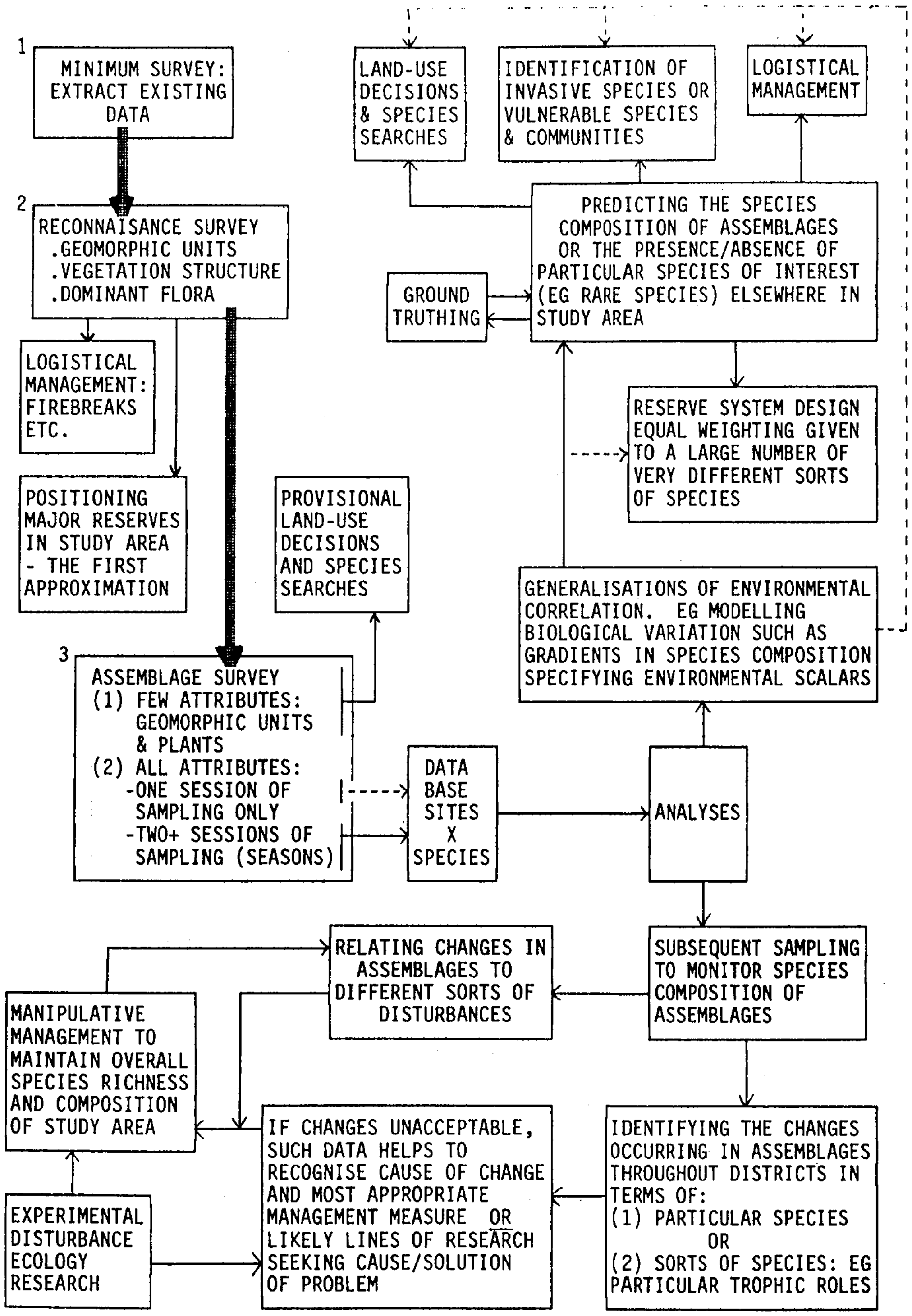

Figure 1. A model of biogeographic survey. The "Reconnaisance Survey" provides a basis for positioning the sampling quadrats used in the "Assemblage Survey".

biogeographic data can provide for discriminating and investigating biotic patterns, and for using the derived patterns as an explicit basis for setting priorities for management.

It was pointed out that disturbers have been rampant across Western Australia since settlement by Europeans, and it was suggested that these would have disrupted biogeographic patterns and would confound attempts to find gradients in the physical environment that have such a close correlation with the biotic patterns discriminated that they can be used as scalars. Would this reduce the potential value of quantitative biogeographic analyses by thwarting attempts at prediction? This was likely to be true for groups of organisms (such as mammals) in which many species have declined or become extinct (see Baynes 1987, Boscacci et al. 1987); for others, such as reptiles and perennial plants, such disruptions would probably not mask these original patterns. Further work was needed to find out the extent to which such masking had occurred. Disturbances would create some problems in monitoring (things were sure to be changing anyway) but, in principal, some initial "what and where" was needed before any soundly based management decisions could begin.

Several members of the discussion group suggested that data derived from sampling at biogeographic (regional) scales would be too sparse to provide the detail needed to predict assemblage composition from such scalars. Problems requiring further research were seen with the intensity (how many organisms do you need to sample?), extent (size of the study-area versus number of quadrats), timing (in relation to seasonal and year-to-year changes), and localized or unpredictable events (fire, drought, windstorms, tree-falls, etc.).

To dispell the pessimism, it was pointed out that analysis of a biogeographic data-base recently collected from the 260000 square kilometre Nullarbor District (McKenzie et al. 1987), in which equal weighting was given to 373 species (comprising birds, reptiles, mammals and both ephemeral and perennial plants), found very close correlations between biological patterns and gradients in a number of climatic and substrate attributes. During further investigations of this data-base, carried out in conjunction with CSIRO Division of Wildlife and Rangelands, a set of predictive maps was derived using the identified scalars; subsequent ground-truthing, by sampling at 10 new quadrats, substantiated the predictions with somewhere near 80% accuracy (for assemblage composition). However, most of the Nullarbor District had a subdued topography that simplified the modelling.

There was some concern that broad scale biogeographic studies would not detect (or represent) rare species; that generalized scalars would give generalized predictions. Thus, reserve systems and priorities for management selected on the basis of these sorts of data would overlook relictual and other rare species. Such populations comprise extreme genotypes so they are important for conserving genetic variation. The discussion group agreed that systematic biogeographic surveys were needed to evaluate species status objectively. In assessing the status of Western Australian plants from Herbarium collections, Marchant & Keighery (1979) found that many plants were considered "common" because they occurred along roads travelled by botanists and that many "rare" plants belonged to remote or inaccessable areas. The group also agreed that as wide an array of species as possible should be sampled though the importance of common species should not be overlooked, and that particular priority in management, including the provision of special reserves, would be needed by populations of rare species. In this context, studies that specialized in rare species were needed (and exist, see Hopper et al. 1982, Friend et al. 1982, Christensen 1980) as a complement to generalized surveys.

The use of biogeographic survey quadrats for monitoring (by carrying out subsequent sessions of sampling at the quadrats) was considered important and it was accepted that these surveys can be designed for detecting change through time, though a wider range of physical data would give better insights into the reasons for changes observed in the species composition of assemblages.

Biogeography does not provide solutions to all management issues. For instance, the above model would have little value for gaining insights into the "how and why" of marine systems because of randomising affects caused by the mobility of propagules (see Sale 1977). Even so, the sampling strategy proposed for Ningaloo Reef during subsequent discussion was quadrat / transect based.

Management priorities and decisions that are influenced or determined by biogeographic data include: legislation to protect species and communities; positioning of firebreaks and facilities for public use; selection of optimum areas of land in reserve system design, and other land-use decisions; searches for additional populations of particular species, guilds or communities of interest; and priorities in more specific research, such as manipulative experiments on populations or communities.

It was questioned whether biogeographic approaches to optimizing the representativeness (sensu, Austin & Margules 1984) of reserve systems were worthwhile. The reality of acquiring reserves today (e.g. in the Shark Bay region of Western Australia) involves accepting virtually every available patch of land and, in the context of "the real versus ideal" in setting priorities, ecosystem boundaries derived from biogeographic data are not necessairily the same as management boundaries. Nevertheless, while pragmatic decisions often have to be taken, the processes of setting priorities for management (including the selection of reserves when acquiring reserve systems) should have a rational biological basis; the more relevant and the better the available biological data, the more effective the decisions are likely to be (see Game & Peterken 1984, Margules & Nicholls 1987, Robinson et al. 1987).

In this context, the managers and planners present at the discussion were asked to consider practical examples of decisions they regularly had to make, and to identify the sorts of information they thought would be most useful for setting priorities for management. A request to relinquish a reserve was suggested as an example. Four discrete sorts of data were identified during the discussion that followed. All woe of the "what and where" sort.

(1) Are any rare or endangered species present?

(2) What is the species diversity (especially in richness and composition of the communities found in each region)?

(3) What are the major geographic patterns in diversity (especially richness and composition)?

(4) Is each ecosystem / community / species protected by a reserve?

Reference to Figure 1 indicates that these categories of information are all available or potentially available through biogeographic studies.

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REFERENCES

Austin, M.P., Cunningham, R.B. & Fleming, P.M. (1984). New approaches to direct gradient analysis using environmental scalars and statistical curve-fitting proceedures. Vegetatio **55**: 11 - 27.

Austin, M.P. & Margules, C.R. (1984). The concept of representativeness in conservation evaluation with particular reference to Australia. CSIRO Aust. Div. Water Land Resour. Tech. Memo 84/11.

Baynes, A. (1987). The original mammal fauna of the Nullarbor and southern peripheral regions: evidence from skeletal remains in superficial cave deposits. In : "A biological survey of the Nullarbor region, South and Western Australia in 1984" (ed. McKenzie, N.L. & Robinson, A.C.) Department of Environment and Planning, Adelaide.

Beard, J.S. (1980). A new phytogeographic map of Western Australia. W.A. Herb. Res. Notes, No. 3: 37 - 58.

Biological Survey Committee (1984). The biological survey of the Eastern Goldfields of Western Australia. Part 1. Introduction and methods. Rec. West. Aust. Mus. Suppl. **18**: 1 - 19.

Boscacci, L.J., McKenzie, N.L. & Kemper, C.M. (1987). Mammals. In : "A biological survey of the Nullarbor region, South and Western Australia in 1984" (ed. McKenzie, N.L. & Robinson, A.C.) Department Environment and Planning, Adelaide.

Christensen, P.E.S. (1980). The biology of *Bettongia penicillata* Gray, 1837 and *Macropus eugenii* (Desmarest, 1817) in relation to fire Bulletin No. 91. Forest Department, Western Australia.

Diamond, J.M. (1983). Laboratory, field and natural experiments. Nature **304**; 586 - 587.

Elton, C.S. (1966). "The ecology of animals". Methuen, London.

Friend, J.A., Fuller, P.J. and Davis, J.A. (1982). The Numbat in Central Australia, SWANS **12**(3): 21-26

Game, M. & Peterken, P.F. (1984). Nature reserve selection strategy in the woodlands of central Lincolnshire, England. Biol. Conserv. 29: 157 - 183.

Hopkins, A.J.M. & Hnatiuk, R.J. (1983). An ecological survey of the kwongan south of Eneabba, Western Australia. Wildl. Res. Bull. West. Aust. No. 9. Department of Fisheries and Wildlife, Perth.

Hopper, S.D., Campbell, N.A. & Moran, G.F. (1982). *Eucalyptus caesia*, a rare mallee of granite rocks from south-western Australia. In : "Species at risk: research in Australia" (ed. Groves, R.H. & Ride, W.D.L.) Australian Academy of Science, Canberra.

Hopper, S.D. (1979). Biogeographical aspects of speciation in the southwest Australian flora. Ann. Rev. Ecol. Syst. 10: 399 - 422.

Hnatiuk, R.J. & Hopkins, A.J.M. (1981). An ecological analysis of kwongan vegetation south of Eneabba, Western Australia. Aust J. Ecol. 6: 423-438.

Kitchener, D.J. (1982). Predictors of vertebrate species richness in nature reserves in the Western Australian wheatbelt. Aust. Wildl. Res. 19: 1 - 7.

Kitchener, D.J., Chapman, A., Dell, J. & Muir, B.G. (1980). Lizard assemblage and reserve size and structure in the Western Australian wheatbelt -- some implications for conservation. Biol. Conserv. 17: 25 - 62.

Marchant, N.G. & Keighery, G.J. (1979). Poorly collected and presumably rare vascular plants of Western Australia. Kings Park Research Notes 5: 1 - 103.

Margules, C.R. & Nicholls, A.O. (1987). Assessing the conservation value of remnant habitat "islands": mallee patches on the western Eyre Peninsula, South Australia. In : "Nature Conservation: the role of remnants of native vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M.) Surrey Beatty & Sons, Sydney.

McKenzie, N.L. (1981). Mammals of the Phanerozoic South-west Kimberley, Western Australia: biogeography and recent changes. J. Biogeog. 8: 263 - 280.

McKenzie, N.L. (1984). Biological surveys for nature conservation by the Western Australian Department of Fisheries and Wildlife - a current view. In : "Survey methods for nature conservation." Proceedings of a workshop held at Adelaide University in 1983 (ed. Myers, K., Margules, C.R. & Musto, I.). CSIRO Division of Water Land Resources, Canberra.

McKenzie, N.L. & Robinson, A.C. (eds)(1987). A biological survey of the Nullarbor region, South and Western Australia in 1984. Department of Environment and Planning, Adelaide.

McKenzie, N.L. & Rolfe, J.K. (1986). Structure of bat guilds in the Kimberley mangroves, Australia. J. Anim. Ecol. 55: 401 - 42

McKenzie, N.L., Belbin, D.L., Gunjko, A. & Robinson, A.C. (1987). Biological patterns in the Nullarbor study-area. In : "A biological survey of the Nullarbor region, South and Western Australia in 1984" (ed. McKenzie, N.L. & Robinson, A.C) Department of Environment and Planning, Adelaide.

Moran, G.F. & Hopper, S.D. (1987). Conservation of the genetic resources of rare and widespread eucalypts in remnant vegetation. In : "Nature Conservation: the role of remnants of native vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M.) Surrey Beatty & Sons, Sydney.

Nix, H.A. & Gilleson, A.N. (1985). Towards an operational framework for habitat and wildlife management. In : "Wildlife management and forestry-controlled lands in the tropics and the southern hemisphere." Proceedings of a workshop at the University of Queensland in July 1984 (ed. Kikkawa, J.).

Robinson, A.C., McKenzie, N.L. & Davey, A.G. (1987). Conclusions and conservation recommendations. In : "A biological survey of the Nularbor region, South and Western Australia in 1984" (ed. McKenzie, N.L. and Robinson, A.C.) Department of Environment and Planning, Adelaide.

Sale, P.F. (1977). Maintenance of high diversity in coral reef fish communities. Am. Nat. 111: 337 - 359.

Shaffer, M.L. & Sanson, F.B. (1986). Population size and extinction: a note on determining critical population sizes. Am. Nat. 125: 144 - 152.

Zimmerman, B.L. & Bierregaard, R.O. (1986). Relevance of the equilibrium theory of island biogeography and species-area relations to conservation with a case from Arizona. J. Biogeog. 13: 133 - 143.

BIOGEOGRAPHY AND ITS USE FOR SETTING OF PRIORITIES FOR MANAGEMENT

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INTRODUCTION

This workshop discussion was organized around four themes: the scope of biogeography, the choice of species for study, the use of biogeographical data in setting priorities for management of conservation values and land, and using the experience of managers of conservation values and land to assist in the setting of priorities for the biogeographer.

SCOPE OF BIOGEOGRAPHY

It is difficult to define the scope of biogeography. This is partly semantic (many geographers use the term synonymously with ecology) but is important because the discipline has recently undergone a rebirth. Consequently it is now considered quite insufficient for a biogeographer to produce maps of the distribution of species, to describe patterns of distribution and to infer historical explanations for the patterns discovered. Over two decades ago, MacArthur and Wilson (1963) showed that it was possible to make interesting and practical predictions about the number of species present in well defined areas without necessarily considering history or having to work from detailed distribution maps.

The scope of biogeographical studies is best illustrated by showing their intimate relationship to population and community ecology. Population ecology considers the distribution and abundance of a particular species chosen for detailed study (e.g. a pest insect, a rare plant, a colonially nesting seabird) and tries to explain why that species is found where it is (and not elsewhere), why it is more common at some locations than others, and why fluctuation in numbers at the same locality occur over a particular period. Counts of individuals are necessarily involved and there is a recent trend to distinguish by experiment the importance of factors such as habitat characteristics, intraspecific competition, interspecific competition and predation in determining the distribution and abundance of the species being studied.

Community ecology involves studying assemblages of species at a local scale e.g. the nectariphagous birds found together in a heathland, the seabird species nesting on an island, the species of parrot fish found on a coral reef. Its essence is that a lot of detailed data is collected from a particular place. Originally, community ecology studies were descriptive (e.g. a checklist of plant species occurring in a particular reserve) but the recent trend is towards estimating numbers of species and investigating the effect of some disturbance on the set of species studied (e.g. effect of logging on the birds in a forest stand, impact of fire on soil and litter fauna).

Biogeography is still more general in scope. Like community ecology it embraces the study of assemblages of species but at a broader scale, regional to global. Because of its breadth it cannot often be experimental because experiments at such grand scales are very costly and require large teams of people to manage them. Similarly, it is often difficult to synchronize the collection of census data over a regional scale. For these reasons, biogeography is mostly descriptive (presence/absence of species or abundance on an ordinal scale) but is always comparative, i.e. the species checklists collected from many localities within a region are compared. These checklists are really basic resource inventories and can be used to generate detailed site-vegetation types or simple measures such as species diversity indices or total number of species present for the taxa of interest. These checklists also serve as the context in which the conservation value of other pieces of land can be judged.

Biogeographical studies provide a framework in which it is possible to:

1.determine accurately how particular ecosystems are put together;

2.evaluate the effects of habitat fragmentation on species richness;

3.calculate the size of reserves optimal for particular groups of organisms;

4.infer how some of the component species may interact;

5.infer how disturbance affects species in an ecosystem; and

6.monitor stability of species in an ecosystem over time.

Experimental validation of 4, 5 and 6 involves working at the community ecology level.

Examples of these uses of biogeographical studies follow.

1aIdentifying patterns in species richness e.g. Isoflor maps for species of *Eucalyptus* and *Acacia* (Hopper 1979), similar maps for vertebrates (Pianka and Schall 1981). Biogeographers try to associate these patterns with environmental characteristics such as average annual rainfall, soil types and altitude.

The other way of studying these patterns is more rigorous, and involves multiple regressions between species richness and a host of environmental attributes (e.g. Kitchener et al. 1982, Abbott 1985). This approach can often indicate which factors are worth manipulating in experiments. (It seems pointless to consider further those factors which do not significantly regress on species richness).

1bIdentifying patterns in the distribution of particular species (e.g. Abbott 1981).

2&3Determining species/area relationships and the minimum area necessary for the long term survival of particular species (e.g. Kitchener et al 1982, Abbott 1981). Identifying the dependence of certain species on particular habitat types (e.g. Kitchener 1982, Humphreys & Kitchener 1982). In the jarrah (*Eucalyptus marginata*) forest, rare and endangered plant species are found on granite outcrops or on the western edge of the Darling Scarp and not in areas where forest is logged (Hopper pers. comm.).

4.Identifying chequerboard patterns in the distribution of ecologically similar species (e.g. Main 1961).

5.Comparing disturbed areas with nearby areas which are less disturbed (e.g. Nichols and Watkins 1984) (the rare plant species *Acacia guineti* occurs more commonly on disturbed areas).

6.Repeated visits to specific plots or quadrats enable detection of any trends in distribution (e.g. a contraction or expansion in range of species over several decades). Subtle changes in abundance would not be detected (they are the province of community or population ecology).

All the above can help identify species, communities or habitats requiring more intensive research or management. These features can contribute to the formulation of a land use planning scheme for future short and long term management.

WHICH SPECIES TO STUDY?

The ecological verity that larger areas support more species than smaller areas makes difficulties for the biogeographer in selecting taxa for recording. This is illustrated by data collected from the forest ecosystem of south-western Australia, which contains more than 120 000 species of organisms, more than 50 site-vegetation types and at least 28 vegetation complexes (Table 1). Biogeographical studies to data (Christensen et al. 1985) have emphasized vertebrates and the vascular flora, about 1.5% of the total number of species probably available for study, and hardly representative. This emphasis on higher organisms simply reflects the training of biogeographers, the considerable scientific progress made over 150 years in formally naming Western Australian species of vertebrates and vascular plants, the comparative ease of studying these organisms, and the interest shown by the wider community.

CAN BIOGEOGRAPHICAL DATA HELP IN THE SETTING OF PRIORITIES FOR CONSERVATION AND LAND MANAGEMENT?

The goal of the biogeographer is not only to accumulate useful biogeographical information but also to disseminate it in a form useful to

Table 1. Species richness, site-vegetation types and vegetation complexes of the forest ecosystem of South-western Australia.

		Authority
Area	5x106 ha	
Taxa		
Mammals	32 species	Batini 1974, Strahan 1983
Land Birds	94	Kimber & Christensen 1977
Reptiles	67	Storr et al. 1981, 1983, 1986; Cogger 1975
Frogs	19	Tyler et al. 1984
Insects	16 000 est.	Abbott, unpubl.
Other invertebrates	1 500 est.	Anon., pers. comm.
Vascular plants	1 500 est.	Marchant, pers. comm.
Bryophytes	150 est.	Marchant, pers. comm.
Macrofungi	3 000 est.	Hilton, pers. comm.
Microfungi	100 000 est.	Hilton, pers. comm.
Site-vegetation types		
Northern Jarrah Forest	21	Havel 1975
Southern Jarrah Forest	17	Strelein unpubl.
Karri Forest	12 est.	Inions, pers. comm.
Sunklands	6	McCutcheon 1980
Vegetation Complexes		
System 6	28	Heddle et al. 1980
System 1	?	-
System 2	?	-

managers of conservation values and land. There are two possibilities. First, these biographical data can contribute to the formulation of a land use scheme. Second, land which already has a designated land use scheme can assist the biogeographer's choice of species to be studied (addressed in the next section).

Biogeographical data can be used to formulate a land use scheme for a newly acquired reserve, particularly if rare, endangered or otherwise biologically interesting species are present. Repeated biological surveys indicate which species have small distributions and might be rare or endangered, and identify scientifically interesting distributional outliers (e.g. jarrah at Jilakin Rock and Mt Lesueur). It is likely that one-off surveys would miss many species, so it is essential to repeat surveys at different times of the year.

Biogeographical data can also be used to ensure representativeness of conservation reserves. In Western Australia such use has helped in the reservation of adequate areas in the Kimberley (Biological Survey Committee 1981, 1985), arid zone (Burbidge & McKenzie 1983, McKenzie 1981, McKenzie & Burbidge 1979) and the south west (Forests Department 1978, McKenzie et al. 1973).

Many of the efforts of earlier naturalists and scientists in Western Australia (e.g. Preiss, Gilbert, Drummond, Hartmeyer and Michaelsen) were spoiled by their failure to record precise localities. Therefore biogeographical data, to be useful in the long term, must be referable to specific sites. These data form a baseline for future monitoring of the effects of managers and permit appraisal of their efficiency (whether a particular species still survives in a reserve, whether a particular habitat has not been degraded). Thus, the biogeographer could advise the manager that the current fire regime applied to a reserve appears to be associated with a decline in a a particular species or habitat. The next step is for a properly designed research project to examine if the association is in fact cause and effect. Pending such research, the manager can at least alter or introduce more variety into the fire regime after seeking expert advice.

The sorts of management questions that land and conservation managers could turn to biogeographers for are set out in Table 2. Local managerial knowledge about the precise location of rare, endangered or scientifically important species or habitat types would help answer questions 1-4, and 7-9. Knowledge of the occurrence of obligate seed-regenerating plant species could help answer question 4. Concerning question 7 : yes, if the unvested land is particularly rich in species, or if the region has not enough representative reserves. A reserve with many species of Proteaceae could be at risk if the fungus *Phytophthora cinnamomi* established (Question 10).

USING THE EXPERIENCE OF MANAGERS OF CONSERVATION AND LAND IN SETTING PRIORITIES FOR THE BIOGEOGRAPHERS

The previous section described how the biogeographer can help conservation and land management. It should also be recognized that the manager can aid the biogeographer. The example in Table 1 shows that the biogeographer has more indigenous species and communities to study than resources to study them with. The manager knows (Table 2) the kinds of information that he/she is lacking in order to manage effectively a piece of land. The manager could therefore advise the biogeographer on organisms worthy of study.

The land use plan that is already available for a piece of land very much dictates how the land is to be managed. For example, the Western Australian State Forest ecosystem has had seven types of land use : flora, fauna and landscape; scientific study and education; protection; wood production; water production; recreation; and mining (Forests Department of W.A. 1982). Thus if an area of forest is set aside for recreation it would be prudent for the biogeographer to accumulate data on the distribution of weeds and of indigenous plant species sensitive to soil compaction, whereas in forest managed for flora, fauna and landscape several of the rarer species of vertebrates of plants and habitat types might be the object of biogeographical study.

CONCLUSION

Biogeographical information can make a useful contribution to the setting of priorities in the management of forests, national parks and nature reserves. This information can be used to ensure representativeness of conservation reserves. However because most biogeographical data rep-

Table 2. Some questions often asked by conservation and land managers and which biogeographical information can help answer.

1. Where should access tracks be put?
2. Where should fire breaks be put?
3. Which access tracks should be closed?
4. When and how should the land be burned?
5. Where precisely are populations of rare, endangered or scientifically interesting species located?
6. Should my Department consider purchasing land adjacent to land already managed by my Department?
7. Should my Department consider bidding for some unvested Crown Land in my District?
8. Where can sites for camping, picnicking, beekeeping, extraction of gravel and trails for horseriding and bike riding be located?
9. Of all the land under my control, which reserves are most important biogeographically and therefore require the closest management?
10. Does any land under my control contain many species susceptible to the introduction or spread of Phytophthora cinnamomi?

resent documentation and description, the manager of conservation values and land still needs to liaise with community and population ecologists who could offer more detailed advice derived from experimental studies.

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REFERENCES

Abbott, I. (1981). The composition of landbird faunas of islands around south-western Australia : Is there evidence for competitive exclusion? J. Biogeog. 8 : 135-44.

Abbott, I. (1985). Influence of some environmental factors on indigenous earthworms in the northern jarrah forest of Western Australia. Aust. J. Soil Res. 23:171-90.

Batini, F. (1974). Distribution of modern mammals in the south west of western australia. Forests Department of Western Australia, unpublished report.

Biological Survey Committee (1981). "Biological Survey of the Mitchell Plateau and Admiralty Gulf, Western Australia." Western Australia, Perth.

Biological Survey Committee (1985). "The Biological Survey of the Eastern Goldfields of Western Australia. Part 3, Jackson-Kalgoorlie study area." Western Australian Museum, Perth.

Burbidge, A.A. & McKenzie, N.L. (eds) (1983). The wildlife of the Great Sandy Desert, Western Australia. Western Australian Wildlife Research Bulletin No. 12.

Christensen, P., Annels, A., Liddlow, G. & Skinner, P. (1985). Vertebrate fauna in the southern forest of Western Australia. A survey. Forests Department of Western australia, Bulletin No. 94.

Cogger, H.G. (1975). "Reptiles and Amphibians of Australia." Reed, Sydney.

Forests Department of Western Australia (1978). Land Use Management Programme. Northern Jarrah Forest Management Priority Areas. Perth.

Forest Department of Western Australia (1982). General Working Plan for State Forests in Western Australia. Perth.

Havel, J.J. (1975). Site-vegetation mapping in the northern jarrah forest (Darling Range). 1. Definition of site-vegetation types. Western Australian Forests Department Bulletin No. 86.

Heddle, E.M., Loneragan, O.W., and Havel, J.J. (1980) Vegetation complexes of the Darling System Western Australia. pp. 37-72. In : "Atlas of Natural Resources Darling System Western Australia". Department of Conservation and Environment, Perth.

Hopper, S.D. (1979). Biogeographical aspects of speciation in the Southwest Australian flora. Ann. Rev. Ecol. and Syst. 10 : 399-422.

Humphreys, W.F. & Kitchener, D.J. (1982). The effect of habitat utilization on species-area curves : implications for optimal reserve area. J. Biogeog. 9 : 391-6.

Kimber, P. & Christensen, P. (1977). Birds of Western Australian forests. Western Australian Forests Department Information Sheet No. 12.

Kitchener, D.J. (1982). Predictors of vertebrate species richness in nature reserves in the Western Australian Wheatbelt. Aust Wildl. Res. 9 : 1-7.

Kitchener, D.J., Dell, J., Muir, B.G. & Palmer, M. (1982). Birds in Western Australian Wheatbelt reserves - implications for conservation. Biol. Conserv. 22 : 127-63.

Main, A.R. (1961). The occurrence of Macropodidae on islands and its climatic and ecological implications. J. Roy. Soc. West. Aust. 44 : 84-9.

McArthur, R.H. & Wilson, E.O. (1963). An equilibrium theory of insular biogeography. Evolution 17 : 373-87.

McCutcheon, G.S. (1980). Field classification of vegetation types as an aid to soil survey. Forests Department of Western Australia, Research Paper No. 57.

McKenzie, N.L. (ed.) (1981). Wildlife of the Edgar Ranges area, south-west Kimberley, Western Australia. Western Australian Wildlife Research Bulletin No. 10.

McKenzie, N.L. & Burbidge, A.A. (1979). The wildlife of some existing and proposed nature reserves in the Gibson, Little Sandy and Great Victoria Deserts, Western Australia. Western Australian Wildlife Research Bulletin No. 8.

McKenzie, N.L., Burbidge, A.A. & Marchant, N.G. (1973). Results of a biological survey of a proposed wildlife sanctuary at Dragon Rocks, near Hyden, Western Australia. Western Australian Department of Fisheries and Wildlife Report No. 12.

Nichols, O.G. & Watkins, D. (1984). Bird utilisation of rehabilitated bauxite minesites in Western Australia. Biol. Conserv. 30; 109-31.

Pianka, E.R. & Schall, J.J. (1981). Species densities of Australian vertebrates. Pp. 1675-94. In : "Ecological Biogeography of Australia" (ed. Keast, A.) Junk, Den Haag.

Storr, G.M., Smith, L.A. & Johnstone, R.E. (1981). "Lizards of Western Australia I. Skinks." Western Australian Museum, Perth.

Storr, G.M., Smith, L.A. & Johnstone, R.E. (1983). "Lizards of Western Australia II. Dragon and Monitors." Western Australian Museum, Perth.

Storr, G.M., Smith, L.A. & Johnstone, R.E. (1986). "Snakes of Western Australia." Western Australian Museum, Perth.

Strahan, R. (ed). (1983). "The Australian Museum Complete Book of Australian Mammals." Angus & Robertson, Sydney.

Tyler, M.J., Smith, L.A. & Johnstone, R.E. (1984). "Frogs of Western Australia." Western Australian Museum, Perth.

MANAGEMENT IN UNCERTAINTY: USING THE OPPORTUNITY TO ADOPT AN EXPERIMENTAL APPROACH TO MANAGEMENT

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INTRODUCTION

Managers and researchers have a common aim in the effective conservation of our natural resources. Most managers would like the security of research to assist in the correct choice of management prescriptions. Similarly most researchers would like to be able to provide the information needed by managers. In reality such an ideal situation is not possible. Managers will have to manage in varying degrees of uncertainty. This workshop discussion revolved around two themes (although these were not treated as separate topics).

1.Managers adopting an experimental approach to management so as to improve the choice of prescription in the future.

2.Support that can be provided by researchers in gathering and analyzing data.

SIMPLE AND ROUTINE SITUATIONS

Many actions by managers are responses to simple situations which may be "one-off" or recurring. The appropriate action is usually chosen by applying ecological principles or from experience and many current management prescriptions have developed from an accumulation of experience. However, much of this knowledge is stored only in peoples' memories and it is important to capitalize on this experience. Written records must be kept to ensure the availability of accumulated knowledge to other people and to evaluate the results of management actions. It is important to record why something was done as well as what was done and what the result was. It is also important to record a decision to do nothing, why that decision was made, and what happened. Managers can record management actions to evaluate the effectiveness of their action. However, to achieve this objective, records must be made on a structured scientific basis, treating the operation as an experiment.

There are a number of constraints that must be taken into account. These include time, resources and the level of expertise of field staff as they are usually not trained researchers. Techniques should be simple. For example photographic records are valuable. Setting up quadrats and controls may not be appropriate. Researchers can assist with advice on designing experimental procedures and analyzing results.

Where management actions are frequently repeated under similar situations, it would be sufficient to treat a proportion as experiments requiring experimental procedures to be followed.

It is very important to build up a history of management actions. Thus it is important to record each event whether or not it is treated as an experiment. Fire is a good example of this approach. It may only be necessary to follow experimental procedures to record a proportion of control burns in order to determine the effects of fire under different circumstances. Nevertheless it is essential that a fire history for the area is maintained.

Useful information could be gathered by encouraging rangers and other managers to keep notes on organisms that interest them. Researchers should be contacted for advice before rangers and/or managers started such a study.

RECORDING METHODS

Record keeping is often inadequate. Personal notes and daily logs may not be accessible to others. There have been some attempts in the Department of Conservation and Land Management (CALM) to devise formal data sheets but there is no centralized or computerized system for storing, sorting or disseminating these data. This is an area that must be addressed with the assistance of researchers. In CALM there are three different reserve inspection forms in use now.

COMPLEX SITUATIONS

Researchers should be involved with complex problems. Many complex issues are the subjects of research programs already. It may be possible for managers to assist in these programs, e.g. in regular data collection.

Managers who have complex problems should liaise with researchers who may be able to establish research programs, include the problem by adapting existing programs or advise the manager on the setting up of a program. In any event the researcher may be able to advise the manager on the most appropriate action to take until research results resolve the problem.

It is appropriate for managers (with the assistance of researchers) and institutions such as universities to undertake relatively short-term research projects. Long term programs should be undertaken by properly funded research bodies such as CSIRO and the research division of CALM.

MONITORING

The value of monitoring as a means of solving management problems is important. For example zoning of public use and sanctuary areas on the Ningaloo Reef has been proposed without a good knowledge of the effects of public use. However, transects will be set up in each zone and monitored so that, perhaps ten years hence, managers can assess the impact of use and review the effectiveness of zoning.

OTHER RELEVANT ISSUES

Management plans could be useful as a framework on which to base experimental management.

Environmental stress and change caused by long term phenomena such as climatic change creates an element of uncertainty that is usually overlooked. Researchers should consider allocating more resources to this area.

Fears of a backlash from public opinion or political considerations may influence the decisions that managers make.

CONCLUSIONS

Managers will always have to make decisions on limited knowledge. However they can do much to improve the situation by adopting an experimental approach to management prescriptions. Advice from researchers is available to managers who intend following this approach.

In any event, managers should maintain records of management actions so as to compile a management history of the areas under their control.

At present, methods for recording and storing data are inadequate. This area needs to be addressed as a matter of urgency.

Complex problems should be investigated by researchers although managers may be able to assist. Generally organizations like CALM and CSIRO should be involved in long term programs while universities and competent managers should address short term projects.

ACKNOWLEDGEMENTS

I thank all members of the group for their participation in this useful discussion. I also thank Gordon Friend for taking meticulous notes during the workshop session and Denis Saunders for his assistance with editing of the report.

MANAGEMENT IN UNCERTAINTY; USING THE OPPORTUNITY TO ADOPT AN EXPERIMENTAL APPROACH TO MANAGEMENT

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TERMINOLOGY

Uncertainty arises from lack of scientific information, e.g. uncertain consequences arising from apparently certain action due to the complexity of ecosystems or uncertainties arising from unforeseen public and political reactions.

APPROACH

Management in uncertainty may be conservative or adventurous. Before an approach can be decided the relevant issues and strategies must be developed. These issues include the amount of latitude the manager has to decide a course of action e.g. there may be a high level of freedom to decide a fire regime but very little on mining and other exploitation. The coercion factor imposed by other organisations or individuals must be recognised.

Managing in uncertainty requires a high level of staff support. Within a large organisation there is a considerable inertia which resists change and this may be an important factor which can affect a manager's ability to react.

ISSUES

Three areas can be identified as affecting implementation of new initiatives; the Government level, Departmental policy level, and branch or land manager level.

Government level. Uncertain consequences create a cautious approach. The spectrum of political influence will affect Government reaction while other organisations/individuals will influence Government reaction.

Departmental (policy) Level. Political influence will affect Departmental response. Senior support will depend on the breadth of support within the Department. It will also depend on entrepreneurial and other benefits for the Department, the likely backlash from public/others as well as available finance and current priorities.

Land Manager Level. The management problem must be defined and of sufficient importance to warrant action. The action must take into account the level of scientific uncertainty and likelihood the consequences are unpredictable and serious. It is also important to establish the position of the project in relation to current priorities.

These issues defined a number of management objectives for which the discussion group were able to define strategies. Time did not permit treating all the issues.

STRATEGIES

Government Level. Coercion by other organisations/individuals must be managed. The possibility of winning community support for the project should be assessed. The uncertainties need to be explained and then minimised. The positive benefits from the project must be established and pointed out to all concerned.

Departmental Level. Broad support from staff and the community should be sought. A Departmental policy should be written and the constraint of inertia minimized by sowing the seed of the idea and developing a statement of benefits flowing from the project. Staff and the public should be involved in designing the process/project so that they develop a sense of ownership. Once the Department has set a course of action it must be firm and not changed as a result of pressure.

Support from senior staff is essential for the success of any project. Any proposal for change must identify and assess the likely backlash both externally and internally and advise senior staff. Finally the proposal must be widely circulated so that all who have an interest in it are informed and feel that they have a stake in the project and its outcome.

Land Manager Level. The level of scientific uncertainty must be assessed. It is necessary to define the management problem, ensure a clear objective and state the hypothesis regarding the end point of the management program. Management procedures should be written and involve all relevant staff expertise. The management procedures should be reviewed and the results assessed with a view to refining the objective or the management procedures as necessary. It is important to set aside control areas.

The level of historical uncertainty should be assessed by examining the evidence of historical fire regimes, etc. and seeing if they are relevant to current plant/animal communities.

EXPERIMENTAL APPROACH

An experimental approach should be based on a systematic method for establishing the proposals for management. It is necessary to identify the risks and the constraints. A clear objective which relates to landuse objectives must be provided. The full range of knowledge on the subject both internal and external should be collated and finally a proposal developed. This should specify hypotheses, procedures, consequences, recording methods, monitoring methods and the review process. The review process is extremely important as the success of this stage will allow for the interpretation of the results of management practices and the refinement or change to these practices, where necessary.

MONITORING : IS IT OF USE IN INTEGRATIONOF RESEARCH AND MANAGEMENT?

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BACKGROUND

Monitoring, as applied in a land (and water) management agency embraces the whole process of keeping track of changesin the environment over time. The changes may be a direct result of a management decision or action or they may merely reflect the passage of time and the effects of local or regional events. A comprehensive monitoring program will have the components listed below.

1.A system of recording and maintaining records of management decisions and actions.

2.A program for the establishment and systematic resampling of sites designed to evaluate the consequences of those decisions and actions (preferably in an experimental management framework).

3.A program for the systematic resurvey of selected, representative (benchmark) sites to track general patterns of change across the landscape. These changes may be as a result of long-term climatic cycles, for example, or may merely be long-term successional effects.

4.A program for establishment and systematic resurvey of long-term study sites where the network of sites is specifically designed to test hypotheses about particular types of change across the landscape (i.e. monitoring as a research tool).

5.A system for systematic evaluation of the results of monitoring and subsequent review of management policies and actions.

Monitoring should become an integral part of management to provide for a gradual increase in knowledge about, and understanding of, the ecosystems and communities being managed. A process that would encourage integration of research, planning and management is indicated in Figure 1. This process would necessitate some changes in the roles of key personnel.

Planners typically collate existing information and interpret it in the light of policy to develop management plans. Planners are ideally situated to identify gaps in knowledge and areas of uncertainty. They should collaborate with researchers to write into their plans programs of experimental management that will fill these gaps; these programs should include detailed monitoring methods.

Managers normally interpret and implement management plans. They can also implement monitoring programs. Researchers should be involved in the establishment of monitoring sites and should provide training in sampling techniques. Subsequent resampling would be a component of ongoing management (inspired by feedback).

Researchers in this scenario would liaise with planners and managers in the formulation and implementation of management programs and would collaborate with managers in the interpretation of results from the monitoring programs. This liaison should make researchers increasingly responsive to the needs of managers.

INTEGRATION

In the light of this background, the response of the workshop members to the question posed

Personnel	Action & Result
Policy Makers	Policy formulation Information Policy
Planners & Researchers	Project Definition Planning Identification of gaps, uncertainties
	Plan
Managers & Researchers and Records/Inventory Staff	Implementation includes reporting, establishment of monitoring sites
Managers	Monitoring
Managers & Researchers	Interpretation of monitoring results

Fig. 1. A flow diagram of the planning and management process indicating how monitoring might become a focus for collaborative activity and lead to integration of research and management.

in the title was: "Ideally - yes but, realistically, probably no!". Managers, particularly, felt over-committed and unable to take on further responsibilities despite the clear recognition of the importance of monitoring.

The next most immediate response was: "What is actually involved?" and "are additional resources to be provided?"

In the ensuing discussion, a number of points were made about the general concept of monitoring and its role in bringing together researchers and managers. Included were the following.

1.Monitoring must be cost-effective (can we monitor <u>communities</u> in a cost-effective way?) and must produce interpretable results. It is desirable to establish hypotheses which can be tested through a monitoring program as this will ensure that the program has clearly defined objectives and methods. Simple, standardised methods are important.

2.There is a need for clear objectives of any monitoring program. Among other things, this permits evaluation of costs and benefits.

3.There are already monitoring programs being undertaken by Department of Conservation and Land Management managers; examples cited were monitoring rare flora populations, wheatbelt recreation areas and impacts of human use in national parks.

4.Researchers should play a leading role in generating interest in an agency monitoring program by providing good examples of the values of such a program (e.g. the Noisy Scrub-bird program, the Short-necked tortoise program, the Carnaby's Cockatoo program) and by designing studies that incorporate a potentially collaborative monitoring phase.

5.Because most monitoring is seen to be long-term (i.e. at least 30 years) then the program should be structured to ensure continuity. There should be a clear, unequivocal commitment from the organization to long-term monitoring before any major work is undertaken. A reporting system with regular feedback to the observers is important to encourage observer continuity.

6.Managers and researchers endorsed the concept of a pilot project (perhaps two per management district) and suggested the need for a full-time co-ordinator to get this (these) established.

7.Integration of research and management in the Department was being achieved to some degree through the establishment of multi-disciplinary teams such as those developing management plans. The collaborative approach to monitoring, as outlined above, was seen to be a positive step.

8.Monitoring was seen as essential to the production of regular State of the Environment reports. However, some possible overlap with other agencies (especially the Environmental Protection Authority) was identified.

9.It is highly desirable that the public should become involved in any monitoring program. Firstly, users of Departmental lands should be required to monitor the effects of their uses (or to pay a levy for professional monitoring). Secondly, the public is a largely untapped labour force - the program could be made attractive to volunteers. (Note that any monitoring program involving voluntary observers would have to be carefully designed if the results are going to be reliable.) And finally, the involvement of the public would have considerable educative value. The monitoring program would cover a wide range of environments which people would come to appreciate and, at the same time they would become aware of the management issues and problems.

MONITORING; IS IT OF USE IN INTEGRATION OF RESEARCH AND MANAGEMENT?

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The Macquarie Dictionary definition of monitoring is "to check, observe or record the operation of something without interfering with the operation". It was accepted that in natural systems, monitoring must provide long term records of ecosystem components, and facilitate measurement of the direction and rate of change in the system. This was the definition coming from the report by Friend (1987) from a workshop on remnants of native vegetation.

There was a consensus that monitoring must be structured so that results are independent of the observer, and that any monitoring system must be carefully designed; casual observations provide but anecdotal information.

It was agreed that monitoring is of use to both manager and researcher, and that it may help integrate research and management but examples of how were not discussed. There was an assumption that managers should do much of the monitoring whilst the researcher ensures the scientific integrity of design and methodology. Both manager and researcher are concerned with recording changes in the ecosystem they are managing and studying; and monitoring allows the changes to be recorded. Monitoring has an educational value for the manager in that it demonstrates the dynamics of ecosystems. The manager's monitoring may well (a) provide research problems for the researcher, and (b) when monitoring the effects of a researcher's proposed management procedure, will help prove or disprove the value of the procedure.

METHODOLOGY OF MONITORING

Much of the discussion revolved around the methodology of monitoring in the real world of limited resources. This was because the Department of Conservation and Land Management (CALM) is considering setting up long-term monitoring sites to provide baseline information on changes in the major ecosystems of Western Australia.

It was agreed that the objectives of any monitoring program have to be clearly set out. Some will be short-term to monitor the effects of a management operation, whilst others will be long-term (e.g. follow changes in an ecosystem).

The latter category may need to be of hundreds of years duration if changes occur as a consequence of rare events.

Measurements need to be kept to a minimum because of the shortage of resources and the problems of data storage. They should include information on the lithosphere and atmosphere as well as the biosphere otherwise the reasons for changes will be hard to determine.

A centralised data base system is desirable within CALM. This should be within a group that will provide advice on the design and analysis of monitoring systems.

REFERENCE

FRIEND, G.R. (1987). Monitoring of management practices. In: "Nature Conservation : the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.). Surrey Beatty and Sons, Sydney.

PLANNING/COMMUNICATION

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The workshop was developed around the question "how can planning help managers and researchers achieve successful biological management?" General discussion was preceded by an introduction to the planning framework, the values of planning and communication as a planning tool. The following discussion then focused on planning as a framework for decision-making, the role of planners in biological management, setting priorities and communication. Management plans and planning within the Department of Conservation and Land Management (CALM) dominated the discussion.

INTRODUCTION

The Planning Framework. Planning has been defined as a method by which decision-makers can gather all the facts and consider alternatives before embarking on a course of action (Anderson 1977). The following diagram summarises this process.

Objective
Resources
Constraints Uncertainties
Strategy
Options
Best Option
Test
Implement
Monitor
Modify

These components may be defined as follows.

Objectives. These may range from corporate objectives to specific objectives for management of a particular parcel of land.

Resources. The information required is determined by the objectives. Generally information on natural, social and financial resources is essential.

Constraints. These may be political, physical (capability of the land to support a particular use), social or financial.

Uncertainties. This term refers to environmental uncertainty; for example, epidemics, disease, climatic change.

Options. Options are formulated based on initial objectives and taking account of the resources, constraints and uncertainties. A range of options should be considered.

Best Option. Objective criteria are used to select the best option.

Test. Modelling or "pilot" studies can be used to test the best option.

Implement Communication between the various staff involved is essential to ensure efficient implementation.

Monitor. Implementation should be monitored so that the level of achievement of the objectives can be determined.

Modify. Following monitoring, modification should occur, as necessary, at any of the above stages.

Values of Planning. Planning is a way of recognising the spatial and temporal implications of a management action. Spatially, planning creates a framework which draws on information from numerous sources and then facilitates recognition of the second and third consequences of the action. Temporally, planning encourages the development of a "management vision" - a perception of the preferred, future character of an area.

Management effectiveness is increased by using planning to set priorities and to ensure the efficient allocation of resources.

Accountability can be encouraged by planning, particularly when the public are involved. Such accountability generally encourages management agencies to use methods which can be readily explained and justified. Public involvement in planning is also generally accepted as resulting in better management.

Planning allows systematic management in the face of uncertainty (a characteristic of most natural environments). In this instance planning provides a framework which can be used to guide decision-making, while still retaining flexibility.

Communication as a Planning Tool. Communication may assist planning by: facilitating the provision and collection of information; enabling decisions to be more readily accepted, particularly if they are discussed prior to implementation; facilitating questioning, which often leads to review, modification and a resultant increase in management efficiency; and allowing recognition of the trade-offs which are an essential part of decision-making. Familiarising all participants and the wider community with the steps involved in planning also encourages a wider understanding of the decisions involved.

Communication is essential in the planning process, both prior to decisions being made and during the process itself, particularly in the evaluation and modification stages.

GROUP DISCUSSION

Much of the following discussion is devoted to management plans. It is based directly on points raised in the group discussion.

Planning as a Framework for Decision-Making. One of the most important functions of planning is to provide a framework within which management decisions can be made and then readily communicated to enable implementation. Planning within such a framework should be flexible enough to cope with changes in demand over time - for example, the recent annual requirement, by Wundowie, for 100,000 tonnes of firewood. Management plans, and particularly regional plans covering such resources, should be flexible enough to cover a reasonable number of such unexpected demands.

Within CALM a hierarchy of plans exist, including the corporate plan, policy statements, regional and area management plans, and operational plans. All plans should be regularly reviewed and evaluated to ensure that they are being implemented and objectives met. There should be a major review of a given plan when it expires. Planners should remain involved until a plan is running smoothly.

Role of Planners in Biological Management. Planners are part of a triangle, of which researchers and managers are also part.

Planners

Managers Researchers

The degree of interaction between the above three groups is dependent on the amount of information required by, and available from, each group. Through this interaction, plans often provide the first written information for managers.

Planning can offer services other than management plans, e.g. frameworks for evaluating acquisition/management priorities for a reserve system, or for evaluating the environmental impacts of a proposed management action.

Priorities. It is essential for all sections within a conservation agency, whether they be research, management or other specialist staff, to develop and work towards a common set of priorities.

Within CALM, planning priorities should reflect overall management and research priorities. This is best achieved by encouraging management, research and other specialist staff to generate their perceived priorities, based on pre-determined criteria. Departmental priorities can then be determined. If changes to these priorities are necessary, information supporting these changes should be made readily available.

Priorities should be given to prescriptions so that if resources are limited, allocation decisions can be readily made. Priorities may be hierarchical or more generally noted as being of low, medium or high priority.

Often management plans assume a greater dedication of resources to management of a given area than are currently available. If all desired prescriptions are included, as well as those that can be readily achieved given current resources, false expectations may be created. This may lead to credibility problems, particularly with the public. However, such plans can prove valuable in justifying additional funding. Similarly with prescriptions relating to research, adequate funding or staff may not be available. However, management plans provide a mechanism for highlighting areas where management-orientated research is sorely needed. This "shopping list" is useful in guiding the allocation of extra resources if they become available.

Communication. Communication is a two-way process, based on talking and listening. It is a specialist skill requiring specialist staff, plus training for others.

Scientists should be more open about what they know, and more importantly, what they do not know. However, scientists should ensure that the community remains confident in a research agency's professional abilities. Better communication between scientific colleagues is a good first step.

"Pro-active" communication is advocated, i.e. going out and asking for comments. However, target groups should be carefully selected. Also, communication with the public may be a painful process, with some parts of the community remaining unconvinced, no matter how well scientists communicate with them.

Management plans facilitate communication by getting people from different disciplines together. Those most critical of plan preparation should be invited to become involved in the planning process. This often encourages realisation of the trade-offs and constraints inherent in resource management.

Public participation results in better management, but is expensive in terms of both finance and time. The level of public involvement should be regulated by the level of complexity of the planning project, with more complex projects requiring more public participation and vice versa.

CONCLUSION

Most of the workshop discussion was general, with some specific discussion directed towards the role of planning in successful biological management. The workshop indicated that planning contributes to successful biological management in a number of ways: by providing a framework for decision-making and providing written information for managers; by setting priorities between areas and setting priorities for management actions; by highlighting areas where management-orientated research is required; and by facilitating better communication.

REFERENCE

ANDERSON, E.W. (1977). Planning the use and management of renewable resources. Rangeman's Journal 4. 99-102, 5, 144-147.

PLANNING/COMMUNICATION

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INTRODUCTION

The Workshop Leader stressed the importance of communication between managers, planners and researchers and the importance of regular feedback between these groups. For example, the results (including interim results) of research need to be communicated to the planner and manager if the value of research is to be realized. As the importance of this communication was generally accepted, and had become a major point of discussion in many of the previous workshop sessions, the Workshop Leader suggested that the topic could be rephrased for initial discussion in this session as:

"How can ecological theory assist in the planning for the management of the biological component ecosystems".

DISCUSSION

Ecological theory in planning. There is no "ecological theory", but many theories which together form a body of accepted principles. Examples relate to minimum viable population size, species competition, sociobiology, and population dynamics. The theories may be very broad, or extremely specific. As well as the many recognized ecological theories, others are espoused as such.

It was generally agreed that ecological theory could be valuable in many aspects of planning. For example, planners and managers must often make decisions in the absence of complete or reliable information. Factual data may not be available. Ecological theory can provide the most useful "best bet" basis for decision making.

Not all theories have stood the test of wide critical examination. Wide and popular promulgation is no guarantee of wide acceptance. Even widely accepted theories may be amended or discredited by new information. Considerable concern was expressed at the possible misapplication of ecological theories. There are numerous examples of such misapplications which have lead to disaster (e.g. population dynamics and fisheries). The less secure the foundations of the theory, or the less the theory is understood, the greater the risk of mistakes.

A theory may be widely accepted as sound, and yet its application may still prove difficult. For example, there are many differing views on the minimum size of reserves, all based on the same concept of maintaining viable populations. The differences arise not because of disagreements on the basic theory, but on the details as to what constitutes the minimum viable population.

While ecological theory is a legitimate basis for decision making, it was emphasized that planners and managers must exercise caution to ensure they are using the best current information.

Checklists. To educate planners and managers it was proposed that a checklist of recognized theories be prepared. This checklist should be widely circulated at least within the Department of Conservation and Land Management (CALM) to assist planners and managers in their detailed planning and decision making. Any such checklist should be subject to regular review to ensure it remains current.

Concern was expressed that a checklist for theory could do a great deal of harm if blindly applied and not understood or tested against common sense. (This is a presentable argument against publication). It was felt that, where ecological theory was used as the initial information, its predictions could be checked through a monitoring process.

It was suggested we also spell out our "articles of faith" - those things that we believe to be correct and basic to our management (which would include our general conservation objectives and various conservation strategies). These "articles of faith" may overlap with recognized and accepted ecological theories, and could possibly be combined with them to form a single checklist. A. Hopkins and I. Abbott undertook to compile such a provisional list.

When such a checklist for planners is developed from a list of recognized theories it is important that it is checked against individual management plans (particularly those proven in practice) and other relevant documents to ensure that they are appropriate. If there appears any conflict, both the checklist and plans should be closely examined.

Communicating theories. Ecological theory is dynamic. Accepted theories may be discredited with new information; apparently conflicting theories may exist. Communication between scientists, planners, and managers on ecological theory is important to provide a critique of theories, maintain updated knowledge of the latest ideas, and minimize the risk of mistakes.

All professional staff must be encouraged to regularly update their knowledge. This can be difficult because of conflicting work pressures and the mass of information available - not all of which is relevant to each individual but the reading of which is time consuming. This applies particularly to planners and managers who need to remain competent in a broad range of disciplines.

A process of periodic upgrading of theoretical knowledge by management staff could be usefully carried out in a structured way such as sabbaticals for senior staff. In addition, it was agreed that as research scientists may be expected to have a greater depth of reading in their area of specialized knowledge they should ensure that key articles are brought to the attention of planners and managers. Within an organization such as CALM this can be readily done by internal circulation.

The dissemination of information outside an organization can be more difficult and time consuming, utilizing a number of avenues. For example, CSIRO disseminates information through such publications as "Ecos", annual reports, specific research program reports, scientific publications and by providing information for CALM technical publications; through talks to management groups; and through organizations of workshops such as this one. Despite these efforts a shortfall was recognized by the group. Greater use of "popular" publications such as "CALM News" as well as technical journals was suggested as a means to more widely distribute information regarding CSIRO work.

As well as the above "formal" channels, much of the effective communication between organizations is on a personal basis between scientists in such organizations who in turn have a key role to disseminate relevant information to the planners and managers. Whilst seminars and various documents (e.g. management plans and scientific papers) were recognized as contributing to the distribution of information on the application of ecological theory, they frequently reach only a limited sector. Meetings such as research working groups are also an extremely valuable forum to exchange information but their very restricted membership at best limits the spread of information , and at worst may give a false impression of the overall level of knowledge. In the extreme situation, if the same limited group write and read papers and meet to discuss the issues, that select group may become very knowledgeable, and incorrectly assume much of this has become general knowledge. In addition to these avenues of communication there must be more communication between researchers, planners and managers. Three ways were suggested in which this could be done.

1.There should be more integration between management and research in both planning and implementing projects. This could have mutual benefits relating to the project itself (e.g. greater ownership of trial plots will lead to their better care by Districts; early involvement can reduce problem siting; resources and ideas can be pooled) and improve the communication between these group on wider topics (including the application of ecological theory).

2.Review seminars and workshops on particular subjects would increase the interaction between groups. There are many suitable themes (e.g. fire management in different ecosystems; insect population/management/host effects) for such discussions. Because each group directly involves relatively few people, a number of such seminars/workshops may be desirable to widely canvas and disseminate views.

3.Extend the scope of workshops to cover wider topics. A great value in the gathering together of a diverse group for a workshop, particularly if it is residential, is in the interchange of ideas, better communications and resultant greater understanding on wide ranging issues beyond the particular theme of the workshop.

More use should be made of this and many of the issues expanded on. It was strongly recommended that, in addition to "technical, theme-specific" workshops, that there be a biennial meeting of a working group comprising researchers, planners and managers (similar to the group for this workshop) to provide interaction on more general issues. Such issues could include directions for research; application of research findings through management; the needs of the various groups; topical projects.

The possibility of deploying a liaison officer to facilitate the transfer of information between research and planners/managers, and assist in getting research findings into management practice was raised at an earlier workshop session. It was not expanded further in this session, but the importance of liaison by individual researchers was stressed.

PRIORITIES OF RESEARCH AND MANAGEMENT AND THE SETTING OF OBJECTIVES

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INTRODUCTION

Basic objectives for a nature conservation agency are often set out in enabling legislation and the agency's corporate objectives. These can be translated into policies and strategies by the corporate executive. The policies and strategies may then provide the basis for deriving the objectives and setting the priorities of research and management programs. There are three problem areas in effectively deriving the objectives and priorities for research and management. There must be means of getting maximum input from staff and outsiders during the initial information gathering and evaluation phase, prior to executive decision. There must be regular review and avenues for feedback from staff to ensure a flexible approach. There must be capacity for change inherent within the system so that policies and priorities can be improved as experience grows.

RESPONSIVENESS TO CHANGE

Good research requires a high degree of specialization but this can compromise flexibility. By definition, a research specialist is seldom capable of changing the nature of his or her work without risking loss of quality. A research unit built upon individual speciality i.e. scientific discipline or biological taxon, has an inbuilt tendency for inflexibility when change of direction is required. The most flexible research unit would be one staffed by generalists who can turn their hand to anything, but standards may then suffer. This lack of depth of expertise may mean that there are no quick solutions to specific problems. This problem is confounded by the need for security of tenure for research staff. The world's foremost expert on dugong reproduction, for example, might play an extremely important role until management has enough information to effectively manage the dugong populations - what does he or she do then? And who should determine the cut-off point where a specialized project, while continuing to contribute valuable science may have reached the limit of practical use for management?

For many research units the principle opportunity for changing research directions occurs when a scientist resigns or retires!

After discussion the group concluded that the staffing strategy for staff in research units in the nature conservation field should seek a blend of long-term tenured positions, with short-term contract positions, and that greater opportunity for exchange of scientists between government and other agencies is essential. The group also identified rigid financial management and a variety of industrial problems as contributers to inflexibility in conduct of both research and field management programs.

EVALUATION AND REVIEW

Although initial evaluation and objective setting on the one hand and review and re-setting on the other, are different phases of the process, they should be based upon the same principles and were considered together for our purposes. As an exercise the group decided to consider one of the primary objectives of the Department of Conservation and Land Management's Corporate Plan, viz. "management of land to maintain species and genetic diversity". A series of critical decisions were envisaged in implementation of this objective.

Definition. It is essential that the meaning of the objective is widely understood. In this case there must be consensus on the meaning of the terms "species and genetic diversity", and the action verb "maintain".

How? When the intention of the primary objective is agreed, the question arises, how do we manage land to maintain species and genetic diversity?

In this exercise we can assume that the land in question is a series of reserves already selected for their representativeness of species and genetic diversity - our objective is to maintain it. We are led to a consideration of those ecological processes which maintain diversity, those which mitigate against it, and of the impact of human activity. On the basis of this evaluation we must decide whether direct action to enhance diversity is necessary, or whether it is sufficient to prevent or contain those natural processes and human activities which mitigate against it.

Are existing knowledge and techniques adequate? Clearly this particular corporate objective presupposes a sound knowledge of the ecological principles involved? Is the current theory capable of being translated into practical management? If not, what is lacking?

These questions lead directly to research objectives and priorities.

The discussion group then considered, briefly, the question of the relative importance to the objective of autecological versus synecological (in-depth single species studies versus community) studies. It was recognised that this is a matter needing urgent consideration and resolution in the context of setting departmental research priorities.

What can be done with existing knowledge and techniques? Some broad principles about diversity are known. For example, environmental heterogeneity (in both space and time) is an essential factor in creating and maintaining species diversity (richness). Periodic or episodic disturbance of certain types is often necessary.

It is known for example, that fire is one important disturbance element in Australian terrestrial environments. It can be used as a management tool to maintain species diversity in some circumstances. It is also known that introduction of exotic species may have flow-on ecological effects leading to loss of native species. Therefore control of exotic species can be an important component of management programs.

The group concluded that existing knowledge of this kind can be used, cautiously, in reserve management programs, while research continues; this combination will result in better understanding and better techniques.

Experimental management. The group discussed the notion that, in the absence of relevant detailed ecological knowledge, a deliberately experimental approach to land management could be an important complement to research.

This approach requires sufficient resources for monitoring results of management, and the forging of links between field management staff and research staff, in order to maximize its effectiveness.

The group noted that experimental management incurs greater risk taking. It implies a greater frequency of failure but the offsetting likely benefits were considered to justify the extra risks.

Costs and benefits. What are the costs and benefits of each increment of diversity to be protected? Any extra money should be spent where the benefit is likely to be greatest. What are the criteria for selection of reserves for priority management or research? High diversity, presence of rare species, low cost, degree of current detrimental pressures are all potential criteria to be taken into account.

Once again there is a need for information. Which are the high diversity areas? Where are the rare species? Biological survey is an essential prerequisite for establishing priorities.

Public pressure. There are some areas where incorrect public perceptions create pressures resulting in allocation of resources to matters which might not otherwise be given high priority, e.g. kangaroo management. The group acknowledged this problem as being a fact of democratic life.

CONCLUSIONS

The discussion group did not attempt to deal with the organizational aspects of objective and priority setting. However, from the exercise whereby one of the agency's corporate objectives was worked through, a number of points were made.

1. Program objectives and priorities must derive originally from the agency's corporate objectives.

2. Wide discussion of the meanings and purposes of the corporate objectives is essential if

middle-management is to be effective in setting program objectives and priorities. Holding workshop sessions on key issues is one way of achieving this.

3.Some of the agency's most important corporate objectives relate to matters where current knowledge is deficient as a basis for effective action (e.g. distribution of species and communities, ecological community function). While immediate management action is necessary, well-directed research is an investment for future improvement, and the two functions are inextricably linked.

4.Both field operations staff and research staff must be involved in the information gathering and evaluation phase, prior to objective and priority decision making.

5.Management objectives and priorities must be set after cost-benefit analysis, particularly when there is limited knowledge.

6.Research objectives and priorities must reflect management objectives, setting out to provide necessary knowledge currently lacking in critical areas.

7.Experimental management, though requiring extra resource allocation and incorporating greater risk of failure, is a worthwhile investment to complement research.

8.All objectives and priorities must be subject to regular review and up-dated in the light of experience and results from research, as well as in response to new circumstances.

9.Management, in particular financial and staffing decisions, must be deliberately designed to accommodate change following review of corporate objectives and reviews of program objectives and priorities.

PRIORITIES OF RESEARCH AND MANAGEMENT AND THE SETTING OF OBJECTIVES

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INTRODUCTION

Setting objectives and priorities may be divided into process and content. The former includes the procedures and definition of responsibility for writing and selecting objectives and priorities. The latter concerns the specific program items and their order of priority.

This workshop discussion group focused on process because understanding this is essential if content is to be effectively manipulated; furthermore, process has an important direct impact on content. Four main issues were covered during the discussion.

1.The structure of organizations in relation to the setting of objectives and priorities.

2.The effects of external influences on the objectives and priorities of organizations.

3.The criteria required for setting priorities.

4.The method for changing priorities in an organization with diverse responsibilities and major external pressures.

Criteria for selecting objectives were not discussed as this process was considered to be comparatively straightforward.

ORGANIZATIONAL STRUCTURE

The broad structure of government organizations, as evidenced by recent changes instigated by State and Federal Governments, is often established outside the organizations themselves. Obviously such structural changes may have a profound influence on organizational objectives and priorities. This potential is recognized under "external influences" below (Fig. 1), but is not considered further in this report.

Despite external influences, government organizations themselves decide on the important internal processes for decision-making with respect to objectives and priorities. One aspect of this is allocation of responsibility for writing, selecting and implementing objectives. For the Department of Conservation and Land Management (CALM), these responsibilities are allocated as shown in Table 1. This pattern is applicable to other groups, such as CSIRO, although the latter has a shorter hierarchy.

The following points emerge from Table 1.

1.Objectives and priorities flow down the hierarchy. For example, departmental corporate objectives are based on relevant Acts and Regulations, and themselves form the basis for divisional objectives, which in turn form the basis for branch objectives, and so on.

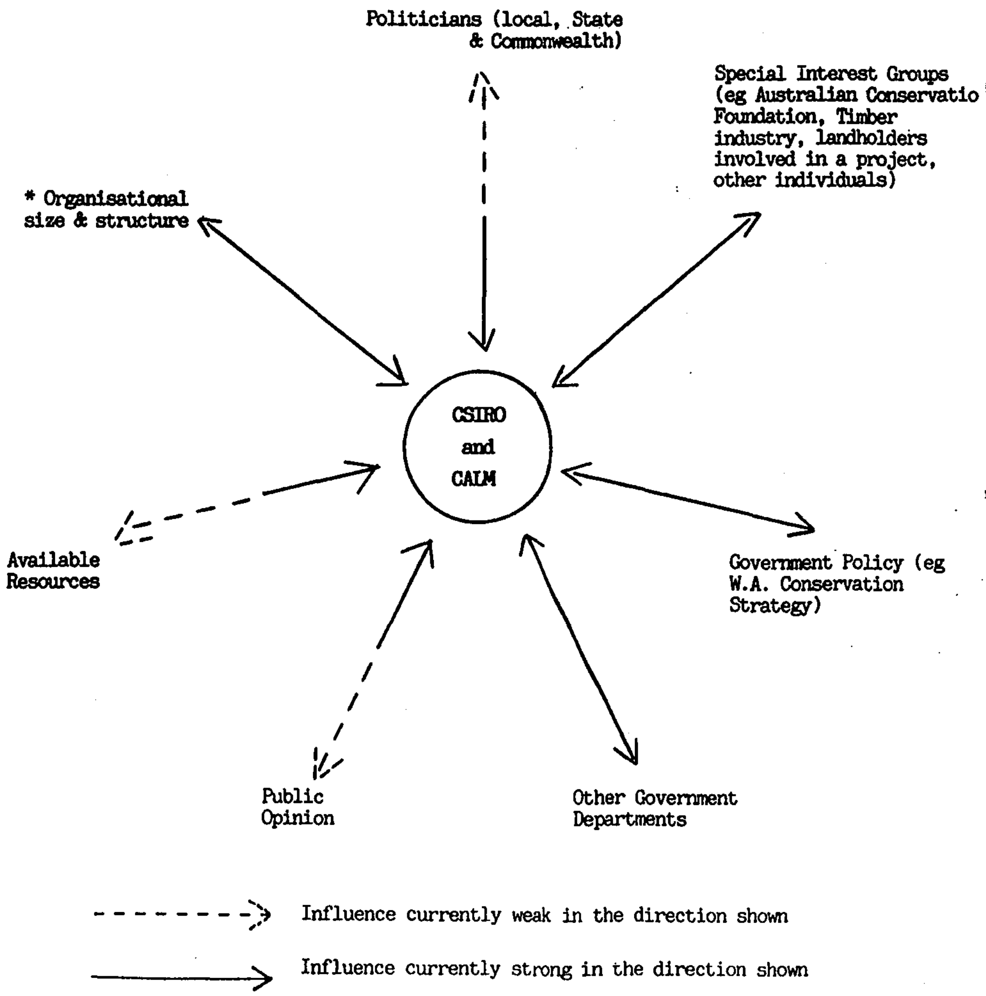
2.It is important that those who implement objectives should also contribute to their formulation.

3.While final selection of objectives and priorities at any level will, where necessary, be made by the Executive Director or equivalent in other organizations, decision-making is usually devolved to more junior levels.

During periods of rapid and continuing external change the ability of organizations to adapt priorities and objectives is severely tested. At these times a further characteristic of organizations, inertia (or internal resistance to change), may become apparent. Means of overcoming organizational inertia are well covered in manage-

FIGURE 1: Outside Influences on Objectives & Priorities

The two-way nature of relationships is recognised by the double-headed arrows. Although very important, relationships between outside influences are not shown.



* While to a large degree an internal matter, the general form of government organisations is often imposed.

ment literature. During discussion the personalities of staff and quality of personnel management were stressed as crucial factors affecting the degree of inertia. In addition, it is important that all personnel subscribe to a common set of objectives if adaptation is to be successful.

Personnel management is critical in any organization and, in particular, all staff involved in this field should receive relevant training in personnel management and in leadership skills.

OUTSIDE INFLUENCES

Priorities and objectives are greatly influenced by the environment in which organizations operate, and organizations themselves influence their environment. Major elements of this relationship are shown in Figure 1.

Government organizations generally have a weak influence on politicians and it is extremely important that organizations keep the public and special interest groups informed. This is especially so during periods of declining resources. One method for land management bodies to shape outside influences is for their publications (e.g.

TABLE 1. Department of Conservation & Land Management (CALM): Responsibilities Within the Organisation for Setting Objectives & Priorities.

Policy Level \ Action	Writing	Comments	Final Decisions	Implementation	Monitoring Implementation
Departmental	Policy Directorate	Branches Regions National Parks & Nature Conservation Authority Lands & Forest Commission Outside Groups	Executive Director	Department	Executive Director Policy Directorate
Divisional	Division	Policy Directorate Regions Branches Outside Groups	Policy Directorate General Manager Divisional Manager	Division	Policy Directorate Divisional Manager
Branch	Branch	Divisional Managers Branches Regions Outside Groups	Policy Directorate General Manager Divisional Managers Branch Manager	Branch	Divisional Managers Branch Managers Regional Managers
Regional	Region	Divisional Managers Branches Districts Outside Groups	Policy Directorate General Manager Divisional Managers Regional Manager	Region	Divisional Managers Regional Manager Branch Managers
District	District	Region Branches Outside Groups	Policy Directorate General Manager Divisional Managers Regional Manager District Manager	District	Regional Manager District Manager Branch Managers

CALM publications "Landscope" and "Beating about the Bush") to become more effective communicators of an environmental ethic.

Organizations concerned with land management may have strong opposing influential groups and while industrial lobby groups (i.e. those both for and against resource harvesting industries) are strong, there is no effective lobby group for the land itself. More "friends of the park" type groups should be established to fill this role. While these would not always support organizational objectives and priorities, they could at least be kept informed of constraints on the organization and the reasons for decisions.

There are a number of methods that have been used by various organizations for keeping politicians informed and these range from holding open days to distributing calendars with the organization's objectives on each page. Whatever the means, the importance of better explaining priorities and objectives is apparent. It is also important to achieve a balanced, positive media coverage.

SETTING PRIORITIES

Priorities may be established by using the concept of broad themes. Examples of themes for an organization like CALM include wildlife research, timber production operations and nature interpretation in parks and forests.

For setting priorities between themes the following five criteria were proposed by the discussion group.

1.The intensity of external pressures with respect to individual themes, particularly in view of the factors shown in Figure 1 (in this context instructions from Ministers and Cabinet are considered to be external pressures).

2.The degree to which particular themes contribute to achieving departmental objectives and policies.

3.Have historical commitments been made for individual themes?

4.The urgency with which individual themes are to be implemented.

5.The capacity to implement individual themes.

By scoring different themes for each criterion and adding scores for all criteria, a hierarchy of priorities can be established.

In some organizations scientific merit would be an additional criterion. This criterion is covered in CALM within Departmental policies and objectives at the theme level. Nevertheless, criteria for assessing competing interests within themes (e.g. within the theme of wildlife research) would necessarily include criteria additional to those listed, and some of these would pertain to scientific merit.

There was general agreement, within the discussion group, concerning the five basic criteria but the relative importance of each was debated. In particular, there was disagreement concerning whether "external pressures" was the most important criterion, or whether priorities should be established for the remaining criteria before considering "external pressures". This conflict was not resolved, thus underlining the importance of having objectives that are meaningful in the short term and that also provide direction over the longer term despite short term external pressures.

Having identified criteria for ranking competing themes, and, together with more specific criteria, for ranking competing programs within themes, a procedure for changing priorities could be developed as follows.

1.Describe and analyze the current situation including allocation of staff and expenditure to each function and the degree to which objectives have been attained.

2.Through internal debate establish the most important trends between and within themes. That is, identify where the need for resources should decline or increase and quantify these increases or decreases. This process also serves to prepare personnel for change.

3.Allocate specific priorities to themes and within themes, balancing the increases and decreases defined in (2).

4.Define the trends that should be followed and re-define objectives if necessary. Disseminate information concerning trends to personnel so that they are informed and prepared for change.

5.Re-direct resources as soon as possible, but this may be a gradual process.

6.Regularly evaluate achievements and resource expenditure between and within themes. Use this information to continue the process of changing priorities as time goes on.

This procedure is more difficult in the current climate of declining resources. In this situation work may cease in some sub-themes, or indeed, whole themes may disappear. While private enterprise may use profit-based criteria to make these decisions, many government organizations do not have objectives that can be categorized on a strict profit/loss basis. It is very difficult to choose between widely disparate themes (e.g. resources for control of timber production or resources for development of a marine park) and largely impossible to quantify.

CONCLUSIONS

The setting of priorities in a large and multi-purpose organization is a most difficult task for management, particularly when very different themes or programs are being compared, but it is a critical step in ensuring the most efficient use of resources. While the criteria and process for setting priorities developed during this workshop will assist managers, a significant component of major decisions will continue to reflect the subjective view of senior staff. This occurs in all organizations.

A second issue is the significant impact of external factors on the priorities and objectives of organizations. It is, therefore, extremely important for organizations to exert a positive influence on their external environment (Figure 1).

Finally, a most significant issue is the attitude to change (including the adoption of new research findings) in an organization. A positive attitude to change may stem from effective training and personnel management programs. Without these, changes will be resisted and efficiency will decline.

ACKNOWLEDGEMENTS

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ECOLOGICAL THEORY AND BIOLOGICAL MANAGEMENT OF ECOSYSTEMS : WORKSHOP SUMMARY AND DISCUSSION

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In this chapter we summarize the issues raised by the three introductory papers (Burbidge, Hobbs and Underwood) and the 12 discussion reports (Walker, Mercer, McKenzie, Abbott, Start, Peet, Hopkins, Arnold, Moore, Muller, Wilson and Wallace). We then discuss some of these issues and present what we believe were the conclusions of the workshop. No formal recommendations were sought or made during the workshop and the discussion that follows is our own view of the issues raised.

WORKSHOP SUMMARY

As explained in the Introduction to this publication, the workshop was held to explore some of the issues associated with the management of ecosystems as carried out by land managers in a nature conservation organization. The workshop involved 21 people from the Western Australian Department of Conservation and Land Management and three from CSIRO Division of Wildlife and Rangelands Research. There was equal representation of those involved in policy, planning and operations and those carrying out research. There was also a balance between those involved with timber production from hardwood forests and those involved in nature conservation.

The aim of the workshop was to explore the researchmanagement continuum and examine methods to integrate the two activities. The discussion topics were suggested by the organizing committee and the participants, but few constraints on interpretation of allotted topics or conduct of workshop discussions were given to discussion leaders.

While the title of the workshop was "Ecological theory and biological management of ecosystems" only four of the 12 workshop groups discussed the subject of ecological theory in depth and two of these were the groups discussing biogeography and its use for setting management priorities. Most of the discussion over the two days was concerned with non-biological principles of management - chiefly the mechanisms to ensure that managers of biological systems make the most efficient use of all of the resources (including information) available to them. It is obvious from the various discussions reported here that many participants have doubts about some of the present mechanisms and felt that they could be improved.

The introductory presentation by Burbidge discussed the reasons for managing biological resources and the principles involved with the management process. Four reasons were presented for the necessity of management: that species preservation is demanded on compassionate, aesthetic and/or economic grounds; that many species (often unnamed and unseen) contribute to life-support systems essential for the continued existence of humans; that species currently used by people should be managed on a sustained yield basis (not mined); and that all species should be preserved for possible future use (the maintenance of genetic diversity). The thrust of the presentation was that our goal should be to prevent the loss of any species so that we and future generations maintain the option of using (practical value) and/or enjoying them (quality of life). This is, of course, an anthropocentric view of nature conservation but the moral view that species should be preserved for their own sake was also discussed.

Burbidge also stated that as conservation and land managers and researchers we need to be aware that we are dealing with extremely complex ecosystems and that we do not know the consequences of most of our actions. This point was also raised and discussed by Hobbs and Underwood. In order to minimize detrimental effects of management we should be both conservative and conservationist in our approach. To manage successfully we need to adopt an environmental ethic and implement a conserver approach to our use of resources. If we, as public servants, are to be successful in this aim we must ensure that a conservation ethic is embraced by the public as well as our own staff. A major step towards this goal would be to ensure that staff devote at least a tenth of their time towards educating the public about ecological values and the importance of managing our biological resources so that they will be available in perpetuity.

Hobbs started by presenting a view of research and management sometimes propounded by critics: management goes on in isolation taking no account of research results and research is largely irrelevant, taking no account of the needs of managers. He went on to show that this view, which is still held by some managers and research workers, is totally out of step with the real world where managers use ecological theories in almost every biological management decision they make. These theories have been developed by relevant research which has then been applied. Hobbs pointed out that there is a need for greater cooperation between researchers and managers so that theoretical developments may go hand in hand with practical requirements. Researchers need to make sure that managers are kept informed of recent developments in ecological theory and practice, and point out the limitations of current theory where necessary.

Hobbs also pointed out that biological systems are extremely complex and that ecology is a science in its infancy. Often, something being manipulated is but a part of a more extensive ecosystem. It is becoming increasingly obvious that we need to manage ecological units in their entirety. An added complication is that a single ecosystem may cross several legal or political boundaries.

Underwood stated that managers have very limited knowledge on which to base decisions. Regardless of their lack of knowledge, they must manage. He proposed a series of steps to minimize the risks associated with managing in uncertainty (an issue that came up several times during subsequent discussions). He reinforced Burbidge's "conservative and conservationist" approach to management by stating that we should seek to oppose (or defer) interventions in ecosystems where the outcome is uncertain.

The need for clearly understood objectives was stressed by Underwood as was the need for a method for allocating priorities (a point raised by 10 of the 12 discussion groups [Table 1]). He suggested that integration of research and management is best fostered by using multidisciplinary teams, improving research extension, effectively communicating research results, involving researchers in management and holding subject-specific workshops like the one reported here.

Underwood stated that managers are suspicious of scientific theories that have not been thoroughly tested and that managers are dependent on research workers to clarify the distinction between fact and hypothesis. He pointed out that most managers (particularly those in large, complex regions) simply do not have the time to see the scientific literature and keep up with and integrate research findings.

Three important points regarding research were raised by Underwood: effective research direction is the direct responsibility of the research scientist and his/her director and it is up to them to ensure the work is relevant; those responsible for the direction of research should ensure that research staff spend part of their time on extension work; and managers can conduct useful experiments as part of their management activities.

The main issues raised by the 12 discussion groups are shown on Table 1.

The first two groups discussed the initiation of research and the process of carrying it through to management. This involves the identification of areas for research, setting priorities for the work identified and ensuring that results are actually

Table 1 Issues raised in discussion group reports

ISSUES RAISED / WORKSHOP LEADER	Communication/ education	Publication of research results essential	Importance of clear objectives/priorities	Integration of researchers/ managers/ planners	Data gathering by managers	Management Plans used for integration of all staff	Involvement of Public	Review of management/ research	Accountability	Comments
Walker	✓*	✓	✓	✓		✓				*onus researcher → manager
Mercer	✓	✓	✓	✓	✓	✓		✓		
McKenzie			*							*use of biogeographic data for setting priorities
Abbott			*							*use of biogeographic data for setting priorities
Start				✓	✓					
Peet	✓		✓				✓	✓		
Hopkins	✓		✓	✓	✓		✓		✓	
Arnold			✓	✓						
Moore	✓		✓	✓		✓	✓	✓	✓	
Muller	✓*	✓		✓						*onus researcher → manager
Wilson			✓	✓			✓	✓		
Wallace	✓		✓				✓	✓		

applied. Walker's group felt that research projects should be identified by all parts of an organization and will be dictated by organizational objectives, while Mercer's group believed that a list of potential projects has to be drawn up. Possible research projects can come from many sources, including outside bodies (other organizations and the public) as well as organization staff. The list should be widely circulated as it may act to focus on the needs of the organization and attract outside interests to work on some of the problems. Potential projects need to be screened and priorities set so that resources can be allocated. Walker's group listed criteria that could be used to set priorities. These related mainly to avoiding potential degrading changes to the ecosystems being managed.

Both Walker's and Mercer's groups believed that integration between policy makers, researchers and managers was necessary for efficient prosecution of research of relevance to managers. They stressed that communication is an essential part of this process with publication of research results an absolute necessity to disseminate information and to allow for evaluation of research staff and their work.

Walker's group stated that the onus for effective communication lies with the research worker who should be involved in communication at all levels: with peers, managers, planners, policy makers and the public. Mercer's group thought that extension officers could be a useful adjunct here.

Both groups believed that research workers must be involved in the formulation and review of management prescriptions and in the monitoring of the effects of management. Their involvement would foster more efficient integration of research and management as research workers would have a stake in the results and would be less insulated from the "real world".

The next two discussion groups mulled over the topic of biogeography and its use for setting priorities for management. Basically, both groups stated that biogeographical studies were of use for setting management priorities, but some participants felt that the topic was out of place in the workshop - an interesting view since it was the only topic which explored an accepted ecological theory and its relevance to management. McKenzie's group summed up by stating that the setting of priorities for management should have a rational biological base; the more relevant and better the available data, the more effective the decisions are likely to be. This topic also raised the issue of the relative merits of autecological versus synecological studies, an issue discussed further by Wilson's group.

The topic of management in uncertainty and the possibility of adopting an experimental approach to management was explored by Start's and Peet's groups. The former group stated that record keeping is essential so that others may benefit from the results of management experiments. At present in CALM records are not kept in a structured way that allows others access to this information. Staff change and memories blur, with the inevitable consequence that information is lost or distorted. An efficient system for recording, storing and retrieving management decisions must, threfore, be developed. The group also felt that monitoring is important for gathering data for solving management problems or reviewing management prescriptions.

The issue of the amount of latitude allowed to managers was raised by Peet's group; it may be broad for issues like fire but narrow for issues like mining or other forms of exploitation. Influences from outside the managing organization may be strong and constrain management decisions. Cognizance must be taken of all such influences and actions may be needed to counter their effects. For management in uncertainty to be a success, flexibility is required so that managers may react to various and changing situations. External influence may reduce flexibility; so does inertia in the organization. Inertia is a product of various factors including over-specialization of staff, over-commitment to low priority tasks or a large back log of work. To counter inertia, staff and the public should be involved in designing management plans, thus developing a sense of ownership - an important point for fostering an environmental ethic.

Two groups, led by Hopkins and Arnold, addressed the question of whether monitoring is of any use in the integration of research and management. Hopkins' group agreed that monitoring has considerable potential for the integration of research and management, but because managers already feel over-committed, it may not be of practical value. Many managers believe that they are unable to take on further responsibilities, despite recognizing the importance of monitoring. The group endorsed the concept of pilot monitoring projects in CALM of perhaps two per management district and suggested that a full-time coordinator should be appointed to start the monitoring project. They also pointed out that the public should be involved in the monitoring process as it constitutes a large, untapped labour force; also public involvement would educate those involved about management issues and problems and would help to inculcate a conservation ethic. Arnold's group agreed that monitoring may help to integrate research and management, but did not discuss how this could be achieved.

The issues of planning and communication in the management of biological systems were discussed by groups led by Moore and Muller. Moore stated that uncertainty is a characteristic of most natural environments. Planning is a tool that allows for systematic management in the face of uncertainty by encouraging the development of a management vision. Planning has the added benefit of encouraging accountability because planning persuades management organizations to use methods that can be easily explained and justified. Surprisingly, this was one of only two workshops that raised the issue of accountability (Table 1) yet accountability is essential in organizations charged with managing natural resources on behalf of the community and future generations.

Moore's group considered that communication is essential in the planning process, basically because it encourages a wider understanding of management decisions. For communication to be effective we need to be open about our knowledge and activities and the reasons for them. Planning, because it formally involves planners, researchers and managers, must aid their integration and contribute to more efficient management of biological resources. For efficient mamagement to occur, it is essential for all sections of the managing organization to develop and work towards a common set of priorities.

The way ecological theory can assist in planning for management of biological systems was discussed by Muller's group; however, they worried about the possibility of misapplying some theories. To guard against this, they felt a checklist of recognized theories should be prepared and widely circulated. The list could be checked against individual management plans and other relevant documents to see if there is any inconsistency. The group stressed the role of communication and felt that all professional staff should regularly update their knowledge, recognizing that pressures of work can mean that this is neglected. The group placed the onus on research workers to pass information to managers and planners. More use should be made of small workshops on specific themes and perhaps a biennial meeting of a working group of managers, planners and researchers should be held to provide interaction on more general issues. Workshops like the one reported here are one way of overcoming problems associated with having the three groups concentrated in centres that are isolated from one another. The group also raised the possibility of employing liaison officers to help transfer information between researchers and managers and to help apply the work.

The final two groups discussed the problems of drawing up priorities for research and management and the setting of objectives for the management of biological systems. Wilson's group decided that there needs to be a mechanism for obtaining input from staff and outsiders and for regular review with feedback from staff. Organizations need flexibility in their approach to researching biological systems but flexibility is often lost when specialist groups are employed as it is difficult to change their direction. The best opportunity for altering directions of research comes when staff leave and a blend of long and short term positions could provide for some flexibility.

The group raised the issue of autecological studies versus synecological studies and suggested that the balance needs urgent consideration and resolution in the context of setting research priorities. The need to adopt an experimental approach to management was identified, as was the need to hold workshops to discuss specific issues related to management, research and setting objectives and priorities. This group also raised the spectre of pressure resulting from incorrect public perceptions about nature conservation, leading to diversion of funds to lower priority areas. The group saw this as a fact of democratic life.

The issue of internal resistance to change (or inertia) as an important factor in the redirection of an organization was discussed by Wallace's group. It was pointed out that resistance to change could be lessened if all personnel subscribe to a common set of objectives. The group also raised the matter of outside influences and the importance of having an informed public to help an organization achieve its objectives. The environmental ethic and the organization's role in fostering this discussed. The absence of an environmental ethic in much of the community means that there is no effective lobby group for nature conservation lands, a fact which makes it difficult to allocate adequate resources to the management of biological systems. Outside influences were regarded as important enough to rate (by some of the group) as the first of the criteria to be used for setting priorities. However, applying such a criterion above all others will mean that the organization may be entirely reactive in its management and have constantly changing priorities. This point highlights the importance of having clearly stated organizational objectives to provide stability of direction in the face of changing external influences as well as the necessity of organizations exerting a positive influence on their external environment. The group saw the setting of priorities as a critical step in ensuring the most efficient use of resources; a step that becomes even more important when resources are diminishing. Underlying all of the above are the training and personnel management programs operating within the organization. If these are poorly developed or not relevant then the organization will be incapable of functioning efficiently.

DISCUSSION

An environmental, conservation or land ethic. The issue of fostering an environmental or conservation ethic in the community to promote the management of biological systems was raised several times during the workshop, but no definition of such an ethic was given. We discuss it here because we believe it underpins our management and research and we should be clear about our beliefs.

The World Conservation Strategy (1980) defines conservation as:

"The management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs of future generations. Thus conservation is positive, embracing preservation, maintenance, sustainable utilization, restoration, and the enhancement of the natural environment. Living resource conservation is specifically concerned with plants, animals and microorganisms, and with those non-living elements of the environment on which they depend. Living resources have two important properties the combination of which distinguishes them from non-living resources: they are renewable if conserved; and they are destructible if not".

The word ethic is defined in the Oxford English Dictionary as a set of principles or morals, rules of conduct, concepts of right and wrong.

Aldo Leopold (1949) outlined his concept of a land ethic after stating that there was no ethic dealing with man's relation to land and its biota:

"The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land.

"This sounds simple: do we not already sing of our love for and obligation to the land of the free and the home of the brave? Yes, but just what and whom do we love? Certainly not the soil, which we are sending helter-skelter downriver. Certainly not the waters, which we assume have no function except to drink, water gardens, turn turbines, float boats and carry off sewerage. Certainly not the plants, of which we exterminate whole communities without batting an eyelid. Certainly not the animals, of which we have already extirpated many of the largest and most beautiful species.

"A land ethic of course cannot prevent the alteration, management, and use of these 'resources', but it does affirm their right to continued existence, and, at least in some spots, their continued existence in the natural state.

"In short, a land ethic changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such."

The ethic should also promote the maintenance of life-support systems for this and future generations - the ability of the biosphere to withstand change is clearly limited. Leopold expressed this view succinctly by writing that "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise".

If we accept this ethic, we are charged with promoting "the care of 'natural resources' and their protection from depletion, waste and damage, so that they will be readily at hand through perpetuity" (Livingston 1981). This is an awesome task and a guide to achieving it is suggested by Devall and Sessions (1985).

"Furthermore, in order to insure the compatibility of interim measures with long-range ecology futures, restoration managers and interim managers need to cultivate a biocentric perspective. Some are just beginning to understand the relationship between cultivating one's own ecological consciousness and 'managing'. Any real understanding of the land means attuning oneself to the land, to a specific bioregion, and developing a sense of place. Otherwise, land management will continue to 'manage' on the basis of subjective economic criteria to the detriment of the Earth and the future."

Note the change to a biocentric perspective where we are part of the biotic community as opposed to an anthropocentric view of management where we dominate nature. Working within a land ethic will ensure that we do adopt both a conservationist and conservative approach to management as suggested in the State Conservation Strategy for Western Australia (1987) and reiterated by Burbidge in the introductory chapter to this publication. Leopold (1949) expressed the view that:

"A land ethic, then, reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity."

Having outlined a land ethic, how does one get such an ethic adopted by all of the staff of an organization managing biological resources and, more importantly, the community as a whole? This is perhaps the biggest challenge facing those involved with conservation and land management because their task would be made a great deal easier if all worked with a common set of objectives based on a common set of beliefs.

Perhaps the greatest barrier to engendering a conservation ethic is the increasing alienation of people from nature. Western Australia is a good example of this situation; occupying approximately one third of the area of mainland Australia, it has a population of around 1.6 million but over 85% of people live in one city - Perth. Many people seldom venture into undisturbed natural environments and have a jaundiced view of nature - a view restricted to their urban gardens, parks or street scapes. Similar restrictions apply to many country town dwellers and even to farmers.

Most people who have a land management problem can solve it with products of technology; they can mow it, snip it or spray it. In contrast, conservation authorities have no easy technological "fix". To compound the problem, they have vast areas and complex ecosystems to manage and too few resources with which to perform the task.

Education. Clearly, education is essential to enable the public to understand conservation issues and adopt a land ethic. However, we should heed Leopold's (1949) words. "The usual answer to this dilemma is 'more conservation education'. No one will debate this, but is it certain that only the volume of education needs stepping up? Is something lacking in the content as well?"

The importance of generating an informed, involved public was recognized by workshop participants and one recommendation was that staff should spend a significant proportion of their time in educating others about their work. Organizations like CALM and CSIRO have several communication outlets open to them, including several popular publications. As stated by Burbidge in his paper, these should promote the development of a land ethic and present nothing that promotes the opposite view. Staff should be required to write and speak to an audience wider than their peers. This important duty needs to be recognized by institutions and duty statements need to be drawn up to reflect this extra role (Saunders et al. 1987). Tertiary institutions should make more effort to train students to communicate with the community as well as with their peers.

Public views can be shaped by involving the community in land management issues and activities. This is already done widely by CALM in planning (Wallace and Moore 1987) and makes for a more concerned, supportive community. Public involvement should be extended to involvement in monitoring programs and in management programs. An example of limited involvement in management is provided by the many voluntary Bush Fire Brigades, but the scope of management activities involving the community must be broadened as it is beyond the capacity of government land management agencies to adequately manage all of the land under their control. Active involvement in planning and management will go a long way towards achieving successful management of biological systems in Australia.

Integrating managers, planners and researchers to achieve more efficient management of biological resources. The issue of integrating managers, planners and researchers took up a significant proportion of time at the workshop and several points were aired. The subject of integration was discussed by Hopkins and Saunders (1987, fig. 5) and they advocated a change in the role of planners, managers and researchers. Planning should include assessment and analysis of information and prescription of management procedures. Management should include implementation of management plans and establishment of sites to monitor the effectiveness of management. Research should include helping managers with the design and interpretation of experimental and monitoring programs. Hopkins and Saunders viewed monitoring and re-evaluation as key factors for successful integration. This means that every management action is assessed and the results fed back into the information base so there is a gradual improvement of knowledge about the systems being managed.

The objectives of the organization must be clearly stated, understood and agreed on. Without clear objectives it is impossible to allocate priorities and, without a system for allocating priorities, available resources are not efficiently allocated to tasks. Objectives and priorities must be understood throughout the organization and be accepted by the community on whose behalf the organization is acting. Having agreed on priorities, a multidisciplinary team approach to planning and management is an effective way to make the most efficient use of human resources. The team approach uses individual skills to achieve objectives and it is imperative that all members communicate with each other and keep themselves informed about advances in their field.

The onus should be on all managers, planners and researchers to keep abreast of the current literature and draw others' attention to articles of relevance. This can be done informally by circulation of papers, or more formally by organizing workshops around particular papers, ideas, theories, etc. It should not be the sole responsibility of the research worker, as suggested by some discussion groups - policy makers, planners and operations staff have an equal responsibility to ensure that they retain and improve their professional knowledge. We are not arguing that researchers should not take the initiative in helping managers keep abreast of advances - research scientists will spend more time keeping up with the scientific literature than managers and are more likely to come across articles of interest.

Accountability. Given the importance of the task facing all those involved in managing biological resources (policy makers, managers, planners and researchers) and the inadequate resources available, it is imperative that mechanisms are developed to ensure that resources are used efficiently. The prospects of an organization meeting the goals and objectives it has set depends on the nature of those objectives, the setting of priorities, the amount of available resources and the quality of its staff. All four are vitally important. The first three were discussed at length at the workshop but the quality of staff and their direction received little attention - monitoring of individual performance is as necessary as monitoring biological systems.

There is a tendency in large organizations for individuals to be insulated from the consequences of their actions as they can shelter under the "corporate umbrella". Staff need to be aware that they are accountable for their actions. As land and conservation management organizations we are trustees of community assets and the community has the right to question us about our goals and the use of their resources. Individuals within the organization need to be accountable both to the organization and to the public. Mechanisms are needed to assess individual performance in the light of corporate objectives and accountability. Such mechanisms should make it easier to redirect and train staff where necessary as well as counteracting the inertia inherent in large organizations.

CONCLUSIONS

The workshop on ecological theory and the biological management of ecosystems was very successful. In particular we believe it achieved the following results.

1.It provided a forum where policy makers, planners, managers and research scientists could exchange ideas and discuss common goals.

2.It identified important issues and problems that these groups felt needed solving.

3.It went some way to fostering a better understanding of the roles of the various groups and the problems they face.

Major outcomes of the workshop are listed below.

1.More time should be committed to fostering a land ethic in land management and research agencies as well as in the community.

2.There is a need for a common set of goals and objectives and for a method for allocating priorities that is understood and accepted at all levels.

3.Better integration of research scientists and conservation managers is needed and the multidisciplinary team approach to problem solving was agreed as one method.

4.There is a clear need to develop a method of recording, storing and retrieving management decisions and the reasons they were taken. Without such a system we will not be able to learn from experience and the value of biological monitoring will be lessened.

5.Small, select, thematic workshops that examine specific topics of biological resource management (e.g. managing for biological diversity) should be organized and the results widely disseminated.

Perhaps the most obvious shortcoming of the workshop was its failure to come to grips with the title; little time was spent actually talking about the use of ecological theory by managers. This was due to the general view that integrating the different groups of professionals was more important at this stage.

The success of this workshop suggests that it could be repeated, perhaps every two years, with some change in topic and participants.

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REFERENCES

DEVALL, B. and SESSIONS, G. (1985). "Deep Ecology". Gibbs Smith, Utah.

HOPKINS, A.J.M. and SAUNDERS, D.A. (1987). Ecological studies as the basis for management. In: "Nature Conservation : the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.). Surrey Beatty and Sons, Sydney.

INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE AND NATURAL RESOURCES (1980). World Conservation Strategy: Living Resource Conservation for Sustainable Development. IUCN, Switzerland.

LEOPOLD A. (1949). "A Sand Country Almanac and Sketches Here and There". Oxford University Press, New York.

LIVINGSTONE J. (1981). "The Fallacy of Wildlife Conservation". McClelland and Steward, Toronto.

SAUNDERS, D.A., ARNOLD, G.W., BURBIDGE, A.A. and HOPKINS, A.J.M. (1987). The role of remnants of native vegetation in nature conservation : future directions. In: "Nature Conservation : the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.). Surrey Beatty and Sons, Sydney.

STATE CONSERVATION STRATEGY FOR WESTERN AUSTRALIA CONSULTATIVE COMMITTEE (1987). A State Conservation Strategy for Western Australia. Bulletin 270. Department of Conservation and Environment, Perth.

WALLACE, K.J. and MOORE, S.A. (1987). Management of remnant bushland for nature conservation in agricultural areas of Southwestern Australia - operational and planning perspectives. In: "Nature Conservation : the Role of Remnants of Native Vegetation" (ed. Saunders, D.A., Arnold, G.W., Burbidge, A.A. and Hopkins, A.J.M.). Surrey Beatty and Sons, Sydney.