References

Common, M. S. and Norton, T.W. (1992). Biodiversity: its conservation in Australia. *Ambio*, **21**, 258–65.

Gentry, A. H. (1990). Herbarium taxonomy versus field knowledge. *Flora Malesiana Bulletin*, Special Vol. 1, 31–5.

Heywood, V. H. (ed.) (1958). *The presentation of taxonomic information: a short guide for contributors to Flora Europaea*. Leicester University Press.

Heywood, V. H. (1978). European floristics: past, present and future. In *Essays in plant taxonomy* (ed. H. Street) pp. 275–89. Academic Press, London.

Heywood, V. H. (1992). Conservation of germplasm of wild species. In *Conservation of biodiversity for sustainable development* (ed. O. T. Sandlund, K. Hindar, and A. H. D. Brown), pp. 189–203. Scandinavian University Press, Oslo.

Kemp, R. H. (1992). The conservation of genetic resources in managed tropical forests. *Unasylva 169*, **43**, 34–40.

Norton, B. G. and Ulanowicz, R. E. (1992). Scale and biodiversity policy: a hierarchical approach. *Ambio*, **21**, 244–9.

Noss, R. F. (1990). Can we maintain biological and ecological integrity? *Conservation Biology*, **4**, 241–4.

Walker, B. H. (1992). Biodiversity and ecological redundancy. *Conservation Biology*, **6**, 18–23.

Williams, P. H., Vane-Wright, R. I., and Humphries, C. J. (1993). Measuring biodiversity for choosing conservation areas. In *Hymenoptera and biodiversity* (ed. J. LaSalle and I. D. Gauld), pp. 309–28. CAB International, Wallingford, UK.

3. On what we should save: the role of culture in determining conservation targets

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Abstract

This paper examines the role of culture in the protection of biological diversity. The present situation exists that while a few commentators question the urgency sometimes asserted for biodiversity protection, at the same time there is no organized, scientifically respectable, and political influential group that advocates destruction of species, nor suggests that we do nothing. The cultural basis of this enquiry is, that whilst it is not seriously questioned that there is an incumbent moral obligation for us to sustain biological diversity for the benefit of future generations, we still have to find the rationale for consensus and to articulate it in a specific and operational manner. The consensus we seek implicitly sets out the temporal frame over which humans will 'manage' natural systems, provides a basis for strengthening and making more specific the agreed protocol to protect biodiversity, and provides the means to accomplish this task. First, I discuss the view that there is an 'objective' scientific definition of biodiversity. I conclude that there is not for two reasons: one of epistemology, which allows us to realize that all knowledge is theory bound, and undermines any attempts to aggregate multiple levels of biodiversity into a single measure; and secondly, physical theory which admits the irreducible complexity of natural systems. Second I introduce 'hierarchy theory' as a useful technique to identify conservation targets in the absence of a single scientific definition of diversity. Hierarchy theory is used to explain new explorations by many ecologists and ecological economists of methods of minimizing human alteration of natural cycles, shifting attention to 'ecosystem health' and the structures and processes that perpetuate natural systems. I develop three assumptions: that natural systems are dynamic; biotic diversity is maintained when natural populations adapt creatively to dangers and opportunities; and that we can only understand biodiversity if we interpret the dynamics of nature as a natural hierarchy in which the smaller sub-systems tend to change more rapidly than larger units or the whole system. Human

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culture and maintenance of biodiversity must go hand in hand. I will argue that ecological economics is the bridging discipline that links ecology and culture, a link that is forged in the crucible of policy formation to create a dialectical dynamic between culture and nature which drives landscape development and attendant diversity on the intergenerational scale relevant to sustainablity goals.

Introduction

I have been asked to discuss the question, what is the role of culture in the protection of biological diversity? This is a good, but extremely difficult and complex question to answer.

Loss of biodiversity is one of the 'global' environmental problems which, along with ozone depletion and greenhouse warming of the earth's atmosphere, have come to dominate environmental policy discussions. While scientific uncertainties remain about the exact dimensions of the problem, loss of biodiversity, these uncertainties have not stood in the way of a scientific and policy consensus that the problem requires a strong and decisive response. A commitment to protect biological resources has therefore become the centrepiece of the renewed commitment to environmental protectionism that has been intensified by the recent political and economic realignment of Eastern Europe. There may be an emerging opportunity to unify the world behind an environmentalist banner with protection of biodiversity as a centrepiece. While there are still a few commentators who question the urgency sometimes asserted for biodiversity protection (see, for example, Kahn 1982; Simon and Kahn 1984), there is no organized, scientifically respectable, and politically influential group that advocates destruction of species, nor are there even serious advocates of a do-nothing approach to the subject. We can therefore base our exploration of the role of culture in biodiversity policy on a very broad and strong consensus: it is not seriously questioned that the present generation has an important moral obligation to sustain biological diversity for the benefit of all future generations. Our task is mainly to provide a rationale for this consensus, and to articulate this goal in more specific and operational terms.

It is important that this consensus for sustainability introduces an implicit, multi-generational time frame. If we are seriously committed to protecting biological diversity over many human generations, we are committed to understanding and modelling our impacts on populations of plants and animals on scales of at least 150–200 years (Norton and Ulanowicz 1992). This commitment starts to give shape to a rational and comprehensive policy to protect biodiversity. So the consensus in favour of long-term biodiversity protection is no vacuous consensus. It implicitly sets the temporal frame over which humans will 'manage' natural systems and provides a basis for strengthening and making more specific the consensus to protect biodiversity

and how to accomplish this urgent task. It should be noted that 'management' of ecological systems more often than not means 'managing' human impacts on ecological systems. We usually do not know how to manage complex, dynamic, creative, and inherently unpredictable (see Faber *et al.* 1992) systems to produce desired outcomes without undesirable consequences.

From the outset we must recognize that there is much less agreement as to what exactly we mean by 'biodiversity'. What exactly are we trying to save? I call this the question of 'conservation targets'. Should we be trying to save genes, individuals, species, communities, or ecosystems? It is tempting to say that we should save all of these to the fullest extent possible; but this would surely require more resources than will be available, and we must face the question of targets and set conservation priorities. The important question of conservation targets can be illuminated by a careful analysis of the relationship of human cultures with surrounding biotic communities. Accordingly, I consider two questions on the relationship between culture and the natural systems that form their context: (1) should cultural factors influence our characterization and description of biological diversity? and (2) is it possible to save the biological resources in an area without saving, also, important aspects of indigenous cultures?

First I will examine the view that there is an 'objective' scientific definition of biodiversity that can guide conservation efforts. I conclude that there is no objective scientific definition. Second, a theoretical approach, called 'hierarchy theory', is introduced to provide a useful technique for identifying conservation targets in the absence of a scientific definition of diversity. From this technique I can answer two questions by explaining the crucial role that local cultures should play in our selection of conservation targets. I can then begin to address the interaction of cultures with the biological resources they depend upon in the last part, and to sketch a general answer to the second question. Drawing upon insights from environmental history, I will argue that any definition of biodiversity which is potentially capable of guiding an intelligent, multi-generational policy must accept that nature is dynamic and that changes are driven by local interactions of human cultures and biotic communities. Identifying conservation targets—which is necessary to articulate a rational biodiversity policy—consequently requires that we understand how cultural practices, and the aspirations of the institutions that sustain them, are expressions of local values which have evolved in response to local ecological conditions.

Measuring diversity scientifically

Most advocates of biodiversity protection assume that we have—or will have—a precise scientific measure of biological diversity and that the measure, once articulated, will tell us which elements of nature to 'target' in our conservation efforts. The goal of protecting biological diversity would then be precisely stated as the goal of maximizing diversity so measured. This optimistic view is, unfortunately, untenable. Considerable progress has been made in understanding diversity scientifically; but that progress makes it less, not more, likely that a single, scientifically objective measure of diversity will emerge to guide policy.

Several scientific definitions of diversity, applicable at differing levels of natural systems, have been proposed (Whittaker 1960; McNaughton, this volume). Within-habitat diversity is the species diversity that occurs within a particular habitat; but the diversity represented across an entire landscape will also depend heavily on the diversity of types of habitats that occur within the landscape. At first glance these multi-scalar definitions may seem to cause no serious problems—why not simply choose a spatially synoptic concept, such as McNaughton's δ-, or 'landscape' diversity as the concept most descriptive of diversity and use delta diversity as the measure of how well we are doing?

While this step is a useful one, and may help us to explain in general terms what is sought in biodiversity protection, it does not provide a satisfactory theoretical solution to our problem, because the idea of delta diversity is only as 'objective' and 'descriptive' of nature as are the various boundaries and partitions that have been introduced to describe the organization of the landscape as a hierarchy of 'microhabitats' (subsystems), 'habitats' (systems), and 'landscapes' (complexes of interacting systems). If these boundaries could be set based simply on objective data describing ecological systems, landscape diversity would also be a descriptive concept since, on this assumption, it would represent a synoptic indicator of diversity at all levels of the biotic hierarchy. If delta diversity were to reflect unique descriptions of diversity on smaller levels, it could claim to represent an objectively measurable and computable synoptic concept of system diversity, and delta diversity might provide an objective policy beacon.

But hierarchies defining ecological systems are not objective in this way (Allen and Starr 1982). The hierarchical organization is created by the choices of biologists and ecologists who embody scalar and perspectival decisions in the models they produce for understanding systems. Even among ecologists there are significant choices as to the scale and level at which any system is described. Since nature can be modelled on many different levels, there is therefore a real question as to which model to choose and what perspective to take when one 'measures' diversity.

There are actually two powerful arguments to support the conclusion that there exists no single, correct descriptive model for any natural system. First, there is a philosophical, or 'epistemological', argument (Quine 1960; Kuhn 1962; Allen and Starr 1982, p. 6). According to this very abstract argument, any amount of data gathered to describe a system will, in and of itself, underdetermine the choice of theoretical principles that describe and explain that system. Scientific perception is therefore theory-bound to some degree. Two different, but equally 'objective', scientists can observe the same natural system and, depending on the language they choose, the assumptions they make, and the goals that motivate them, provide nonequivalent descriptions of the systems they both observe. In particular, scientific describers can interpret the world as composed of many, quite different hierarchies, with alternative and conflicting boundaries.

While this argument is admittedly abstract it has surprisingly direct applications to the measurement of diversity; it implies that diversity measures are constructs by human individuals who undertake their studies for many different motives. Each motive gives rise to at least one 'useful' scale for interpreting and predicting the events around us. But differing motives, and attention to events occurring on multiple levels exist on many scales, some of which are not commensurate with others. The argument also implies that the choices that descriptive scientists make in deciding to characterize observed events—the models they construct and the descriptive concepts they employ—cannot, in principle, be executed independently from theory construction or of motivational pressures. It follows that the choices we make in describing natural events cannot be understood independently from our theories, our attitudes, and our goals.

There is also another argument for the same view of descriptive scientific concepts. This is based on physical theory rather than on logic and philosophical reasoning. Contemporary physicists, in the aftermath of the stunning discoveries of relativity theory and quantum mechanics earlier this century, have been forced to accept the irreducible complexity of natural systems. This acceptance is marked by the introduction of physical constants, such as Planck's constant, into physical descriptions and calculations. But these constants are indicative of a fundamental truth about physical systems: these systems are irreducibly complex (Prigogene and Stengers 1984; Gleick 1987). The proposal to use delta, or landscape diversity, as a synoptic definition of diversity implicitly assumes that landscape diversity does reflect a unique product of the appropriate diversity measures that are applicable on each level. But the irreducible complexity of natural ecosystems undermines any attempt to aggregate multiple levels of diversity into a single measure that is both synoptic and objectively descriptive of the system.

Consider an example that illustrates this point. Suppose we assumed that there exists a synoptic measure of biodiversity over a large geographic area, and that we can use the total number of species that exist in that large area as a rough guide to its 'diversity'. Looked at naively it would be possible to reason as follows: since the area contains *n* species now, we would increase its diversity by adding *m* additional species from other ecosystems. For example, we would have reasoned, in the 1920s, that adding Melaleuca (*Melaleuca quinquinervia*) and Brazilian Pepper (*Schinus terebrinthinus*) to Florida's landscape would increase species diversity there. In fact this effect was only achieved in the very short run because these exotic species quickly got out of control and destroyed previously existing habitats. These introductions initiated, on a longer scale of time and on a different geographic scale, a reduction in the number of types of habitats and microhabitats in south-west Florida. Addition of exotics to the system can therefore have a negative impact on diversity in the long run. Simple examples such as this, and other, more complex ones, show that we cannot simply assume that a synoptic concept of diversity (such as the total number of species in the landscape) is a useful guide to policy. Any synoptic concept of diversity must be applied with a careful understanding of the irreducible complexity of ecological systems and the importance of not just total numbers of species, but also of the complex ways that species interact.

We must be very cautious of any definition that is put forward as a purely descriptive measure of biodiversity. It is not quite correct to say that, in post-modern, post-positivistic science there are no correct descriptions of actual events. It is more accurate to say that there are *too many* correct descriptions of reality. The different scales and categories that we use to describe nature in all of its multi-levelled complexity cannot all be 'reduced' to a common vernacular, nor can they be plotted in an ideal space inhabited by irreducible atoms. It follows that, even though scientists can provide 'descriptive' accounts of natural systems, these descriptive accounts gain a special nonreducible content by virtue of the conceptual and value assumptions incorporated in them. They are in this sense both true—they are consistent within a given frame of reference—and at the same time relative—they cannot be verified in frames of reference that do not embody the essential assumptions of their own frame.

If our choice of concepts and models to describe a natural object or process depends essentially on the purposes we have in describing that object or process then certain consequences follow. One is that the concepts embodied in the analysis of population biology are not necessarily the most useful concepts to use in characterizing the goals of conservation. They may be, but we need an open and probing discussion of this question before we assume any descriptive model of the diversity we are trying to protect. Indeed, since biologists and ecologists study natural systems on many different levels, we can expect that they will develop many different concepts of diversity that will be applicable at very different scales in the natural world. The task, in designing a rational policy is to choose from among these many scientific concepts a particular concept of diversity that provides the most useful understanding of policy, *from a conservationists' perspective.*

The search for a unique scientific measure of diversity to guide policy is based, ultimately, on the principle that fact is separable from value, that nature can be fully described prior to being evaluated. If this were true, we could use pure science to guide biodiversity policy. Instead, I believe that the definition of biodiversity used by policy makers is *both* scientific and normatively political in a very specific sense. Science defines a whole spectrum of possible meanings of 'diversity'. Choosing a scientifically acceptable public policy concept that we wish to foster is a decision that can only be determined politically.

To summarize, it appears that scientists can offer a very large number of possible 'diversity measures', but that these measures cannot be aggregated into a unique measure of *the* diversity of the system. In the next section, we will see how hierarchy theory can, despite this perplexing theoretical impossibility, provide guidance in choosing a useful definition for guiding biodiversity policy from among the many possible 'scientific' definitions of diversity.

Hierarchy and biological diversity

My theoretical considerations have so far not contributed to the practical question what should be the main targets of conservation efforts? I have only, so far, argued that no fully satisfactory answer is forthcoming from 'objective' science. United States policy has emphasized species protection, under the influence of the Endangered Species Act of 1973. However, this approach is extremely expensive because it institutes protection only after a species is at the brink of extinction. It is also entirely inappropriate in tropical ecosystems suffering deforestation, where many species are lost before they are even identified.

In this volume, the related but more sophisticated idea that conservation efforts should concentrate on 'biodiversity hotspots' is advocated (see Heywood this volume). This policy approach is no doubt justified, at least as a stopgap measure, while we try to stop the haemorrhage of species lost as a result of runaway deforestation in the tropics. Speaking theoretically, however, it should be noted that the hotspots approach remains very species-oriented—it still sees diversity mainly in terms of elements, as an inventory of items, and see Lawton *et al.* this volume for difficulties with the 'hotspots' approach.

Many ecologists and especially, ecological economists, are exploring a more radical alternative to single-species management, one that attempts to minimize human alteration of natural cycles, and shifts attention from the elements of a system to the structures and processes that perpetuate that system. This approach, the 'ecosystem health' approach as it is sometimes called (Costanza *et al.* 1992), advocates a post-positivist science of conservation in which it is readily admitted that environmental management, and also scientific fields such as conservation biology, are explicitly value-laden scientific disciplines. In this respect, they resemble human medicine and veterinarian medicine more than they resemble the 'ideal' of scientific objectivity as it was understood in Newtonian physics.

Conservation biology, like medicine, studies and acts in the service of an ideal; if health is to be pursued as a matter of public policy then this ideal must be articulated in the crucible of public policy formation. While science is extremely important in defining what is meant by health, whether of humans or of ecosystems, our ideal of health goes far beyond 'pure' science to encompass, among other values, our aspirations for our children and our culture. The models chosen and the goals defined, which are inevitably expressions of cultural values and concerns, are also an essential element in the process of policy formation. The question is: how can we identify which cultural values and which natural dynamics should receive priority?

A hierarchical approach to the relationship between cultural values and biodiversity has been proposed (Norton and Ulanowicz 1992). The hierarchical approach is built firmly on three assumptions: (1) natural systems are dynamic and constantly changing on many levels and on many irreducibly complex scales simultaneously; (2) biotic diversity is maintained and enhanced when species, reacting to varied local conditions, adapt creatively to different dangers and opportunities in many varied and constantly evolving communities; variations in gene pools accompanying these adaptations are the markers representing diversity; and (3) we can only understand the complex dynamic of nature if we interpret it as a hierarchy of systems in which smaller subsystems tend to change more rapidly than do the larger systems. On each level one can identify systems that are *both* 'holons' (independently functioning wholes) and 'partons' (individual elements that play a functional role on a larger scale on which they exist as parts) (Koestler 1967). Thus, on the hierarchical approach, nature is seen as a complex of systems in which smaller, nested subsystems change and adapt against a backdrop of 'stability'. Even though every level of the system is dynamic, development of genetic and cultural adaptations is possible because the slow-changing environment provides relative stability over many generations of individuals.

At first glance, this approach may seem to plunge us into subjectivism, because the systems approach apparently leaves us with so many unguided choices regarding which scale of natural systems to focus our attention upon. It is important, however, to distinguish between 'subjectivism' (the view that the multiple descriptions of nature by scientists are all equally valid) and 'relativism' (the view that scientific descriptions are 'relative' to a particular frame of reference). Once it is recognized that a strict separation of description from evaluation is impossible we move past the myth of a value-neutral science and can propose models of nature that are designed to describe natural systems in ways that are appropriate, *given certain purposes*. If purposes are accepted, such as the need to understand and protect biodiversity, then we have a basis on which to develop models that are descriptive of nature.

The distinctive theoretical assumption of hierarchy theory is (3), that smaller sub-systems change more rapidly than do the larger systems they compose. Reasoning, then, from the endorsement of biodiversity protection for many human generations—setting a temporal policy horizon of at least 150–200 years—we can begin to zero in on the ecological scale on which to model the systems that create and sustain biodiversity, and to concentrate on the scales at which to seek the most important conservation targets. We can also begin to eliminate certain candidates as the most central targets of protection. Individuals and also populations of many species will be ephemeral over the period of concern even in systems undisturbed by human activities. Indeed, since species themselves may become extinct for reasons unrelated to human activities, the hierarchical approach directs us to emphasize not species but those particular processes that support energy flows. As long as we maintain 'healthy', self-organizing systems—ones that maintain their varied layers of structure through complex adaptive processes—individuals will be reproduced and populations that lose habitats will invade and colonize new areas as they become appropriate for them in the dynamic of ecosystem development and succession. Species will therefore be maintained by healthy processes, provided we model nature at the larger scale on which the concept of health is applied to a landscape-sized ecological system. A patchy landscape with multiple levels of constancies and change is most likely to protect the most biological diversity possible over many generations of individuals, and as populations wax and wane. The problem is to specify the crucial processes and scales on which to characterize, model, and evaluate landscape-level changes.

Emphasis on processes that maintain patchiness must therefore be supplemented with a coherent, scientifically adequate, publicly understandable conception of scale to guide the choice of patterns of patchiness. It seems certain that any landscape capable of maintaining complex and healthy systems must include undisturbed areas, buffer areas (including migration corridors), and areas of heavier use. But since predation and grazing are important ecosystem functions, it follows that there must be sufficient undisturbed areas in the landscape matrix to maintain viable populations of the largest, free-ranging predators and grazers remaining in the system (Harris 1984). It is possible then, using hierarchy theory in tandem with our assumption that biodiversity protection has at least a 150–200 year horizon, to begin to set ecologically informed boundaries as the basis for an appropriate model for formulating biodiversity policy.

Drawing on our hierarchical assumptions we now have a basis for characterizing crucial scales, as understood from a conservation viewpoint: the concrete goals of management will be dictated by the need to protect processes that support culturally important and politically defined values. In the next section, we will explore the local scale at which values in nature must originate.

How do cultural values shape conservation goals?

The idea I develop here is at least implicit in the ideas and work of Aldo Leopold, the US forester, amateur philosopher, and theoretician of environmental management (Norton 1991). Leopold (1949) realized that we naturally focus on dynamics that are relevant on the human, perceptual scale—this is the scale on which humans act economically, seeking food and shelter. But humans are also part of a human and a natural *community*, a community that has value on an intergenerational scale. Some of these values are expressed on the day-to-day scale of economics; others are expressed in the intergenerational scale in which our culture is passed from generation to generation and in which our species is perpetuated. The need to integrate these various levels is, in my view, the central idea of Leopold (1949) who recognized that, in addition to perceiving and valuing the world in economic time, we must also think in the multi-generational ('ecological') time of mountains and wetlands.

Learning a new way to perceive can only be accomplished in democratic countries through dialogue between scientists, politicians, and the public. But what, exactly, can we expect from this. We have seen above that there is no *objective* scale provided by science. The policy dialogue must therefore originate from many local viewpoints, and flow upward through the hierarchy, integrating individual, economic, and environmental concerns on all levels. Creativity in natural hierarchies occurs when an organism or population responds in a new way to the natural dynamic they live within. New adaptations are given meaning and significance by virtue of their response to constraints implicit in larger, slower-moving systems. It is this dynamic that creates environmental values (Page 1992). As Leopold realized, objectivity cannot be judged in the short run. Drawing upon the American pragmatists' idea that truth is that which survives many observations, experiments, and applications, Leopold argued that a culture has found the 'truth' only if it has developed a set of cultural ideas and ideals that result in behaviours that can be sustained for many generations (Leopold 1923; Norton 1988). If there is rapid alteration of the larger context in which those behaviours evolved and gained meaning, today's genetic and cultural adaptations become irrelevant more quickly than new ones can evolve. Leopold illustrated this point by noting that, in the American south-west, the Pre-Columbian Pueblo cultures survived and reproduced themselves for many generations in the fragile arid ecosystems of the area; but the arrival of European settlers and their grazing culture led to drastic declines in the quality of the environment in just one or two generations, because agricultural methods adapted to Europe were applied in an arid ecosystem. Leopold saw survival in conjunction with a slowly evolving environment as the 'objective' test of whether a culture has found 'the truth'. Note that, on this approach to objectivity, the truth lies in adaptation to *local* conditions.

This insight is expressed on the hierarchical approach by saying that values toward nature are shaped at the local level. Systems that model nature for the purpose of protecting it therefore must be based on an articulation of local values as expressed within descriptive/managerial models for describing nature. See Fig. 3.1 for a flow diagram for policy formation that takes into account the interaction of values and science in formulation of an environmental problem. Note that the formulation of the problem implicitly requires the identification of the correct scale on which to formulate goals and measure progress toward them.

It is now possible to reformulate the question of identifying conservation targets. On the hierarchical approach it is reasonable to equate the problem of conservation targets with scalar problems in conservation ecology. Conservation ecology differs from 'pure' biological sciences (if there are such), in unabashedly choosing a perceptual, observational perspective, and a framework and a scale on which to understand natural systems so as to help us to protect their essential features. We have just seen that science can provide us with many different, equally measurable criteria of diversity—it is the task of policy makers, with the guidance and cooperation of scientists, to choose among the possible models for describing a natural system. It has been argued (Norton and Ulanowicz 1992) that the proper scale at which to model biodiversity decisions can be set rather precisely, provided one can decide on a goal for management that embraces a time scale. Determination of an important social value allows us to articulate goals because the social value allows us to choose a relevant *perspective* and *associated* scale for modelling a system that produces the desired goals (e.g. maintenance of biological diversity). But the recognition of the multi-generational scale of biodiversity policy guides us away from a static, elements-oriented plan to protect diversity. Instead, it pushes us toward a more dynamic, process-oriented view, and it also directs our attention toward processes that are expressed at the landscape level.

Consider an example of a difficult policy problem now facing environmental managers in south-west Florida. The Everglades ecosystem has been in serious deterioration for decades because of reductions in the flow of water due to draining and removals of water for agricultural and residential purposes. Recently, there has emerged a political commitment to restore the

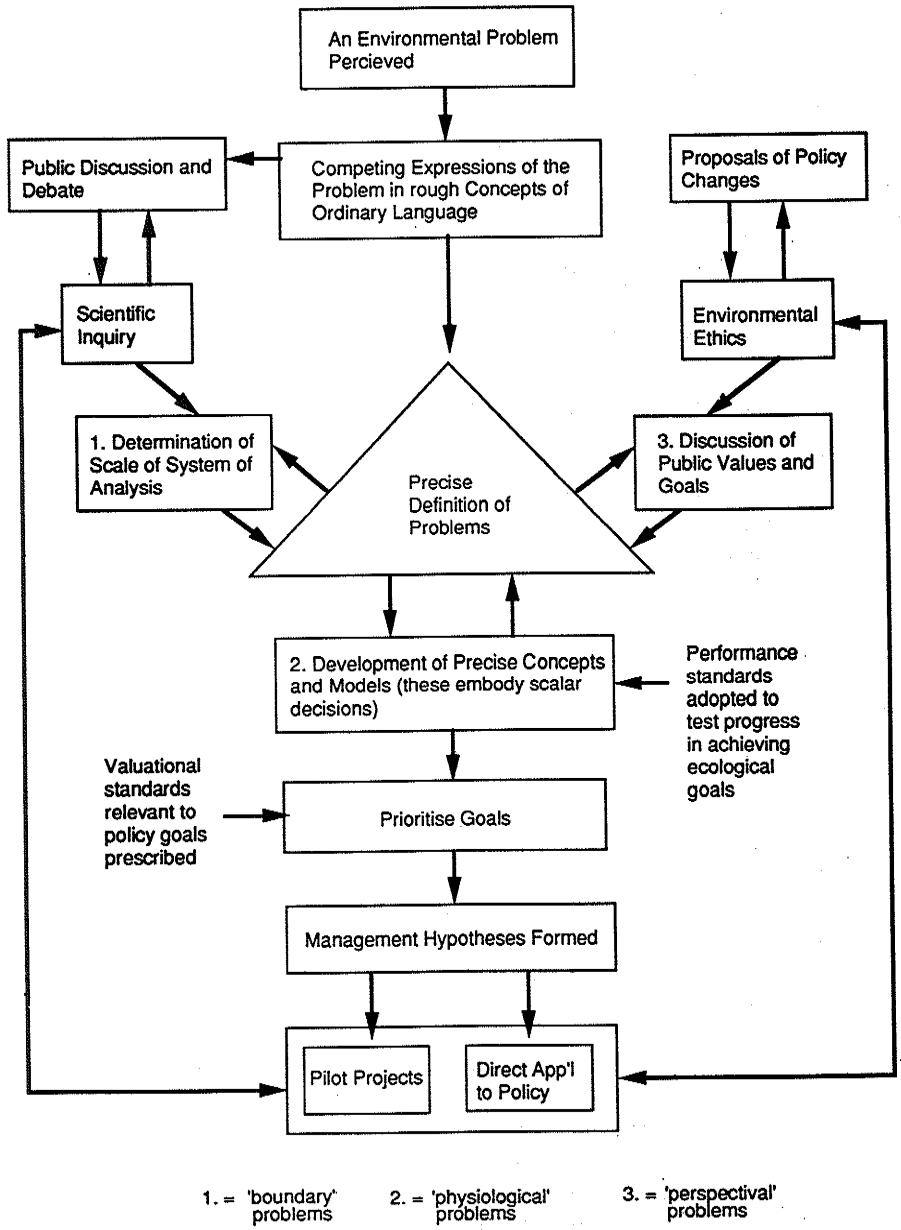

Fig. 3.1 Public policy formation does not begin with clearly worked out 'problems'. Definition of a problem requires development of a model for understanding changes in natural systems. This flow diagram shows how values, science, and public policy discussion all contribute to the development of a model, and an associated perspective and scale for modelling a system that requires management. From Norton and Ulanowicz (1992).

Everglades ecosystem by increasing water flow through it, but the restoration is now being held up because of a conflict between ecosystem restoration and responsibilities implied by the Endangered Species Act (Alper 1992). Increasing water flow would, in addition to re-establishing the temporary marshes that flood in the wet season and dry out gradually through the year, flood the hunting grounds of the Everglades snail kite (an endangered species), which feeds on one species of snail that is exposed and easily available when water is low. The conflict is clearly stated by David J. Wesley, Florida supervisor for the US Fish and Wildlife Service:

> In the Everglades we have over a dozen endangered or threatened species, each with varying needs that aren't necessarily compatible, within a changing ecosystem. As an ecologist, I would argue that the best solution is to restore the Everglades as a functioning ecosystem, and in the long-run, that will benefit all the wildlife there. But as an official of the agency that oversees the Endangered Species Act, I have to consider the effects these changes will have on those species that are endangered at this moment (Alper 1992).

The shift to the more dynamic, long-term view of Wesley-the-ecologist does not, of course, mean that species are unimportant. Species are essential elements in ongoing processes; and for a long time to come, rough species counts over specified areas including the trends in their numbers, will remain our best general indicator of ecosystem health. But species counts will not be valued so much for their own sakes as for their ability to indicate that the system remains in sufficient health to support and sustain the ecosystem structures (such as forest cover and patchy dynamics at many levels) necessary to support healthy processes. This change in emphasis will affect policy by making explicit the extent to which our understanding of social values, such as the goal of sustainability, shape the models we construct for understanding and modelling nature. The social goals we emphasize serve to focus our attention, and our descriptive prowess, on certain levels and scales of complex natural systems that form our environment. The idea of landscape, or delta diversity (see MacNaughton, this volume), may now be able to be revived as an important indicator of system health through time. But δ-diversity should not be considered a measure of elements that occur at many levels; δ-diversity must be related more directly to the dynamic models we choose to track, understand and manage, and to achieve our goal of protecting biodiversity for many generations into the future.

Why cultures and habitats must be saved together

I believe that the theoretical structure and set of assumptions outlined above provides a basis to address our second question: is it possible to save the biological resources in an area without saving, also, the local indigenous cultures that have developed there? Hierarchy theory helps us to explain the importance of local valuations. Another way to understand the importance of culture in biodiversity protection is to examine a well-documented case history of how cultural changes alter landscapes in dynamic ways.

Perhaps the most intellectually influential book published on environmentalism and environmental studies in the last decade is William Cronon's (1983) *Changes in the Land*. Cronon challenges on historical grounds the 'wilderness' ideal which has guided so much of our thinking (especially in the US, but elsewhere as well) about how nature preserves should be managed (see also Callicott 1991). This ideal assumes that natural systems are most healthy, and most diverse, in the absence of human disturbance. He challenges this idea, which apparently assumes the already-discredited idea that each landscape will tend toward a single 'climax' ecosystem type, by showing that, for one landscape, the New England area of the North American continent, the existence of a 'wilderness' at the time of the arrival of European settlers, is based entirely on myth.

Cronon (1983) shows that the New England landscape had been intentionally managed by New England Indian tribes for millennia prior to the arrival of Europeans, and that it is meaningless to imply any ideal of a 'pristine' wilderness as the ideal state that we should try to perpetuate or recreate in natural preserves. He argues that:

> The replacement of Indians by predominantly European populations in New England was as much an ecological as a cultural revolution, and the human side of that revolution cannot be fully understood until it is embedded in the ecological one (Cronon 1983, p. 6).

Admitting the difficulties involved in reconstructing that ecology, Cronon painstakingly uses multiple methods to arrive at a general account of changes taking place between 1650 and 1800. To summarize, he found that the Indians had maintained a diverse landscape, employing such tools as fire and cultivation. This diversity was made possible by the Indian's lifestyle, which was to collect few possessions and to migrate seasonally from one productive resource-producing subsystem to another. The possession of loose, but recognized rights to use areas such as shellfish beds or reed ponds, rather than fixed ownership of surveyed plots, allowed many family bands to use shared resources. European settlers, who brought with them a much more rigid concept of private ownership of land, and different concepts and institutions of property ownership characteristic of developed capitalist economies, disrupted these patterns and, simultaneously, reduced much of the diversity of the landscape as private owners 'improved' their land, by clearing it, draining it if necessary, tilling it, and eventually fencing it. Since settlers considered only these intrusive improvements true 'use' of the land, they justified forcing the Indians off more and more of their lands which had been dedicated to diverse uses such as hunting, reed-gathering, and so forth.

Since improvement was often the only recognized requirement for establishing ownership of 'open' land, the Indian lifestyle became increasingly untenable as more and more areas were 'improved' and fenced. The result was a shift from a relatively diverse, managed landscape to an increasingly monotonic and homogenized one, with attendant losses in landscape diversity:

> The colonial interaction of forests, furbearers, hunters, axes, grazing animals, plows, crops, [—introduced old-world] weeds—and the rival way of owning and selling these things—all contributed to a redrawn map of New England. It was a map that, over the course of European settlement, more and more traced, not the earlier world of movement between hunt and harvest, but the new world of cropland and pasture, of agricultural cycles entrapped within the fixed boundaries of individual possession. In the hands of the colonists, New England had become a world of fields and fences (Cronon 1983, p. 156).

Cronon's elegant ecological history is premised on the central, hierarchical assumption of ecological economics, that economies are faster-changing systems that can be more or less well 'adapted' to their spatially larger, ecological context. Besides forcing us to re-think the nature of 'pristine' reserves as a management ideal in most situations, Cronon's work points toward two further important consequences for biodiversity policy. First, he supports the importance of *dynamic* models which trace processes. Second, he shows how social values and institutions shape, and are shaped by, the interaction of human populations with their *local* environments; as well as how external demands, such as the need to produce goods tradable in world markets to obtain money to buy the various necessities Indians could gather from their more diverse environment. Since Indians managed and shared a richer landscape, they had no need to accumulate, and no need to exchange money for necessities. But the clearing and destruction of those local habitats to satisfy international demand for a few cash crops set up a positive feedback system ensuring deforestation in a short period. The point is not that we should try to return to a presettlement landscape, which would now be impossible, but that we should analyse large historical changes in the landscape on these local scales if we wish to understand how human populations affect biodiversity. Using sensitive interpretation of the interplay of culture and landscape may provide the best guidance in future development activities both in undisturbed areas of developed countries and also in less developed countries.

Conclusion

Ecological economics is a 'bridge' discipline—it examines the link between ecology, economics, and culture, a link that is forged in the crucible of public policy formation. This new discipline, which seeks to create an integrated conceptual framework, represents an essential forum in which to discuss crucial issues in biodiversity protection, including the location of conservation targets (Costanza 1991).

Ecological economics understands environmental management as taking place on multiple scales and in pursuit of many different values. The problem is to integrate these values and to reduce conflicts among them. For example, we value economic development to increase the standard of living of current human populations, especially for the poor. But we also hope to pass on to the future a healthy and well-functioning planet. If it is assumed that every type of development is equally destructive of natural systems, then development for human welfare necessarily entails destruction of natural systems. If, however, it is hypothesized that there are multiple scales on which management takes place—economic events occur at a more rapid-fire pace than do ecological changes—and that we must articulate goals on multiple levels, it becomes possible to seek integration among levels, by seeking policies that have positive impacts on all the multiple levels that are identified by scientists and the public as socially and culturally important.

The goals of ecological economics, in other words, is not simply to maximize productivity, but to find approaches to development that are consistent with protecting natural systems on the intergenerational, social scale on which we hope to sustain our culture *and* the natural context that gives it meaning over many generations. It is that dialectical dynamic between culture and nature which drives landscape development and attendant diversity on the intergenerational scale relevant to sustainability goals; this is the scale on which human populations depend upon, and either support or destroy the diversity essential to a rich interplay of human and natural forces.

References

Allen, T. F. H. and Starr, T. B. (1982). *Hierarchy: perspectives for ecological complexity.* University of Chicago Press.

Alper, J. (1992). Everglades rebound from Andrew. *Science*, **257**, 1852–4.

Callicott, J. B. (1991). The wilderness idea revisited: the sustainable development alternative. *Environmental Professional*, **13**, 235–47.

Costanza, R. (1991). *Ecological economics: the science and management of sustainability.* Columbia University Press, New York.

Costanza, R., Norton, B. G., and Haskell, B. D. (ed.) (1992). *Ecosystem health: new goals for environmental management.* Island Press, Washington, DC.

Cronon, W. (1983). *Changes in the land.* Hill and Wang, New York.

Faber, M., Manstetten, R., and Proops, J. (1992). Toward an open future: ignorance, novelty, and evolution. In *Ecosystem health: new goals for environmental management* (ed. R. Costanza, B. G. Norton, and B. D. Haskell), pp. 72–96. Island Press, Washington, DC.

Gleick, J. (1987). *Chaos: making a new science.* Penguin Books, New York.

Harris, L. (1984). *The fragmented forest.* University of Chicago Press.

Kahn, H. (1982). *The coming boom: economic, political, and social.* Simon and Schuster, New York.

Koestler, A. (1967). *The ghost in the machine.* Macmillan, New York.

Kuhn, T. (1962). *The structure of scientific revolutions.* The University of Chicago Press.

Leopold, A. S. (1923). Some fundamentals of conservation in the Southwest. In *The river of the mother of God and other essays by Aldo Leopold* (ed. S. L. Flader and J. B. Callicott), pp. 86–97, (reprinted 1991). The University of Wisconsin Press, Madison.

Leopold, A. S. (1949). *A Sand County almanac.* Oxford University Press.

Norton, B. G. (1988). The constancy of Leopold's land ethic. *Conservation Biology*, **2**, 93–102.

Norton, B. G. (1991). *Towards unity among environmentalists.* Oxford University Press, New York.

Norton, B. G. and Ulanowicz, R. E. (1992). Scale and biodiversity policy: a hierarchial approach. *Ambio*, **21**, 244–9.

Page, T. (1992). Environmental existentialism. In *Ecosystem health: new goals for environmental management* (ed. R. Costanza, B. G. Norton, and B. D. Haskell), pp. 97–123. Island Press, Washington, DC.

Prigogene, I. and Stengers, I. (1984). *Order out of chaos: Man's new dialogue with nature.* Bantam Books, Toronto.

Quine, W. V. O. (1960). *Word and object.* MIT University Press, Cambridge, MA.

Simon, J. L. and Kahn, H., (ed.) (1984). *The resourceful Earth: a response to global 2000.* Blackwell, Oxford.

Whittaker, R. H. (1960). Vegetation of the Siskiyou mountains, Oregon and California. *Ecological Monographs*, **30**.