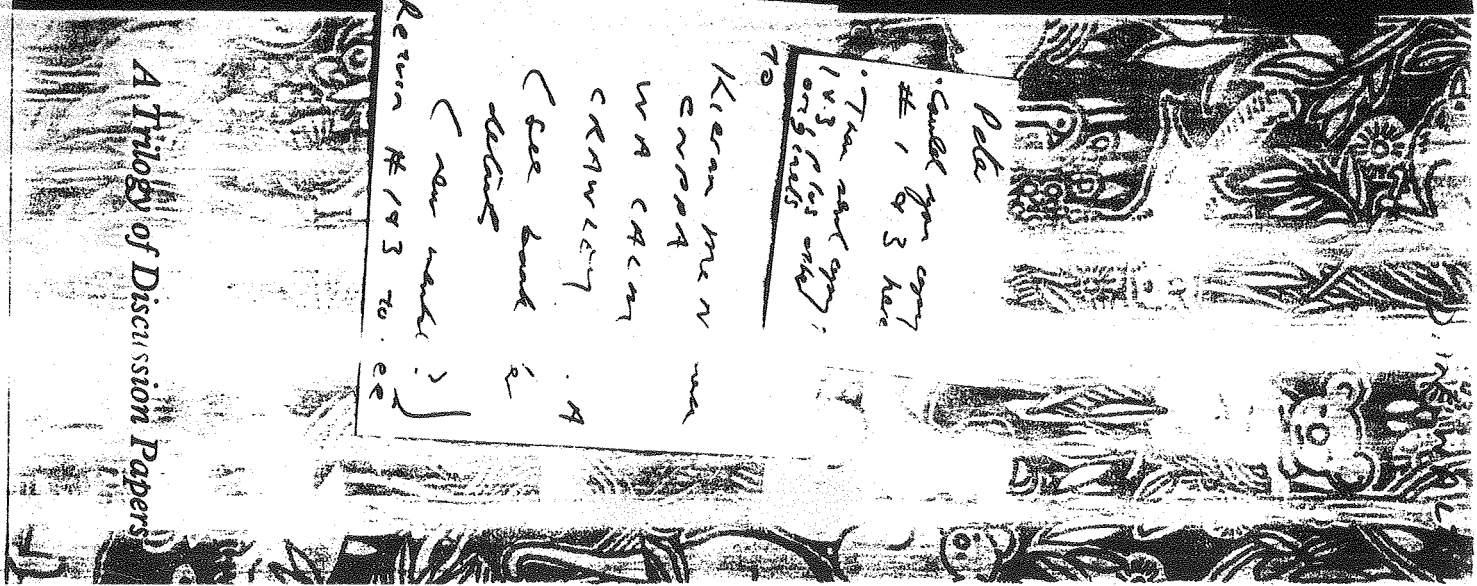
BIODIVERSITY

Broadening the Debate



A Trilogy of Discussion Papers

PREFACE

The articles which comprise this publication were prepared in 1991 for the specific purpose of broadening the debates which have surrounded ecologically sustainable development and biological diversity. The Australian National Parks and Wildlife Service has specific statutory responsibilities in regard to the flora and fauna as well as the landscapes and seascapes of Australia. The articles herein reflect these responsibilities, but in no way are the articles to be construed as the views of the Commonwealth Government, the Department of the Arts, Sport, the Environment and Territories or the Australian National Parks and Wildlife Service.

During 1991 and early 1992, the articles, in various drafts, were circulated widely within Australia and overseas for comment and to further the debates referred to above. In response to the continuing request for copies of the papers and to facilitate their citation by other authors, the papers are presented here.

I hope that you will find the contents stimulating and informative.

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THEORY AND PRACTICE IN FRAMING A NATIONAL SYSTEM FOR CONSERVATION IN AUSTRALIA

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INTRODUCTION

There are many challenges associated with the concept of biodiversity, particularly those associated with the maintenance and management of biological diversity. At the scientific level these challenges may be perceived at each and all three levels: ecosystem, species and genetic. The greatest challenge, however, lies in the area of human behaviour. We must renounce the image of ourselves as masters of all we survey and accept the challenge as the only species apparently with the capacity and imperative to maintain and manage (or the capacity to debilitate and destroy) what constitute the life support systems of our planet. Too few people are aware of the nature and the significance of the interrelationships between and among the living and non-living components of our world.

What do we mean by biodiversity? Biodiversity is the variety within and among living organisms and of the ecological systems they comprise (Reid & Miller, 1989; McNeely *et al.*, 1990). The definition does not exclude people, domestic plants and animals or the ecological systems of which they are part. There is no judgement of what is natural or unnatural and nothing is endowed with supernatural attributes (see Soulé, 1990 for a discussion of "Natural"). The term biodiversity does recognise the variety of life and the variety of life support systems which comprise the biosphere - life on planet Earth.

Biological diversity is the product of millions of years of evolution and has always been the basis of human food, shelter and culture. Australian biodiversity is very much global biodiversity in microcosm, the more so since Australia is a megadiversity country (Mittermeir, 1988; McNeely *et al.*, 1990). The comments which follow concentrate upon the terrestrial and freshwater components of Australia's biodiversity while recognising the critical importance of the marine environment.

CHALLENGES FOR AUSTRALIA

What is the concern for the conservation of Australia's biological diversity? Conservation is not "the wise use of natural resources for the benefit of all", conservation is the state of the health of Australia's lands and waters; biological diversity is integral to and a measure of the ecological health of Australia. Living systems, human or otherwise, can be regarded as ecologically healthy when their inherent potential is realised, their condition is relatively stable, their capacity for self-repair when preturbed is preserved and minimal support for management is needed (see Karr, 1990).

What do we mean by maintenance and management? Maintenance is the housekeeping, keeping the environment for life processes free from the ravages of people - ravages, not use. Management largely will be devoted to how we do the housekeeping, knowing where to act and where not to interfere.

While the maintenance and management of biodiversity are the responsibilities of each

of us as individuals, we must look to organisation and division of these responsibilities in terms of human institutions. Confrontation must be replaced by sensible debate, but we must all accept that vigorous debate there will be. The future of the maintenance of biodiversity will depend as much on skills in the management of that debate as upon scientific and technical management skills. The workings of the inner circles of science and politics will be of less long term significance than the broad picture of environmental science that reaches the public and shapes public attitudes (Dunlap, 1988; Murphy, 1989).

When must these challenges be accepted? Do we have enough information upon which to base maintenance and management of biological diversity?

There is no complete inventory of Australian biodiversity (*cf.* Richardson, 1984 and see Hnatiuk, 1990). To achieve such a complete inventory even for a tiny area of Australia would be a formidable task. The acceptance of the challenge, therefore, cannot wait for a complete inventory. We must, nevertheless, persevere in the task of establishing an inventory.

Do we have all the information needed to assess the impact of human activity upon living systems? Do we understand the processes within and between abiotic and biotic systems? In truth, we must admit that we are largely ignorant of these processes. Work must continue, however, to unravel their intricacies.

Can we afford to wait until we have all the information before management begins? Obviously, we cannot. Management must begin based upon what we know and research efforts balanced with management. Pursuit of scientific truth is fascinating, but it is an unaffordable luxury when species and communities are vanishing and when that truth arrives only in time to be included in a eulogy (Coblentz, 1990).

A management plan for biodiversity conservation is essential, but the plan must be built upon three fundamental principles:

1) the plan must be flexible enough to accommodate new and improved information as these data become available;
2) abiotic and biotic processes have a long evolutionary history and events of today and in the future will be driven by this history; both are highly dynamic. The management plan must accept the historic and dynamic aspects of these processes and their interactions;
3) human impact upon abiotic and biotic processes will not diminish, but increase as population levels increase.

What does this mean? We must muster whatever resources we can to increase our understanding of the life support systems of spaceship Earth as they exist in Australia. Change must be accepted as a fundamental characteristic of living and abiotic processes. We must be increasingly innovative and creative, as human pressure on the environment increases, at maintaining genetic diversity and at directing or diverting change. If we do not understand that which we must manage, we cannot maintain biological diversity. If we fail to manage, then an ecologically sustainable economy is impossible. Because our knowledge and management skills are and will be inadequate for some time to come, there will be losses above the background rate. Our creativity and innovations must work harmoniously with natural evolutionary processes to ensure that gains in biodiversity balance the losses - that balance is the measure of whether development is sustainable.

DOCUMENTATION

Australia is a continent of great biological and ecological simplicity at the continental scale, a narrow mesic fringe around a large xeric centre. At the local scale, however, Australia is incredibly complex, with high levels of biodiversity and endemicity (Barlow, 1981; Bridgewater, 1987; Heatwole, 1987; Main, 1987). Australia is a continent of great age and has a long history of isolation from other continental land masses (Frakes, McGowran & Bowler, 1987).

Australia is a continent, but Australia also is an island. Three major oceans provide biodiversity to the coasts, continental shelf and marine zones of Australia (Bunt, 1987; Wilson & Allen, 1987). Although surrounded by water, much of Australia is semi-arid. Dramatic fluctuations between aridity and flood are the rule, yet the diversity of life associated with the fluctuating freshwater supply of inland Australia is astonishing (Williams & Allen, 1987; Williams & Campbell, 1987).

Australia has had Aboriginal impact for thousands of years. This impact, linked with the increasing aridity of the continent, produced the landscapes seen by early European colonists (Bridgewater, 1990). Today, one may safely say that no area of Australia is free of human influence (Soulé, 1990); Australian landscapes, to varying degrees, are anthropogenic and as such require management (Saunders, Hopkins & How, 1990).

Scientific documentation of the biological diversity of Australia began in the 17th Century with the arrival of Dutch explorers. Aboriginal Australians already had an extensive folklore associated with the biodiversity of Australia - but that is only now being appreciated, understood and documented (Stanbury, 1987).

Scientific collection efforts have been largely opportunistic or have been made by individuals with great curiosity. Only during the past 20 years have systematic biological surveys been conducted. Remote, sparse or apparently monotonous areas have been largely ignored, as have those portions of the Australian biodiversity which are cryptic, very small in size, difficult to obtain or considered "uninteresting".

Funding for biological survey in Australia, as in most countries, has never been generous. Despite that, there is a national Government initiative - the Australian Biological Resources Study (ABRS) - which was initiated in 1974 to describe and document the biodiversity of Australia (Bridgewater, 1986). The ABRS recently has been allocated increased funds. The aim is to concentrate on the completion of a concise flora within the current decade and to produce catalogue/databases of animal species which incorporate biogeographic and taxonomic information.

Ironically, we find that to compile inventories of known biodiversity, taxonomists are diverted from the basic tasks of identification and description essential to extend our inventory of biodiversity. But that is not really the issue - we need to produce up-to-date catalogues as well as to intensify research efforts. More money is part of the answer, more taxonomists working on invertebrates and lower plants is another part, but we also need to wean some scientists from the slower traditional approaches and encourage the use of modern information technology married to rapid techniques of description and documentation.

Historically, scientific talents have concentrated on those elements of the flora and fauna which were conspicuous, possessed endearing attributes or which captured the personal fancy of one or more individuals. Flowering plants, cute and cuddly animals,

the brightly coloured animals and those plants and animals of economic or public health significance received the greatest attention. Museum, herbarium and living collections largely have been devoted to such plants and animals and usually, because of public interest, are the best curated and their conservation status determined. Lower plants and many invertebrate groups are poorly known, poorly collected and poorly curated. In addition, many early collections are held in institutions outside Australia and, as such, are not readily available to Australian workers. Costs and administrative hurdles associated with the shipment of specimens are increasingly prohibitive.

All of this begs the question of just how much effort we can now put into description and documentation of biodiversity *versus* its management, the application of knowledge we do have. The catch-cry that we must describe it to know how to manage it is still valid, but needs to be examined in a highly pragmatic and critical way.

There are several estimates of the number of living species and debate surrounds the various estimates. Does it really matter how many living species there are? If we expect to make an inventory of biological diversity and if we wish to have any appreciation of the diversity of living things, reasoned estimates and rational debate are essential. For management purposes, however, estimates will be of less significance than the application of what we do know in the careful selection of appropriate keystone species to serve as indicators and monitors. If the appropriate indicators and monitors are chosen, we may ensure the survival of countless other species. For the present, selection must remain to some degree an act of faith; to wait for all the information, however, may place all species in greater jeopardy.

The vexing question of why there appears to be so much "redundancy" in biodiversity remains. The implications of redundancy for management of biodiversity may be very great. Research in this area is needed urgently.

MAINTENANCE OF BIODIVERSITY

The establishment of protected areas has gained status and momentum as a practice for the maintenance of biodiversity (McNeely *et al.*, 1990). The importance of these areas must not be minimised, but at the same time what must be remembered is that protected areas do not exist *in vacuo*. Protected areas have histories, are dynamic and interact with surrounding areas. Changes are inevitable (Callicott, 1990b). Efforts to turn back the clock, to return protected areas to some supposedly "pristine" state, will be costly and doomed to failure. Protected areas must be viewed as areas where natural evolutionary processes are allowed to act as free from human interference and contamination as possible. They are reservoirs of diversity, not static displays.

There is a well-organised and growing protected area system in Australia which, in 1988, encompassed approximately 5% of the land mass (Ovington, 1989). The nature conservation agencies of the States and Territories are the main land control agents. There are also enormous areas of semi-natural land under the control of other State or Territory agencies or held as Aboriginal land. These areas are significant reservoirs of biodiversity and with proper management have greater potential. The primacy of State and Territory Governments over land management issues, both inside and outside reserves, in Australia complicates the development and implementation of uniform policies related to the maintenance and management of biodiversity.

Reclamation of areas degraded by poor landuse practice or by mining or other land

disturbance poses a fascinating challenge. To pursue only whatever constituted the "original" is to ignore the potential of these reclaimed areas to develop new living associations and to expand potential biodiversity (von Droste, 1988). Reclamation is essential, maintenance of biodiversity is essential, but we must not confuse these objectives with the ghosts of some real or imagined period in the past.

The maintenance of biodiversity outside protected areas has received too little attention. Agricultural and pastoral areas, disturbed forests and plantations, disturbed freshwater and marine areas, suburban and urban areas have the potential for a much expanded role in the maintenance of biodiversity. No doubt these areas, modified by human activity, have little hope of return to their "original" state, but do represent opportunity for new and different ecosystem, species and genetic diversity, *i.e.* serving as permanent boundaries, transition areas or cushioning links to the protected areas. We need to appreciate and see protected areas with their surrounding landscapes in terms of infrastructure. Ecological infrastructure allows biodiversity to occur, maintains the diversity and permits change within the wider environment.

The mixture of reserves, agricultural and pastoral lands, urban and suburban areas with linkages or corridors forms the mosaic of the landscape. This landscape ecological framework provides the basic units for management.

Good nature conservation management must have a basic understanding of ecological science at all levels, especially focusing on the landscape ecological aspects. Species and community ecology can be dealt with at a local level. If, however, an attempt is made to develop an understanding of ecological infrastructure, the ability to transform information and modelling experiments into regulatory plans applicable to large areas (landscape scale) is vital to national and regional biodiversity maintenance and management programs. This is not to denigrate the importance of the species approach and to better understand species biology, but to emphasise the need to set such knowledge in a wider, more holistic frame of reference.

Traditionally, nature conservation has been seen as being achieved through a dedicated system of reserves and protected areas (especially National Parks). Increasingly, however, there is a realisation that the amount of protected area may not be able to be greatly increased and that nature conservation strategies must be developed and implemented outside reserves - on land that is used for a variety of purposes.

In Australia, protected area managers are involving Aboriginal owners in management frameworks to ensure the flow of vital information on traditional management practice.

For nature conservation to be effective, we must understand not only the biology of individual species, but how species and communities interact at the landscape level. Forman & Godron (1986) note that areas of concern to landscape ecology include:

- structure, *e.g.* establish inventories of the distributions of energy, materials and organisms in relation to landscape elements at various scales, perceive the connectivity between landscape elements and landscapes;
- function, *e.g.* understand the flows of energy, materials and organisms among landscape elements and across landscapes;
- changes, *e.g.* monitor and, where appropriate, manage alterations in the structure and function of ecological mosaics through time.

All are important kinds of information needed by nature conservation managers to discharge their responsibilities properly.

Conservation science so far has been concerned, essentially, with the rare and beautiful, rather than the common and perhaps the less beautiful. In the coming years Australia must produce a much more focused approach on conservation science at a landscape scale to give broader significance to the species or community scale. Australia must avoid what Odum (1982) so aptly terms the "tyranny of small decisions".

Creative and innovative planning, technology and economic structure certainly will be required if biodiversity is to be maintained and the goal of an ecologically sustainable economy is to be reached. None of these represent insurmountable barriers; they do represent challenges and opportunities to all segments of Australian society.

MANAGEMENT

Implicit to an ecologically sustainable economy is the management of biotic and abiotic resources. Management in this context is not a simplistic concept, but requires the development of broad national strategies and the implementation of those strategies.

Information is required for meaningful management decisions. Environmental scientists and technicians will be needed to assess what is to be managed. Long-term monitoring of the environment will be needed to detect changes and, if possible, to provide clues as to the cause of the change or lack of change. Architects, engineers and tradesmen will be needed to assess and determine efficient and effective use of materials and energy. Economists and social scientists will be needed to manage and direct fiscal and human resources. Last, but by no means least, political leadership will be needed with the vision to ensure that the diversity of life tomorrow is no less than today.

Because there is yet much to learn, the assumption that nothing is known would be incorrect. In far too many instances, the loss of biodiversity has resulted from a failure to implement or act upon what is known.

Examples do exist of sustainable use of living resources. There are examples of successful land and water reclamation. There are examples of dramatic increases in efficient use of materials and energy. There are examples of specially reserved areas. There are examples of special breeding or propagation programs. There are examples of germplasm banks. There are examples of genetic manipulation. These examples, and others like them, clearly indicate what can be done. Such proven techniques and approaches must be integrated into and implemented as a national program to maintain and manage the biodiversity of Australia.

The Australian local economy and society are dependent upon one or a very few domesticated species. The effect of this specialisation on local or national biodiversity in too many cases has been devastating. Losses of biodiversity have increased alarmingly. Natural replenishment of the lands and waters has been replaced by additives and irrigation, often with dire consequence. Depopulation of food production areas for urban opportunities and the changes in size of agricultural production units as a result of mechanisation all too frequently have not been followed by economic restructuring to allow for natural replenishment of the lands and waters. Rather, the emphasis has been production at all costs. Powerful market and financial forces make few provisions

for and are largely oblivious to the fundamental tenets of land care (Callicott, 1990a). The costs of reclamation will be high. To maintain and manage biodiversity in agricultural areas there may need to be accompanying economic and social restructuring of rural industries.

Forestry practices in Australia, as in most of the world, have yet to demonstrate that they are sustainable. Pressure on forests as the result of clearing for agriculture and pasture, for fuel, construction and industry has seriously depleted forests. Removal of forests and conversion of the land into often marginal, and too often over-grazed, grassland and cropland are not sustainable and the loss of biodiversity is incalculable. Reafforestation with a functioning ecosystem rather than superficial silvicultural treatment is essential. Human uses of forest products must be geared to sustainable harvests.

That arid lands, while harsh, are fragile ecosystems is poorly understood. Many people, especially those who do not grasp the concept of biodiversity, regard arid lands as areas without biological diversity and so of little significance. The diversity of the living components of arid areas often is extensive and includes extraordinary adaptations to the extreme conditions, species and genetic diversity of a significance as unappraised as that of rainforests. It is pleasing to note the recent declaration by the State of Queensland of a new National Park in the "Mulga" lands - classic semi-arid country that is spatially and temporally diverse and rich - a much unappreciated biodiversity reservoir.

One goal of some management policies is to restore plant communities to the "natural" state, that which existed prior to extensive human influence. In Australia, as Westman (1990a) notes for North America, the time of European contact often is arbitrarily designated as that reference point, despite the fact that Australia, like North America, has a rather long history of human occupation. European contact is only one point on a continuum of escalating human influence on the dispersal of plants and animals, a fact often omitted in the consideration and interpretation of what may be regarded as wilderness (Callicott, 1990b). Such a restoration attempt usually involves an attempt to extirpate all exotics, exotics defined using the same reference point in time.

A policy of total opposition to exotics will not only become increasingly expensive and irrational, but counter-productive. Only the most obvious and offensive exotics probably can be removed. The more resistant and less noxious will remain and the way opened for new invasions. Because plants exhibit some functional redundance (wildlife support, soil binding, nitrogen fixation, *etc.*) in ecosystems, exotic species can substitute in part for natives (Westman, 1990a). If the true goal is maintenance of biodiversity, the more rational approach is to increase the opportunity for the natives and exotics to establish new and different associations (see Fox, 1990). Westman (1990a) proposed that the criteria for the elimination of an exotic should be:

a) potential hazard to humans;

b) potential hazard to native species;

c) cost of elimination.

Few established exotics, however, can be eradicated or controlled and then only at great expense and usually after extensive environmental damage has occurred. Most are uncontrollable once established (Coblentz, 1990). As Westman (1990b) notes,

today's exotic may be tomorrow's naturalised species and we know very little about the impacts on ecosystems of the removal of established exotic species. Noss (1990) points out that the terms "exotic" and "native" are relative, scale-dependent in time and space and only slightly less ambiguous than "natural" in the lexicon of conservation.

Soulé (1990) has suggested that a new ecological discipline will develop to deal with the interactions within these new, biogeographically complex assemblages. The names Soulé proposed for this new discipline are "recombinant ecology" or "mixoecology".

In regard to exotic animals, finer distinctions need to be made. With vertebrates, there is the necessity to distinguish between feral exotics, wild exotics and domestic exotics. To lump them all as undesirable exotics would be to eliminate all domestic animals, especially those with the potential to become feral. While control of the abundance and distribution of domestic animals is desirable and has been practised, meaningfully or not, total elimination is not realistic.

Control of feral vertebrates may not only be desirable, but may provide an excellent opportunity for scientific study of the effects of control. As with plants, some functional redundancy (predators, scavengers, pollinators, seed dispersal agents, *etc.*) occurs and exotic species can substitute for natives. The criteria for the elimination of exotic vertebrates can be similar to those for exotic plants.

The seeming fixation upon exotic vertebrates probably is due in part to the fact that many are conspicuous and their environmental impact often is obvious even to the untrained observer. In the case of exotic invertebrates, unless their presence is of obvious economic or public health importance, very little notice is taken (see Thompson, Long & Horton, 1987 on species introduced to Australia). Many invertebrates are small, the environmental impact per individual usually is minor and tedious, long-term study usually is required for meaningful impact assessment. The possibility exists that ecologically we are straining at camels and swallowing gnats.

Many pathogens of people and other species rely upon invertebrates as vector and reservoir species. With the prospect of global climate change, the potential impact on public health, veterinary health and the economy of a significant increase in the number and variety of exotic invertebrates is staggering (Soulé, 1990).

Exotic flowering plants present very special problems. One must make the distinction between those which are desirable and those which are not. Where exotic flowering plants represent items of food for people or their domesticated animals, there is seldom a perceived control problem. Other exotic flowering plants fall into categories ranging from the ornamental to the noxious. Control of exotic flowering plants usually involves the use of non-specific herbicides or labour intensive manual removal.

More worrisome than the threats posed by the more visible exotics is the destructive power of exotic micro-organisms and fungi. In Australia, the root-rot fungus *Phytophthora* has had debilitating effects in many plant communities, particularly reducing the plant biodiversity in highly species-rich vegetation (Weste, 1990).

Global change, especially climate change, is another area of considerable difficulty for biodiversity management. Work on the physiological and behavioural responses of plant and animal species to various changes in climatic regimes would help the understanding of likely impacts of climate change. Many invertebrates and the Amphibia (Rabb, 1990) are sensitive indicators of environmental change. Research would help to establish more clearly the parameters affecting the autecology of individual species or

BIODIVERSITY – BROADENING THE DEBATE

species groups, especially those at the edge of their range, so that the influence of climatic change can be recognised in the context of other factors, particularly management.

Forecasting techniques will be invaluable for the prediction of the probables and possibles of global change. BIOCLIM is one valuable technique for forecasting species at risk under varying climatic scenarios. BIOCLIM is a system developed in Australia to predict species ranges from a limited set of specimen or observation records, by matching species-specific climate profiles to points on a geographic grid (see Busby, 1986; Nix, 1986; Walton *et al.*, 1991). The climatic profiles are derived from a set of attributes which cover both temperature and precipitation. They emphasise those attributes indicative of mean, seasonal and extreme values of the climatic environment (*e.g.* mean annual temperature, mean temperature of the wettest quarter, precipitation of the driest month). The system also can be used to predict potential changes in species distributions under various scenarios of climate change (*e.g.* Busby, 1988).

Some plant and animal species will give 'early warning' of changes, in much the same way as lichens and bryophytes act as sensitive air pollution indicators. Other 'markers' of changes may include:

- thermophilous (warmth loving) insects (some Lepidoptera, Odonata, *etc.*) which should benefit from global warming and migrate to new areas;
- species which may be at their ecological limits and thus suffer readily from additional stress caused by climatic and associated environmental change;
- communities localised at their limits and coastal communities.

A strategy for nature conservation based on landscape ecology which takes account of the likely effects of global warming should be founded on the following principles:

- remaining areas of natural and semi-natural (Westhoff, 1971) plant-animal association should be conserved and, where possible, expanded;
- outside the protected areas, good plant and animal habitat should be conserved and, where possible, enhanced;
- opportunities should be created for the development of a network of greenways, plant and animal corridors, to connect the areas of natural, semi-natural and good habitat.
- an understanding of the broader implications of endangered species biology, particularly focused on restoration and rehabilitation techniques (Reid & Miller, 1989), needs to be developed.

Examples of natural and semi-natural areas can be selected for inclusion in a protected area network, but all areas provide habitat and are important as reservoirs of biological diversity. The political reality is that only a small proportion of all land can be set aside as reserves. Habitat fragmentation and insularisation are regarded as serious threats to biological diversity (Grumbine, 1990; Lord & Norton, 1990). Maintenance and management of biological diversity outside reserves, therefore, assumes an even greater importance, especially the improvement and creation of corridors.

Selected areas of primary nature conservation significance will bear the effects of global warming and exhibit the changes in species composition noted earlier. Flexible reserve borders should be implemented to ensure that the maximum range of opportunities exists for plants and animals to adapt to the effects of global warming. Areas involved

in primary production also will respond to climate change. A careful review of land tenure practices is needed; flexible borders may be one approach.

The landscape matrix which contains these nature conservation sites will also be subject to changes. New species may be grown in afforestation; new types of agriculture may be introduced as existing systems are replaced. Again, specificity is difficult, but changes probably will be complex and regionally variable. Examples of areas in the surrounding landscape matrix of potentially high biological diversity, where semi-natural habitat has been substantially modified, include verges, ditches and recent plantations. Such areas can be distributed widely through rural and suburban areas and represent a substantial part of the total resource of plant-animal association. Such rural and suburban areas often provide linkages between natural and semi-natural areas and will be of great value in providing a matrix of corridors and stepping stones (or "greenways") for the movement of species in response to climatic change. It may be that some species will move from sites to suitable areas in the surrounding matrix. Conservation strategy, therefore, must address both the sites and the surrounding matrix (see *e.g.* Lawrence, 1990).

In Australia, the same holds for the urban and semi-rural areas. These two areas, however, have distinctly different landscape infrastructure features. Examples of landscape infrastructure features are fencerows, hedgerows, vacant lots, easements for roads, railways, electricity powerlines, airports and similar right-of-ways, streams, creeks, *etc.* More important in many ways are the large semi-rural agricultural areas, now with only remnant vegetation left, and the semi-arid rangelands.

Greenways would form part of a general landscape matrix, with benefits for plants and animals by facilitating adjustment to climatic change. Such land will help to ensure the stability and maintenance of existing areas of semi-natural habitat, especially in protected areas, and provide a vital link for the movement of plant and animal species through the landscape. An important element in this network would be the link between plants and animals in urban areas and those in rural areas. Where opportunities arise, some of the areas of habitat should be managed for particular groups of organisms. Greenways, it must be said, also offer the potential means for invasion by exotic species and provide concentrated hunting grounds for predators. They and their component species are less vulnerable, however, than isolated remnants and their component species.

In Australia, most "greenhouse" effort will likely be concentrated on montane ecosystems and on endangered species now confined to remnant vegetation in an alien landscape matrix. Is this enough? Do we risk losing too much by concentrating our efforts too narrowly? While there are difficulties in establishing appropriate time frames, the development of a range of strategies to respond to emerging situations is important.

There is a general belief that in most protected areas the conditions which existed when reserves were established are static. This is obviously not true, but in no way diminishes the significance of reserves. Global and national monitoring needs to be more formally established using the protected area network. Emphasis should be placed on sites which are known biogeographic/ecosystem boundaries, have relict populations or communities and are characterised by highly seasonal events, for it is across such sites that changes are likely to be first detected. Undoubtedly, a change of

BIODIVERSITY – BROADENING THE DEBATE

climate will favour some terrestrial and marine species presently rare or endangered, provided other environmental features are also favourable to their expansion.

Other species may need to be temporarily stored as seeds, propagules, germplasm or *ex situ* in botanic and zoological gardens. Coping with increased plant and animal immigration and the option of sponsoring translocations as a response to climate change will be one of the most pressing concerns for wildlife agencies. Such organisms that may arrive or expand their distribution and abundance will undoubtedly include a number which pose a threat to native plant and animal species, further emphasising the potential for ecosystem instability.

The difficult problem is to assess the risks of loss and the costs of retention of the nature conservation resource. We must attempt to predict the outcomes of climatic change, but cannot then wait until the prediction is proved. A choice must be made between courses of management actions, each of which will have a financial cost as well as a cost and potential benefit to the conserved biota.

ACTION REQUIRED

What are the major actions needed in Australia to maintain and manage our biodiversity? Some, or all, of these could be enshrined in legislation, or built on existing legislation.

1. National standards need to be established and implemented, with periodic evaluation, to maintain, manage and monitor biological diversity in all reserved areas.
2. Current national programs which deal with biological diversity outside reserves should be strengthened, especially those which deal with the development, support and reinforcement of greenways - wildlife corridors.
3. A major national effort should be undertaken to explore and evaluate recombinant ecology - the biological study of exotic species especially in agricultural, pastoral, suburban and urban areas.
4. Techniques and processes of data handling must be developed to assess the impact of global warming on the social, economic and ecological framework of Australian society.
5. A national environmental planning program should be developed using a landscape scale for the implementation of the national management of biological diversity. This program must be linked with appropriate monitoring frameworks on a range of time and spatial scales. Such monitoring could form the basis of regular biodiversity reports, issued by the Australian Government.
6. The national biodiversity program, properly funded, must be enshrined in national legislation that is interpreted as a mandate to protect genes within populations, populations within species, species within communities, communities/ecosystems within landscapes and landscapes within Australia. While vitally important to look after the sick and injured (endangered species), this is not enough; we must ensure that the home (Australia) is safe and healthy for all.

A FEW WORDS OF CAUTION

The development and passage of environmental legislation often stimulate a euphoria among supporters that prevents or diminishes the essential evaluation of the implemented programs (Karr, 1990). We also must ensure that, in the terms expressed by

Freeman (1990), the feast of legislative pronouncements does not choke on the gristle of reality. The development of strategies, policies and plans is not a substitute for implementation and evaluation. The usual pattern of narrow emphasis upon harvested, threatened and endangered species must be broken if the broader biodiversity is to be maintained and managed. Maintenance and management of biodiversity are a part of the means to achieve the primary goals of the protection of natural resource systems and the ecological health of the biosphere. Programs to protect the biodiversity of Australia must not lose sight of those primary goals. Science can provide the knowledge for maintenance and management of biodiversity. Legislation can give legitimacy to implementation and evaluation of programs and policies. Only a commitment from people can protect the natural resource systems and maintain the ecological health of Australia. Government forces have less to govern and market forces have less to market if the forces of living systems are diminished. We must not be left only with Time's Arrow and a voice crying from what was once a wilderness.

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BIOLOGICAL DIVERSITY AND THE ESSENTIALITY FOR A NATIONAL NATURE CONSERVATION RESERVE SYSTEM FOR AUSTRALIA

D.W. WALTON, M.A. FORBES, J.R. BUSBY AND JEAN JUST

INTRODUCTION

Two basic premises in regard to the biological diversity of Australia must be accepted. These are:

a. no part of Australia's land and sea territories is irrelevant to maintaining the country's biological diversity;

b. human activity, wherever undertaken and by whom and whatever its nature, has an impact on the biological diversity of Australia and on the national effort to sustain and maintain that diversity.

A national framework for the maintenance of biological diversity must be adopted. The framework must be one with which all Australians, as individuals or as members of some governmental or social organisation, can readily identify. The function of the framework is to provide a common focal point with the ultimate aim of providing broad guide-lines and some answers to the question: "Where do I/we belong in the national effort to protect, maintain and manage Australia's biological diversity". The structure of the framework stresses the intimate and unavoidable linkage between all types of environments, regardless of the degree of human influence on the various types, and includes people as a part of the environment. The framework recognises that all of Australia's land and sea areas require management for sustainability and that a national nature conservation reserve system has a particular and essential role if biological diversity and development are to be sustained.

THE PRESENT SYSTEM

At present, the nature conservation estate of Australia includes areas owned and/or managed by the States, Territories, the Commonwealth, Aborigines and various combinations of these. Over 40 different types of reserved areas make up the nature conservation estate. The estate comprises slightly more than 5% of the land surface of Australia. Management regimes vary widely, depending in part on the purpose of the type of reserved area. Components of the nature conservation estate are located in the States, Territories, off-shore islands in State or Territory jurisdiction and the External Territories. The legal backing for the nature conservation estate includes specific Commonwealth, State and Territory legislation, international treaties and agreements, Memoranda of Understanding between the Commonwealth and the States or Territories as well as Constitutional Settlements. Except in unusual cases, boundaries of nature conservation areas are more greatly influenced by imposed political borders than by natural characteristics (climate, topography, soils, flora and fauna).

The States and Territories hold title to approximately 70% of all lands in Australia. The remainder, except for a small part owned by the Commonwealth, is freehold. The Commonwealth has jurisdiction in marine areas, but as the result of the Off-shore

Constitutional Settlement, the States and Territories were given jurisdiction for the coastal zone out to a three mile limit. The Commonwealth retains jurisdiction for marine areas beyond the three mile limit and throughout the Exclusive Economic Zone. External Territories, including the Australian Antarctic Territory, are the responsibility of the Commonwealth.

CHARACTER OF A NEW NATIONAL SYSTEM

This presentation considers the practical and achievable processes for establishing a representative nature conservation reserve system as an essential component of ecologically sustainable development in Australia. Such a system should have the following characteristics:

a. contain areas which are typical (representative) of the major landscapes and seascapes of Australia;

b. form a central part of the national commitment to the protection of Australia's biological diversity and the maintenance of ecological processes;

c. be central to other strategies employed outside the reserve system to conserve biological diversity and maintain ecological processes;d. allow the establishment of national management goals and guide-lines which can be implemented for national management consistency and coordinated nationally;

e. serve, with secure tenure, as central elements in a national environmental monitoring system;

f. play a major role in conservation biology research;

g. be integral to the environmental education of all Australians.

PLANNING A NATIONAL SYSTEM

TERRESTRIAL SYSTEM

Before venturing into this subject, there is a need to define two terms so that the reader(s) may more easily follow the context of what follows.

Landscape - a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout.

Representativeness - the measured variety of patterns and processes found in a bounded area and the extent to which this variety typifies that of a larger area.

The cluster of ecosystem types of a landscape share the same broad climate, have a similar geomorphology, share a similar set of disturbance regimes and interact biologically. Landscapes have three characteristics: structure (spatial relationships), function (interactions) and change (alteration of structure and function). Any bounded area within a landscape should have patterns and processes typical of that landscape, *i.e.* be representative of that landscape.

Ideally, any analysis of landscapes is based on as reliable and valid a sample of patterns and processes as possible. Ecological patterns and processes abound and their relative importance is subject to extensive debate. All patterns and processes, however, interact with and are dependent upon the abiotic aspects of the environment, especially climate, soil and topography. Landscapes can be defined on the hypothesis that interacting ecosystems share a particular pattern of climate, soil and topographic variables, *i.e.* representativeness based on climate, soil and topography. Each landscape defined,

therefore, would be distinctive and representative of a particular climate, soil and topography profile.

The land area of Australia can be separated into distinctive landscapes based on climate, soil and topographic profile. Data for establishing a coarse landscape pattern can be done at a scale of 1 : 1,000,000. Such a continental analysis can be carried out by the Environmental Resources Information Network (ERIN) of the Australian National Parks and Wildlife Service (ANPWS). For the selection and placement of reserves, this landscape analysis should act as the initial or coarse filter, an overview or reconnaissance of Australian landscapes. There is the necessity to again state that landscapes are heterogeneous units and that the boundaries of landscapes are in no way related to political borders.

The selection and placement of reserves will require a finer resolution and attention in more detail to patterns and processes. The analyses for selection and placement of reserves will depend upon the determination of just what should be represented and what comprises the adequacy of representation. Selection and placement must await the results of the coarse screening and agreement on the analyses noted above.

Although there is a variety of reserve selection methodologies with competing advocates, consideration must be given to a variety of relevant matters in the choice of an appropriate selection method. Many parts of Australia are heavily anthropogenic and as such are heavily modified from their status in 1788. Landscape rehabilitation is a real part of conservation biology. Many native plants and animals must have disturbed areas for survival. The idea that only minimally disturbed areas or "remote" areas contain significant biological diversity is mythology. In the 200 years of European settlement, a wide array of plants, animals and micro-organisms have become naturalised and new associations have evolved or are evolving; these must be considered. A national system of reserves has the potential for linkage through remnant patches of native vegetation and other reserved areas to form corridors for future dispersal of flora and fauna in response to climate change. Not only should biodiversity be protected, but the potential for natural evolutionary processes must exist. Climate change, local and global, is a reality and biological responses to change must be catered for where possible.

After identification of the major landscape units of Australia using the coarse filter stated above, determination of the actual location and content of reserves must be made. This step can be carried out best at the State and Territory level with the involvement of the relevant local communities. Data on patterns and processes not included at the coarse filter level can be considered (flora, fauna, human activity, erosion control, watershed, agricultural practices, *etc.*). The Commonwealth should be involved in those landscapes which cross State and/or Territory borders.

The size and shape of nature conservation reserves has been the subject of considerable debate. Fundamentally, one must be aware that nature reserves do not exist in a vacuum. They interact with the surrounding areas and cannot persist as isolated islands in a sea of disturbance. For reduction of exposure to outside disturbed areas, a large circular shape is advantageous (surface to volume ratio). Trees and large animals require large areas if adequate genetic diversity within populations is to be maintained.

Several years ago, the UNESCO Man and the Biosphere (MAB) program developed the concept and recommended the biosphere reserve as an ideal model where ecologically sustainable development was the goal. Australia, like many other countries,

adopted this idea and quickly nominated several areas as biosphere reserves (nine in 1977, one in 1978 and two in 1981). Like many other countries, Australia did not follow the proposed model nor take advantage of the concept by implementation of appropriate management. The nominated reserves and the concept languished for several years. The concept, however, is undergoing a deserved resurgence, both within the UNESCO MAB program and in a number of countries. The concept is excellent and a basic outline is presented below.

The biosphere reserve model comprises three integrated zones. At the centre is a core zone devoted exclusively to the management and maintenance of the contained biological diversity. Surrounding the core is a buffer zone, an area devoted to amelioration of human impact on the core, research in conservation biology, public education and recreation. The outer ring, the transition zone, is an area of controlled human impact with heavy emphasis on the involvement of the local community in the care, maintenance and management of the zone. All three zones are subject to management practices designed to protect the biological diversity of the landscape, foster greater understanding of the environment through research, environmental monitoring, education and involvement of the local community and, by management, research, education and local involvement, ensure that the biological resources of today are not diminished for tomorrow.

A continent-wide system of interconnected (via corridors) representative biosphere reserves in a landscape framework is a clear and unequivocal commitment to ecological sustainability. Such a system carries an implicit commitment to an integrated management program which includes research, education, on-site management, environmental monitoring, conservation outside reserves (connectivity via corridors and a variety of management practices) and involvement of local communities.

COASTAL AND MARINE SYSTEMS

The biosphere reserve model can be applied in both coastal and marine zones. Both zones, however, present special problems. While there is general agreement on the perception of the coastal zone, delineation of the zone requires consideration of two quite different environments: the terrestrial and the aquatic or marine. The interface of the two zones also has quite distinct characteristics which must be considered. Various geographic information systems have been and are being developed to deal with terrestrial landscapes, but corresponding systems for coastal and marine areas have not received the same attention. The majority of the human population of Australia lives in the coastal zone and the majority of the marine resources of Australia is derived from the coastal zone or the in-shore marine area.

Coastal biosphere reserves will require assessment and evaluation of criteria distinct from terrestrial reserves. One very special consideration is that the aquatic portion of such a reserve will require protection from on-shore activities and the terrestrial portion will require protection from off-shore activities. Human occupation and tourism are two major terrestrial concerns while commercial collection of marine organisms, shipping and recreation will be major off-shore concerns.

The biosphere model can be developed for purely marine areas, provided criteria for marine reserves can be agreed upon and are taken into account. Marine reserves may have a greater flexibility denied coastal and terrestrial reserves; boundaries can vary

with time and in response to prevailing conditions, if time and prevailing conditions are relevant to the ecological sustainability of the protected biological diversity.

Three points are clear. Coastal and marine reserves are and must form part of the national nature conservation reserve system. Too little attention has been devoted to the coastal and marine zones and their importance to ecologically sustainable development has been inadequately recognised. Systems for the evaluation and assessment of the coastal and marine zones must be developed.

IMPLEMENTATION OF PLAN

MANAGEMENT

Projections of climate change (due to augmentation of the greenhouse effect) to the year 2050 indicate a rate and magnitude greater than any before experienced by human society. The faster the rate and the greater the magnitude, the less societies and ecosystems will be able to cope without potentially serious consequences and the greater the chances are of surprises. Virtually the entire surface of the Earth, certainly Australia, has been "handled" by people. In the face of rapid and great change, research is not enough; active management is essential. What is known must be implemented, what is suspected must be tried and evaluated and what we need to know determined.

Management will be fundamental to the goals (see Introduction) of a national nature conservation reserve system. Nationally agreed management regimes are essential, but without the on-site managers to implement the plans and evaluate the results of management practices, the goals of the system cannot be achieved. An integrated research strategy must be developed and implemented, a strategy aimed at increasing our understanding of the impact of human activity on biotic and abiotic systems and how to ensure the sustainability of the Australian environment. Management and research should be more thoroughly integrated so that research can be better directed towards problems identified by management and to ensure that the results of research and observations of environmental monitoring can be effectively integrated into management regimes. Education, including that of managers and researchers, should be a basic ingredient of the national management regime. The involvement of the local community in the functioning of the reserves will play a significant role in the ultimate achievement of ecological sustainability.

SITE SELECTION

The present nature conservation estate in Australia is the result of some 100 years of largely independent and totally uncoordinated actions. As noted in the Introduction, there are over 40 types of reserved areas. The development of the nature conservation estate followed no national plan nor is there a nationally agreed set of goals, management standards, minimum data sets for monitoring the environment or funding base. Nevertheless, various components of the existing nature conservation estate, with appropriate adjustments as needed, can be incorporated into the national system proposed herein. Certainly, the formation of a national system of nature conservation reserves provides opportunity to review the present estate and make purpose-directed adjustments as necessary.

The acquisition of new areas may represent a substantial expenditure. As noted in the

Introduction, approximately 70% of all of Australia belongs to the various tiers of government so the capital outlay may be modified by the matter of ownership. Local communities may be in a position to better assist in land acquisition than central government agencies.

The methodology used to make final selection of local areas to comprise the national system should be appropriate to the task and be agreed upon by the various competent authorities. The role of the Commonwealth should be as a facilitator and coordinator of the selection process. There may be a special role for the Commonwealth in reserves which cross political boundaries such as State/Territory borders or areas of marine responsibility, but this depends upon decisions of those involved. There may be merit in distinguishing clearly, in terms of delineating responsibility, between reserves which are part of a national system (nationally important) and those more specialised reserves which are of purely State, Territory or local importance.

FUNDING

Clearly, a national commitment to a national nature reserve system means that significant Commonwealth funding will be required. Organisational costs, costs of the development of systems for the appraisal and assessment of coastal and marine areas, land acquisition, the development of management plans, on-site management costs, costs of establishing environmental monitoring, capital works, education and training costs, organisation of local communities, research funding and coordination expenses must be factored into the total funding. The various tiers of government can and should be expected to contribute; certainly all will expect to benefit from the system.

No reliable estimate of land acquisition can be made until a variety of analyses is completed. The rough assumption can be made, however, that there will need to be at least 30 terrestrial biosphere reserves and 10 coastal and marine biosphere reserves (total of 40 reserves in the national system). Annual administrative, operational and development costs will be substantial as it will be essential for the components of the system to be managed and developed to the highest standard. Once the system is in place and facilities operational, the system can be expected to generate income. Income will be derived directly from use fees, concessions, publications and other similar sources. Indirect income can be anticipated from tourism, transportation, communications and related industries. Properly managed, the benefits to the local and national economies will be extensive and prolonged. The nature conservation estate as proposed here and the supported landscape matrix are the treasuries of biological diversity and the nation's future. The health of ecological processes upon which we depend relies upon biological diversity.

CONTROL

The Commonwealth has certain obligations derived from constitutionally granted powers. Fundamental among these obligations is the management of the economy of Australia, including the protection of and access to natural resources and the natural heritage in specific contexts. The States and Territories have other constitutionally granted powers, including ownership of the land and the protection and management of the flora and fauna. Within this complex and often conflicting framework, the national system of nature reserves proposed here must be established in such a way that the proper obligations of all parties are met and the greatest efficiency is achieved.

National economic development of Australia should lead to a reduction in the heedless extraction of natural resources. Without planning and coordination at the national level, development will be chaotic and resource utilisation without direction. If the word ecologically is to be meaningfully applied in the development of Australia, a coordinated nation-wide system of well managed protected areas is essential. Such a system will play a crucial role in achieving ecological sustainability. How such management is implemented is a value judgement for Australian society, but all available evidence indicates that now is the time to begin.

BENEFITS OF A NATIONAL SYSTEM

The national nature conservation system proposed here will:

1. ensure that areas which encompass representative biological diversity of the major landscapes of Australia are maintained and managed;
2. ensure that there is in place a national environmental research and monitoring program for ecological sustainability;
3. ensure that areas exist which can be used to further the environmental education of all Australians;
4. demonstrate, through the use of the biosphere model and the involvement of local communities, that both development and nature conservation are possible;
5. facilitate the implementation of management practices outside reserves which will conserve biological diversity and maintain healthy ecological processes.
6. provide the essential framework for regional development plans which can be integrated into a national program of ecologically sustainable development.

A national system as outlined above can: provide information vital to the environmental health of Australia, provide insights into past and present events to improve maintenance and management of the Australian environment, be part of the economic diversification and development of Australia, increase the public awareness of environmental hygiene to reduce the potential for crises in nature conservation and provide the protection for the genetic, species and ecosystem diversity for future generations of Australians.

BIOLOGICAL DIVERSITY, ENVIRONMENTAL MONITORING AND THE NATURE CONSERVATION ESTATE IN AUSTRALIA: RELATIONSHIP TO ECOLOGICALLY SUSTAINABLE DEVELOPMENT

D.W. WALTON, M.A. FORBES AND R.M. THACKWAY

INTRODUCTION

There is an unprecedented level of international activity on global environmental issues; to name but a few - marine pollution and dumping of wastes, wildlife protection, depletion of the ozone layer, climate change, regulation of biotechnology and biodiversity. Australian governments inevitably will have to reconsider existing political and Constitutional arrangements with respect to the environment in the light of these growing international concerns and activities. The prospect for tensions from environmental modifications, intentional or not, across political boundaries is great and legal instruments to deal with such tensions are immature (Schneider, 1989).

The centenary of the Constitution of the Commonwealth of Australia is 2001. The present decade offers an opportunity to review the Australian Constitutional system and the process of review has been initiated. While the Constitutional issues confronting Australia on the threshold of the 21st Century are complex, the role of the Commonwealth in environmental issues is central and critical to the debate.

The rapidly changing environmental demands on Australian landscapes by society require real and innovative rationalisation of Constitutional arrangements. As noted by Saunders & Crawford (1990), a farsighted approach would "anticipate the tendency, already evident elsewhere, for increased centralisation on particular matters at national or international level to be complemented by the exercise of power at lower levels of government where that is feasible, in the interests of both the responsiveness of government and broader popular participation".

Significantly, the review of the Constitutional system is running in parallel with two other integrated review processes.

Firstly, the Prime Minister (Hawke, 1990) called for a closer partnership between the three levels of Australian government. A process to reform intergovernmental cooperation was developed under the auspices of Special Commonwealth/State Premiers' Conferences focussing on six specified areas of national activity, including protection of the environment. In outlining the environmental aims of the exercise, the Prime Minister stated: "The environment must increasingly become an area in which common ground and common purpose come to replace controversy and confrontationalism".

Secondly, the Australian Government has independently established a series of industry sector working groups to review the concept of "ecologically sustainable development", *i.e.* development that ensures that ecological processes are not lost or destroyed. One of the fundamental goals guiding deliberations is the protection of biological diversity for the maintenance of ecological processes and systems. These sectoral working groups will report to Government and their reports will be considered at a Special Premiers' Conference presently scheduled for May, 1992.

Ecological sustainability is dependent upon genetic diversity and is not to be confused with sustained yield. Sustained yield, measured as biomass per unit area per unit time, may guarantee ultimate extinction of a species through the loss of genetic diversity implicit to sustained yield (sustained yield is most often achieved by genetic homogeneity of a monoculture). The needs of future generations of Australians will be severely compromised with the loss of genetic diversity, regardless of standing biomass at any given moment in time.

Three central policy streams of government (Constitutional change, the Special Premiers' Conferences and the Ecologically Sustainable Development Working Groups) give recognition to the environment. In acknowledgement of the internationalisation of environmental issues, the Australian Government hosted the World Conservation Union's General Assembly in December, 1990. Significantly, that Assembly agreed to a new and comprehensive sustainability statement- *Caring for the World - A Strategy for Sustainability.* As in the *World Conservation Strategy* (IUCN, 1980), emphasis is on the interdependence of conservation and development, the need to maintain the earth's stocks of natural capital, living only on income and, in addition, taking full account of economic and social as well as ecological requirements of sustainability.

Australia is well placed to grasp the mantle of ecological sustainability, nationally and internationally, as the 21st Century approaches. Underpinning that mantle is the ability to maintain and manage Australia's biodiversity as a priority in the formulation and implementation of responsible ecologically sustainable development policies and practices.

Implicit in the decision by the Australian Government to include the word "ecologically" in its sustainable development strategy considerations is the absolute necessity of ensuring sustainability at the ecological level (inseparable from the processes of life and the genes, species, communities and landscapes that make up the biosphere). Considerations of ecological and evolutionary processes will need priority over subsequent consideration of sustainability of social or economic systems which, in the long-term, cannot exist without a sustained biosphere (Dovers, 1990). The diversity of life is an irreplaceable asset for the future of humanity and to the biosphere. It provides both immediate and long term benefits; its maintenance is essential to sustainable development. Dovers (1990) notes, however, that "biological diversity sits uneasily within the sectoral framework that appears to be the automatic way in which governments translate their concern about sustainability".

The nature conservation estate is among the most valuable management assets for the maintenance and management of genetic, species, community and landscape diversity as well as the various ecological processes of importance to humanity (Reid & Miller, 1989).

This paper develops the integrated theme of the conservation of biodiversity, environmental monitoring and the role of the nature conservation estate. Issues in this context are suggested which need to be addressed in the development of a strategy for an ecologically sustainable Australia.

BIODIVERSITY

Biodiversity is the variety within and among living organisms and of the ecological systems they comprise (Reid & Miller, 1989; McNeely *et al.*, 1990). In the following

discussion, references to the maintenance and management of biodiversity follow Bridgewater *et al.* (1991): maintenance is keeping the environment free from the ravages of people and management is the mechanism of maintenance. Maintenance, unfortunately, is often used to imply preservation of the *status quo*. This concept of maintenance ignores change as an inherent attribute of biotic and abiotic systems (see Callicott, 1990) and is a denial of ecological processes which are change.

Fundamentally, the reason for the importance of biodiversity is simple: biodiversity is essential for healthy ecological processes and we, as large terrestrial mammalian omnivores, are as reliant upon healthy ecological processes as any other species. We, in addition, apparently are the only species with the capacity and imperative to maintain and manage (or debilitate and destroy) ecological processes - the life support systems of our world (Bridgewater *et al.*, 1991). Biological diversity is vital to and a measure of the health of ecological processes.

Conservation of biodiversity, and the implicit maintenance and management, has been wrapped in a cloud of debate (usually called the environmental debate) and confusion. No doubt, some of the confusion derives from the magnitude of life forms, processes, ecosystems, landscapes - quantifiable aspects of the biosphere, and some comes from the fact that some participants in the debate are un- or ill-informed. Whatever may be the reasons, most Australians are concerned about their own personal health and that of their family and friends. Perceptions and priorities do vary, but the bottom line is good environmental health.

Turner (1988) distinguishes (based on earlier work with O'Riordan) four basic world-views in the debate:

a. "cornucopian" technocentrism: a view that accepts as axiomatic that market mechanism in conjunction with technological innovation will ensure infinite substitution possibilities to mitigate long-run real resource scarcity;

b. "accommodating" technocentrism: the axiom of infinite substitution is rejected and a "sustainable growth" policy guided by resource management is supported;

c. "communalist" ecocentrism: emphasis is upon prior macroenvironmental constraints on economic growth in a decentralised socio-economic system;

d. "deep ecology" ecocentrism: extreme preservationist position dominated by the intuitive acceptance of intrinsic value in nature and rights for non-human species.

As Turner (1988) also points out, the new sub-discipline of environmental or resource economics emerged from the debate. Whatever the contributions of this new sub-discipline, there is a growing awareness that a pluralist approach to environmental problems is necessary. Differing values, perceptions and priorities are present, but the bottom line of good environmental health is still real and a point about which agreements in the debate can be achieved.

The maintenance and management of biodiversity depend upon healthy ecological processes and ecological processes are dependent upon biodiversity for health. We, *Homo sapiens*, are as dependent on and as much a part of this relationship as any other species. Protected areas (the nature conservation estate) are among the most valuable management tools for preserving genes, species habitats and for maintaining ecological processes of importance to humanity (Reid & Miller, 1989). If a national nature conservation system is established with the aims set out below and if nature conservation reserves are viewed as part of the landscape matrix rather than islands and are

placed within an integrated management framework for that landscape, a real beginning will be made toward securing the present and future environmental health of Australia.

The concept of nature conservation reserves within an integrated landscape management framework is not new. The biosphere reserve, a concept developed and championed under the UNESCO Man and the Biosphere Program, was formulated to wed conservation and sustainable development. Australia should revisit this concept.

A biosphere reserve is first and foremost a representative ecological area. The concept combines nature conservation with scientific research, environmental monitoring, training, demonstration and local participation. A strictly protected core area is surrounded by a buffer zone in which research, environmental education and training and recreation takes place. An outer transition area surrounds the buffer zone. In the transition area, close cooperation can be developed between researchers, managers and the local population to ensure rational development of the natural resources of the area (Brabyn & Hadley, 1988).

Integral to the conservation of biodiversity is the connectivity of landscapes. The use of landscape follows Forman & Godron (1981): "kilometers-wide area where a cluster of interacting stands or ecosystems is repeated in similar form". Protected areas, within the concept of biosphere reserves, and elements of remnant vegetation connected by corridors or "greenways" can provide the reservoirs of biodiversity and avenues for adaptive responses to environmental change. If, as noted below, protected areas are isolated their purpose is defeated. Also, living associations and their environments change. Corridors or "greenways" provide avenues for dispersal, replacement and formation of new associations (see Noss & Harris, 1986; Harris & Eisenberg, 1989) in response to and as part of change.

Conservation outside reserves not only conserves biodiversity, but has significant influence on the landscape matrix. Erosion control, catchment security, land reclamation, soil fertility improvement, modifications to air temperature and humidity, control of soil salts, water table levels - all are affected by properly placed and designed corridors (Forman & Godron, 1986). Conservation outside reserves cannot be a haphazard affair; done properly, it will be education and information intensive and require appropriate resources for better and increased levels of management.

As noted below, nature conservation areas, often as national parks, traditionally have been associated with "primitive" or "natural" areas, usually remote and protected. Human influence, except under tightly controlled circumstances, is limited. Biodiversity, however, includes people, domestic plants and animals and the ecosystems of which they are part; biodiversity in rural and remote areas is only part of the conservation effort. Urban and suburban areas offer significant opportunity for conservation of biodiversity (Bridgewater *et al.*, 1991). While there may be practical restrictions to designating an urban/suburban area a nature conservation area, healthy ecological processes in dense human settlement are highly desirable. Greater emphasis upon the maintenance and management of biodiversity in these areas is warranted (Murphy, 1988).

Hayden *et al.* (1984) propose a classification of coastal and marine environments. Whether this classification proves useful for the purposes of the maintenance and management of Australia's biodiversity, several points are relevant. Coastal landforms associated with the drainage of fresh waters into oceans and seas are of special physical

and biological significance. Estuaries and wetlands have their own unique characteristics and processes. Coastal and marine areas have landscape and seascape characteristics which do not align with terrestrial landscapes; demands on and content of geographic information systems, therefore, will differ. Innovative techniques will be required to integrate those data which pertain to the zone where three major ecosystems (terrestrial, freshwater and marine) interact.

Biodiversity is not just about the conservation of "pristine" areas. Many species require disturbed and degraded areas (B.H. Green, 1989). New associations undoubtedly have developed in areas which have experienced long-term disturbance or areas which have been subject to extensive invasion (see Fox, 1990; D.G. Green, 1990). These synthetic communities (Bridgewater, 1990) must be assessed within a landscape context. Opportunities must be seized to explore what Soulé (1990) terms recombinant ecology. Hobbs & Hopkins (1990), in a stimulating and provocative treatise, consider the problems and opportunities of restoration or reconstruction of Australian plant communities. Conservation biology offers resolutions for many problems, but the reversal of history and a return of the biosphere to its prelapsarian state are not possible (Soulé, 1985). Ecological rehabilitation techniques, however, may be of great value for maintaining biodiversity in the face of global change; the possibility exists that entire protected areas can be relocated (Jordan *et al.*, 1988).

Man-induced global change very well may produce massive ecological disruptions (Soulé, 1990). Fragmentation of pre-European ecosystems certainly has paved the way for invasion. Colonisation and invasion may be the dominant ecological features of the future.

In what easily can be viewed as the chaotic state of Australian landscapes, a national nature conservation system on the biosphere model, connecting vegetation remnants and landscapes by corridors or "greenways", is essential to the maintenance and management of biodiversity, especially the genetic diversity (Noss, 1983; see also Vida, 1978). Environmental monitoring, including research into past Australian environments and long-term ecological research, can provide information critical to sound management within a landscape perspective. Human impact on most Australian landscapes is at a level where active intervention management strategies are necessary (Goodman, 1987).

MONITORING OF ENVIRONMENTAL CHANGE

In the discussion which follows, the definition of monitoring provided by Izrael & Munn (1986) is followed: "a system of continued observation, measurement and evaluation for defined purposes". Ecologically sustainable development requires proper management. Proper management requires the understanding of patterns and processes in biotic systems and the development of assessment and evaluation procedures which assure healthy patterns and processes in biotic systems (Karr, 1987). Analysis is the objective task of identifying actions, taking measurements of baseline conditions and predicting changes to those conditions as the result of actions. Evaluation is the subjective task, the application of human values, *i.e.* determining the significance of the effects on the affected parties (Westman, 1985).

Changes in the biosphere are from two major sources:

a) changes resulting from natural processes of biotic and abiotic systems;

b) changes resulting specifically from the activities of people and their associated domesticated (and peridomestic) species.

In an era where the activities of people are the dominant force influencing biological systems, assessment and evaluation procedures that assure protection of biological resources must include long-term monitoring (Karr, 1987). Long-term monitoring of the environment is essential to distinguish patterns of change from noise and to characterise the patterns (Chernoff, 1986). To formulate a plan to monitor changes to the environment, consideration must be given to what is meant by long-term. If the aim of ecologically sustainable development is accepted, a monitoring system which assesses sustainability of the environment must be in place for as long as we intend to pursue that aim. The aim of environmental monitoring is the systematic and repetitive collection, assessment and evaluation of data which can be used:

a) to help determine the quality of the environment or condition of living resources as they are or will be; and

b) to help relate environmental quality or living resources to factors which cause them to change or to effects caused by change (Buffington, 1980).

Information is not an end product; the application of information is. Three functions to support environmental monitoring are identified by Buffington (1980).

1. Environmental policy and management decisions by government, including definitions of program objectives and priorities and selection of specific regulatory or enforcement actions.
2. Identification and definition of environmental problems which are not now recognised or which may emerge in the future.
3. Evaluation of impacts on environmental quality resulting from specific governmental policies, programs or actions.

An environmental monitoring system should adopt an integrated approach. Biological and chemical/physical indicators should be included (Karr, 1987). With ecological sustainability as the goal, biological indicators form some of the principal components of the system (Izrael & Munn, 1986). Function, *i.e.* ecological processes, must not be obscured by an over-emphasis on form and structure.

Long-term monitoring will require site tenure and sites should be selected on the basis of landscape representativeness if the gathered information is to be meaningful at a fine scale, but interpretable on a continental scale. Legally protected areas which form a national nature conservation system, based on landscape representativeness, can provide site tenure security. To assume, however, that the species associations captured in reserves today will not change over time is futile (Graham, 1988).

Careful review will be required for the selection of specific biological, chemical and physical attributes to comprise the data. There will be competing interests and requirements. Resources for the implementation of an environmental monitoring program probably will never be sufficient to meet or satisfy all interests and requirements. A minimum data set must be developed which will reveal at least two basic facts: whether there is change and whether the change or lack of change is due to natural processes or to human activity.

A national long-term program to monitor changes to the environment of Australia should be designed and implemented. The program should include the following points:

1. the information gathered for assessment and evaluation must be an integration of biological, chemical and physical factors;
2. terrestrial, marine, freshwater and atmospheric systems, and the boundaries between them, should be monitored;
3. for security of tenure and management purposes, long-term monitoring sites should be legally protected areas, and where possible, within a national nature conservation system based on landscape representativeness;
4. those data gathered should be directly related to the formulation of the objectives and priorities of environmental policies and the evaluation of the effectiveness of policies;
5. specific regulatory and/or enforcement actions should flow from the environmental management goals derived from the evaluation of those data gathered;
6. the assessment of those data gathered should be used not only to determine historical events, but to predict future or heretofore unrecognised problems;
7. a national long-term environmental monitoring program is sufficiently important to warrant statutory protection.

THE NATURE CONSERVATION ESTATE

National parks, as we know them today, are a relatively recent phenomenon in our history (NSWNPWS, 1979). Four main roles usually have been embodied in our interpretation of what constitutes a national park:

a. to single out for special recognition what is considered to represent a "primitive" or "natural" area, *i.e.* an area with special interesting characteristics - a "natural" curiosity;
b. to set aside special places for protection from the ravages of ordinary human use;
c. to have areas available for the enjoyment of visitors;
d. to protect national treasures (Hales, 1989).

The Eurocentric idea that certain places were "natural" or "primitive" usually meant that the places were considered unfit or at least only marginally fit for human occupancy or use. Indigenous peoples may have had a totally different view, considering such areas as "domesticated" or of special spiritual or ideological significance. The fact that such areas could be set aside as curiosities for visitors was no great economic loss and the protection given such areas was largely designed to protect their peculiar attributes. The responsibility for such areas and values usually is vested in the highest competent authority of the nation (Hales, 1989; McNeely, 1989).

The role of national parks in the conservation of flora and fauna, the biological diversity of a nation, represents a major shift in emphasis. Curiosities may remain, enjoyment may remain, but the enormous impact of people on the biosphere leaves little that is wholly "natural" or "primitive". National parks, as reservoirs of genetic, species and ecosystem diversity, have new and added meaning as national treasures. The diversity of the flora, fauna and landscape has shaped (and been shaped by) human culture; the future of human culture depends upon maintenance and management of this same diversity (McNeely, 1987).

Although national parks may be seen as the flagships of the current nature conservation estate of Australia, the range of legally protected areas (national parks to local

reserves and city parks) has a significant role to play in the maintenance and management of biodiversity.

There are those who incorrectly view ecosystems within protected areas as living museums, static displays of nature. Change, as Callicott (1990) reiterates, is an inherent property of ecosystems (see also von Droste, 1988). Communities are temporary assemblages of species brought together by the environmental conditions which prevail at a particular time (Huntley & Webb, 1989). Protected areas, therefore, represent areas with secure tenure where change - evolutionary, climatic, successional, cyclical, seasonal, meteorological and stochastic - can be monitored and studied.

Regardless of the rationale behind the protected areas of Australia, all the landscapes of terrestrial Australia are, to some degree, anthropogenic (Taylor, 1990; Bridgewater *et al.*, 1991). Two major cultural influences have impacted upon Australian landscapes: Aboriginal culture for more than 50,000 years and European culture for more than 200 years (Bridgewater, 1990). European cultural landscapes dominate much of present day Australia; Aboriginal cultural landscapes, seen by the earliest European settlers, only now are beginning to be understood (see Walsh, 1990).

The greatest threat to protected areas in Australia will not be direct human damage or malice, but the results of the expansion of the human population and their activities (Ehrlich, 1988). Parks and reserves do not exist in isolation from the surrounding landscapes (Bridgewater *et al.*, 1991). Boundary lines, which represent almost total protection of lands on the inside surrounded by lands heavily modified by humans on the outside, create islands of ever increasingly degraded purpose (Ehrlich, 1982; Noss, 1983; Hales, 1989; Olson, 1989; McNeely *et al.*, 1990). Critical ecological processes in Australia have experienced extensive disruption with serious impact on Australian ecosystems (Casey *et al.*, 1990). The ecological processes within a protected area will be destroyed as the area loses what Karr (1990) defines as biological integrity and ecological health. Serious consideration should be given to the option of protected area design provided by the biosphere reserve concept (see Batisse, 1982; Brabyn & Hadley, 1988).

Should Australia have a truly integrated "National System" of protected areas, where should these areas be located, how many should there be, how big (or small) should they be, what should be the administrative structure? All of these are relevant questions.

Protected areas are located throughout Australia and the External Territories and vary greatly in size and purpose. Mobbs (1989) lists 45 different types of parks and reserves. Although there has been a move in recent years to develop strategic approaches to the conservation estate in the States and Territories, most protected area acquisitions have been opportunistic or expedient. Parks and reserves (making up the protected area system) are administered either by the Commonwealth, State/Territory and occasionally local governments or combinations thereof. Added to this colloidal suspension of protected areas is a further mixture of World Heritage Areas, Wetlands of International Importance, National Estate natural heritage areas and assorted *ad hoc* arrangements.

Administrative and financial arrangements for the protection and management of this assemblage are complex and often confusing. Many of the problems in the area of nature conservation are attributed to the fact that the Australian Constitution makes no specific reference to the environment or conservation (see Kerr, 1987). While the

Constitution is silent on these matters, there is growing recognition that the Commonwealth does indeed have the powers for extensive legislation to cover environmental protection if it so desired (Crawford, 1990).

Traditionally, the maintenance of landscapes and area regulation have been left to State and local governments, but this position is changing as a result of an increasing number of interstate issues and international agreements. The Commonwealth, over the last two decades, has assumed a direct role in landscape management. While area use control and landscape management at a regional or local level may be more effective, efficient and accountable (see Hall, 1990), national economic, social and conservation planning cannot be accomplished without a national over-view and broad national management.

Clear demarcations of responsibility and authority between the various tiers of government should be established and appropriate mechanisms established to facilitate and simplify cooperation between and among these various tiers. Greater involvement of local communities is essential and, therefore, bureaucratic steps between any tier of government and local communities should be minimal (see Vittachi, 1989). Recent experience in major environmental issues suggests that Australians generally welcome a role for the Commonwealth. The question is not whether the Commonwealth should become more directly involved in the maintenance and management of Australian biodiversity, but where, how and how quickly.

National Parks (the premier protected area classification, see IUCN, 1984) and other nature conservation areas in Australia are dedicated under 32 different pieces of legislation. While the significance of the national parks should not be underestimated, some of these sites, when assessed on the basis of national significance, may be only of local or regional significance. The uncoordinated framework in which these State/Territory national parks were dedicated is compounded when one tries to make sense of the 44 other types of protected areas dedicated for nature conservation purposes (Mobbs, 1989).

The Council of Nature Conservation Ministers (CONCOM) has attempted in the past to rationalise the excessive classification systems created by the States and Territories in order to meet the introduction of an international system recommended by the IUCN; the Council was unable to resolve the issue. Without a rational system of protected areas at the national level, an integrated policy for an ecologically sustainable Australia will not be possible. As Reid & Miller (1989) note: "protected areas must be conceived and managed as a system (their emphasis) of protected sites - no one of which meets all of the possible objectives of protected area establishment but which together provide the essential services that humanity requires from natural and semi-natural ecosystems".

The integration of a protected area system into Australia's overall development planning process is absolutely essential (Ugalde, 1989). Conservation, the maintenance of the environmental health of Australia, is part of what Soulé (1986) terms the "real world", "the face-to-face interactions with others and with their desires, priorities and prejudices". Ecologically sustainable development (if an agreed and effective definition of ecologically sustainable can be achieved) of Australian society has two major prerequisites: that the environment be ecologically healthy and that human society lives on the planet's income instead of depleting nature's capital (Repetto *et al.*,

1989; see also O'Riordan, 1988 and Turner, 1988 for discussions of the interpretation of sustainable).

National standards for the establishment, management and goals of protected areas within the nature conservation estate should be established to ensure that a solid basis exists for ecologically sustainable development. Fundamental to ecologically sustainable development is the conservation of ecological processes (Ricklefs *et al.*, 1984). Ecological processes are not bound by political or other man-imposed artificial boundaries; a continental, nationally coordinated approach to protected areas is critical.

If the maintenance and management of Australian biodiversity is accepted as a national responsibility, as apparently is intended, the Commonwealth will need to ensure that the national perspective is introduced into the system for establishing, managing and monitoring protected areas.

The link between the viability of protected areas and adjacent area uses is important and should not be lost on those policy makers considering the ecologically sustainable development strategy. The Canadians have recognised this important link and adopted adjacent land use as one of their sustainable development principles in managing protected areas for biodiversity and sustainable development (Anon., 1990). A national approach to protected area management under the umbrella of ecologically sustainable development will necessitate a greater Commonwealth role in area management and planning.

If Australia is to have, for example, a truly national National Park System, two fundamental questions must be addressed: what are the aims of an Australian national park system; and how best can these aims be fulfilled?

The national park system in Australia should:

a. single out areas of special cultural or natural interest;
b. provide protection from ordinary human activity;
c. provide areas for human recreation and enjoyment and be part of the national economic diversification agenda;
d. protect and manage national treasures;
e. be part of a national education system to broaden the understanding of the flora, fauna and landscapes of Australia;
f. be reservoirs of biological diversity and maintain healthy ecological processes;
g. preserve representative areas of the major landscapes and seascapes of Australia;
h. be sites for monitoring the effect of environmental change on the ecological health of Australia and the biological integrity of the represented landscapes, *i.e.* serve as field stations much in the fashion suggested by Brussard (1982);
i. be sites of ecological integrity, *i.e.* including appropriate boundary zones, especially at the land/sea interface.

Within the preceding list of aims, the complex and diverse array of Australian "nature conservation areas" should be reviewed to select from that array those areas which best meet the aims on a continental scale and those selected areas brought into an integrated national system. Additional areas, which fill the gaps not represented or inadequately represented in the reviewed array, also should be nominated and brought into the same system. Programs within the Australian National Parks and Wildlife Service, the

National Index of Ecosystems and Environmental Resources Information Network, can provide the information upon which selection and nomination can be based.

Part of the review process suggested above should be to improve cost effectiveness by clear determination of the appropriate roles and responsibilities of the different tiers of government (see Westman, 1985). The appropriate Commonwealth organisation with appropriate legislation already exists, but the legislation should be amended to legitimise those aims presented above and to strengthen a National Conservation Authority (MacDonald, 1989) with the major role specifically in conservation of Australia's biodiversity. Such a review and reorganisation also would provide the opportunity for evaluation of protected areas on a finer scale (see Noss & Harris, 1986).

The opportunity should be created for the inclusion of Aboriginal lands, if the owners so choose, in the network of protected areas. Traditional Aboriginal culture is thoroughly integrated with the Australian flora, fauna and landscapes. Maintenance and management of biological diversity have immediate cultural and physical survival significance for Aborigines.

As Ray (1988) very correctly notes, too little consideration has been given to coastal and marine areas. The coastal zone, that complex and poorly known interface between terrestrial and aquatic (marine, estuarine and freshwater) ecosystems, comprises the coastal plains and the continental shelf and represents a vast area of the continental island of Australia. Far more than half of all Australians live in the coastal zone; more than half the people of the world live in a coastal zone and more than 90% of all marine-living resources are taken from this zone. Alterations of this zone as the result of human activity, though less well documented and obvious than for wholly terrestrial areas, have been extensive, especially the global movement of organisms associated with ocean-going vessels and with commercial fishery products (Carlton, 1989).

For too many Australians, the coastal zone is visualised as either a play ground or dumping area. Perhaps we, as large, terrestrial mammals, have difficulty with the valuation perception of an area much of which is of limited accessibility to us. Perception problems aside, the ecological processes and ecosystems of the coastal zone and marine areas are of national importance and cannot be ignored (Fairweather, 1990). The design of estuarine and marine reserves will differ from that of terrestrial areas; differences are dictated by the vastly different physical and chemical properties of aquatic environments (Westman, 1985).

Agencies, governmental or private, engaged in nature conservation are constrained by budgets based on national resources and the public perceptions of nature conservation needs. Policies for implementation, at best, are based on information available at the time and the time is determined largely by perceived human population needs for space and/or wealth. Nature conservation, therefore, is concerned not only about the environmental health of Australia, but about crisis management (Diamond, 1988). National parks and other protected areas, especially a national system based on the purposes outlined above, can: provide information vital to the environmental health of Australia, provide insights into past and present events to improve future maintenance and management of the Australian environment, be part of the economic diversification and development of Australia, increase the public awareness of environmental hygiene to reduce the potential for crises in nature conservation and provide the protection for the genetic, species and ecosystem diversity for future generations of Australians.

CONCLUSION

Kerin (1990) defines sustainable development as "... if you look after nature it will look after you". Fundamentally, this is a correct and proper statement. One essential point should be added: Australians managed to create the deplorable state of their lands and waters - conservation biology and management (not just bureaucratic activity in capital cities) will be required to prevent further degradation and to implement effective recovery programs. Ecologically sustainable development is a goal, an ideal or philosophy; it is not a plan of action. How we reach the goal, realise the idea or implement the philosophy is the plan of action.

Projections of climate change (due to augmentation of the greenhouse effect) to the year 2050 indicate a rate and magnitude greater than any before experienced by human society. The faster the rate and greater the magnitude, the less societies and ecosystems will be able to cope without potentially serious consequences and the greater the chances are of surprises (Schneider, 1989). The question, therefore, is not whether conservation should be a part of the social and economic fabric of Australian society, but how conservation can be achieved in the face of increasing environmental disequilibrium and the increasing demands of a growing human population (what Soulé (*cf.* 1989) terms "demographic winter"). Nature conservation is an absolutely necessary ingredient of the national ecologically sustainable development process. Ecologically sustainable development and healthy ecological processes must not be equated with sustained yield.

Virtually the entire surface of the Earth, certainly Australia, has been "handled" by people. In the face of rapid and great change, research is not enough; active management is essential. The nature conservation estate of Australia will never be more than a small proportion of the nation. This small portion of Australia, however, will provide the arena for the development of management skills and the opportunity to monitor change and the effects of change *in situ*. The linkage of nature conservation areas by means of corridors or "greenways" will not only provide the avenues for dispersal and colonisation in response to change, but ameliorate the impact of climate change.

Biological diversity, protected in the nature conservation estate with provisions for landscape connectivity, is too valuable to lose. Resources are only segments of the total biodiversity which have been identified as valuable to people and resources undreamed of lie buried in this total biodiversity. The health of ecological processes upon which we depend relies upon biological diversity.

Rational economic development of Australia should lead to a reduction in the heedless extraction of natural resources. Without planning and coordination at the national level, development will be chaotic and resource utilisation without direction. If the word ecologically is to be meaningfully applied in the development of Australia, a coordinated nation-wide system of well managed protected areas is essential. Such a system will play a crucial role in achieving ecologically sustainable development. Likewise, such a system is critical if we are to monitor whether or not we are achieving ecological sustainability. How such management is implemented is a value judgement for Australian society, but all available evidence indicates that now is the time to begin.

The nature conservation estate of Australia and its supporting landscape matrix are the treasuries of biological diversity and the nation's future. The commitment of resources

to the use of the nature conservation estate of Australia as "living" laboratories and to the effective and efficient management of the nature conservation estate as part of the ecologically sustainable development goal will be the barometer of national dedication to the goal, ideal or philosophy of ecologically sustainable development.

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