Biodiversity as the Source of Biological Resources: A New Look at Biodiversity Values

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ABSTRACT: The value of biodiversity is usually confused with the value of biological resources, both actual and potential. A sharp distinction between biological resources and biodiversity offers a clearer insight into the value of biodiversity itself and therefore the need to preserve it. Biodiversity can be defined abstractly as the differences among biological entities. Using this definition, biodiversity can be seen more appropriately as: (a) a necessary precondition for the long term maintenance of biological resources, and therefore, (b) an essential environmental condition. Three values of biodiversity are identified and arranged in a hierarchy: (1) the self-augmenting phenomenon of biodiversity maintains (2) the conditions necessary for the adaptive evolution of species and higher taxa, which in turn is necessary for providing humans with (3) a range of biological resources in the long term. Two broad policy implications emerge: increments of biodiversity should not be traded off against biological resources as if they were the same, and the conservation of biodiversity should be a constraint on the public interest, not a goal in service of the public interest.

KEYWORDS: Biodiversity, biological diversity, biological resources, conservation policy, future generations, public interest, sustainability, tyranny of the majority.

INTRODUCTION

There are many descriptions of biodiversity values in the literature. One more description, therefore, may appear redundant, requiring justification. My justification is simple: whereas previous authors have correctly claimed that biological *resources*, both actual and potential, are valuable, this claim tends to obscure the specific values of biological *diversity* itself. A sharper distinction needs to be drawn between the two sets of values. In this article I will claim that biological diversity is a concept on a higher logical plane than biological resources. In turn, this claim leads to a different conception of biodiversity's value: biodiversity is the *source* of biological resources and therein lies its value to humans.[1]

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As such, biodiversity is a *necessary precondition* for the long term maintenance of biological resources. This conception of biodiversity and its instrumental value holds several implications for land-use decisions and land-management decisions. In particular, biological resources cannot be traded-off against increments of biodiversity as if the latter were substitutable items on the same logical plane as resources. Thus, cost-benefit analysis and similar evaluation techniques are useless for the purpose of determining whether or not to preserve another increment of biodiversity. In order to secure a supply of biological *resources* in the long term, the conservation of biological *diversity* can be seen as a constraint on the legitimate extent and degree of any one generation's use of relatively natural areas. The need for legal reform in constitutional democracies is strongly implied.[2]

Of course, in order to distinguish between the two sets of values, one first needs to clarify the distinction between biodiversity and biological resources. This is my first task. The second is to summarise the major values of biological resources for the purpose of setting them apart from the values of biodiversity. The third is to explicate exactly why biodiversity itself is so important. Finally, I highlight the significance of this conception of biodiversity values within a political decision-making context.

WHAT IS BIODIVERSITY?

Swanson et al. (1992: 407) assert that 'defining exactly what is meant by biodiversity [is] a notoriously intractable question'. Magurran (1988: 1) suggests that 'diversity has a knack of eluding definition'. Salwasser (1988: 87) states flatly that it 'defies definition'. Yet these authors and many others have provided general definitions. One of the best is this:

> Biological diversity encompasses all species of plants, animals, and microorganisms and the ecosystems and ecological processes of which they are parts. It is an umbrella term for the degree of nature's variety, including both the number and frequency of ecosystems, species or genes in a given assemblage. It is usually considered at three different levels: genetic diversity, species diversity, and ecosystem diversity. (McNeely et al. 1990: 17)

This is a carefully worded description. It does not claim that biodiversity consists of genes, species, and ecosystems, or ecological processes, but instead it encompasses them. McNeely et al. (1990: 18) later claim that these entities and processes are the 'physical manifestations' of biodiversity. What, then, is biodiversity itself, if these entities are only the manifestations of it? A clue is the word 'variety'. It is true that 'variety' is a rough synonym for 'diversity' (McMinn 1991: 1), but this does not take us very far. Similarly, 'number' and 'frequency' are important attributes of diversity, but they are not coextensive with the concept.

The main difficulty in defining biodiversity, I suggest, is its multidimensional character, along with the fact that the dimensions are not commensurable; they cannot be reduced to a single, and therefore commensurable, statistic. (If they were commensurable, the several dimensions could be collapsed into one.) The multidimensional character of diversity has long been recognised. Peet (1974: 285) described it as a 'number of concepts...lumped under the title of diversity' (see also: Hurlbert 1971; Patil and Taillie 1982a).[3]

Nevertheless, 'By tradition, diversity has been primarily viewed in ecology as a two-dimensional concept with components of richness and evenness' (Patil and Taillie 1982b: 566). Several reviews of the topic agree that the two basic concepts of biological variety are (a) richness, and (b) evenness, equitability, frequency, or some other measure of relative abundance (cf. Krebs 1985: 514; Magurran 1988: 7; Putnam and Wratton 1984: 320; Westman 1985: 444). Richness refers to the number of entities (of a kind) in a standard sample, and usually refers to richness of species in particular.[4] Evenness refers to the extent to which entities are found in equal relative abundances and, once again, usually refers to species. Some authors emphasise richness as the basic component of diversity while others emphasise evenness or some other notion of frequency.

Yet there are other dimensions of biodiversity. Franklin et al. (1981) and Franklin (1988), for example, suggest that biodiversity's three main characteristics are composition, structure, and function. Noss (1990) arranges these same three characteristics in a nested hierarchy. Many authors suggest that biodiversity also consists of ecological processes. Vane-Wright et al. (1991) and Williams et al. (1991) focus on cladistic hierarchies based on phylogenetic lineage. All these dimensions of biodiversity are important. They take on special significance in operational issues. But none is entirely coextensive with the concept of biodiversity.

I suggest there is a unifying conceptual theme that brings together the several dimensions of diversity. At the risk of stating the obvious, diversity has meaning only in association with some sort of entities. Entities are required before they can be described as being diverse. But it is somewhat less obvious that the entities under observation must also be different from one another before they can be described as diverse. Without the notion of a difference, the concept of diversity cannot gain a purchase, so to speak. At the core of the concept of diversity, therefore, the twin notions of entities and differences appear to be the essential components.[5]

Applying the twin notions of entities and differences to biological phenomena leads to a dichotomy concerning possible definitions of biodiversity. Does biodiversity refer to:

a) biological *entities* that are different from one another, or

b) *differences* among biological entities?

At first glance, this distinction may appear to be a moot point. But it makes an important difference to the conceptualisation of biodiversity. In (a) entities are emphasised, whereas in (b) emphasis is given to an environmental condition or state of affairs relative to biological entities. The two are corollaries of each other; they are the flip sides of the same coin. Nonetheless, I will argue that the latter conception is more consistent internally, and more consistent externally, with the various uses to which the term is applied. Consequently, for the specific purpose of evaluating biodiversity, I propose the following general definition of biodiversity:

Biodiversity = differences among biological entities.[6]

Biodiversity, therefore, is not a property of any one biological entity. Rather, it is an emergent property of collections of entities. More precisely, it is the differences among them.

This definition may appear to be true in a trivial sense only. It certainly will not help in any field measurements of biodiversity. Yet this abstract definition permits a sharp cleavage between biodiversity *per se* and biological resources, and this sharp distinction is needed to separate the values of biodiversity from the values of biological resources.

THE VALUES OF BIODIVERSITY

McPherson (1985: 157) points out that ‘there is little agreement on how to value biological diversity, who should value it, and what dimensions of it should be valued’. People have differing and often competing interests, he argues, and therefore ‘no single group, whether ecologists, biologists, economists, or anthropologists, has proposed a set of reasons which are sufficiently compelling and appealing to generate the necessary support to ensure that all of the biological diversity they value will be maintained’. He concludes by noting that ‘a general approach to valuing biological diversity has eluded scholars and policymakers alike’.

Nevertheless, numerous authors have attempted to describe the values of biodiversity.[7] Typically a list of several values is proposed, and each value is described. However, these lists of values are problematic for a number of reasons. The single largest problem is their lack of a clear distinction between the values of biological resources and the values of biological *diversity* itself.[8] Of course, this distinction can only be made if biodiversity is clearly distinguished from biological resources.

Most of the putative values of biodiversity, such as economic, recreational, aesthetic, and cultural values, can be attributed more meaningfully to biological resources. From this perspective, it comes as no surprise that people have differing and competing interests in these resources. As Ehrenfeld (1981: 177-207) points out, many arguments for the conservation of biodiversity (Ehrenfeld actually focuses on species) rely on attempts to assign some sort of resource value to apparently non-economic aspects of biodiversity. This strategy carries inherent weaknesses, as Ehrenfeld explains: these 'resource' values may not be able to compete with the values of development projects which deplete biodiversity; resource values might change and become more competitive, but would come too late due to the irreversibility of species losses (or other increments of biodiversity) or the irreversibility of many development projects; and the assignment of resource values permits ranking, thereby creating the possibility that one natural area might be pitted against another in decisions to conserve only the most valuable.

The following suggestions for clarifying the values of biodiversity therefore are predicated on the distinction between biodiversity *per se* and biological resources. I begin with a summary of the major values that have been attributed to biological entities as resources or potential resources, and then later I attempt to describe the values of biodiversity.

From a strictly anthropocentric (human-centered) perspective nature (apart from humans) is simply a source of valuable goods and services – i.e. resources. These goods and services span the entire range of human interests in nature from vital sources of food, shelter, and clothing to aesthetic and cultural values. Nature from this perspective is *instrumentally* valuable for human purposes. In summary, and for convenience, these values can be grouped into three broad categories:

(a) Some biological entities are valuable as resources. Wild biological resources are both directly and indirectly valuable for people. Directly, many wild plants, animals, and micro-organisms are used by people for food, shelter, fuelwood, clothing, medicines, and so on, and as the raw materials for manufactured products. They are consumed directly or exchanged in markets. Wild organisms and ecosystems are valued for recreational and aesthetic purposes, and for their cultural values. They can also serve as environmental indicators, either as 'early warning systems' for adverse environmental change (Newman and Schereiber 1984), or as indicators of ecosystem stress (Ehrenfeld 1976: 650).

Wild plants and animals also are indirectly valuable. They provide 'environmental services' such as water cleansing, watershed protection, regulation of hydrological cycles, the absorption of atmospheric carbon dioxide, the release of oxygen, the regulation of local climates (and perhaps even the world's climate – Lovelock 1979), the recycling of nutrients needed for plants, the production of soil, the prevention of soil erosion, the absorption and conversion of human-produced pollutants, and biological pest control.

(b) Some biological entities are valuable as potential resources. Wild plants, animals, and micro-organisms present opportunities for the discovery of new and valuable resources, including new materials such as organic chemicals (Altschul 1973), useful knowledge (Orians and Kunin 1985: 116-122), or genetic resources (Oldfield 1984). For example, the trend in industrialised agriculture is toward genetic uniformity in commercial crops with an accompanying increase in vulnerability to insect and disease pests and to adverse climatic conditions (Oldfield 1984). Wild relatives of commercial crops are a source of fresh genetic material from which resistant and hardy varieties can be produced. In fact, 'nearly all modern crop varieties and some highly productive livestock strains contain genetic material recently incorporated from related wild or weedy species, or from more primitive genetic stocks still used and maintained by traditional agricultural peoples' (Oldfield 1984: 3). Wild genetic resources are now indispensable to modern agriculture (R. and C. Prescott-Allen 1986). Wild gene pools, therefore, are potential resources.

(c) Some biological entities have contributory value. Wild plants, animals, and micro-organisms also may have contributory value, in the sense that they contribute to the functioning of healthy ecosystems which in turn produce organisms and services that are more directly valued (Norton 1987: 60-63). The contributory value of 'non-resource' species cannot be overestimated. Of the world's 5 to 30 million species, relatively few are known to science and even fewer have been screened in modern times for useful resource materials. However, as contributors to the maintenance of resource goods and services, it is reasonable to presume that all species have contributory value.

Similarly, in order to maintain those *in situ* species and gene pools that are potential resources, their specific habitats, both biotic and abiotic, must be maintained. Consequently, those sympatric species (and their gene pools) that contribute to the maintenance of these habitats are valuable because they maintain potential biological resources; they are (once again) important for their contributory value.[9]

The above three categories are intended, in summary form, to describe the human-centered, instrumental values of biological entities. They do not describe the values of biodiversity *per se*. Yet the thread of an argument for the value of biodiversity can now be discerned: biodiversity can be seen as necessary for the maintenance of biological resources, thereby lending value to biodiversity by extension. Biological diversity, in other words, may be instrumentally valuable for obtaining something else – biological good and services – that are more directly valued. Clearly, this is the beginning of a rationale for attributing value to some forms of biodiversity. But there are more detailed reasons for valuing biodiversity itself. I suggest these reasons can be placed into three groups, arranged in a hierarchy.

- At the primary level, biodiversity is valuable because it provides a range of resources, both actual and potential.
- At the secondary level, biodiversity is valuable for maintaining these actual and potential resources, and it does this by providing the preconditions for adaptive evolution. Thus biological entities are able to adapt to changing environmental conditions over time if the preconditions of biodiversity are provided.
- At the tertiary level, biodiversity is valuable as a precondition for the maintenance of biodiversity itself in a self-augmenting (i.e. positive) feedback mechanism. Conversely, a self-diminishing feedback mechanism may be activated if ecosystems are sufficiently disturbed.

Each of these three levels is discussed in more detail below.

1. Primary level of biodiversity: a range of actual and potential resources

As indicated above, biological resources are numerous and varied and therefore provide a *range* of resources. There are a number of reasons for attributing value to a range of resources, which I will discuss. But what needs to be emphasised here is, once again, the distinction between biological resources and biodiversity itself. I have pointed out the major ways in which biological entities are valuable as resources. But whereas biological entities and the differences among them exist in a necessarily reciprocal arrangement, biodiversity can be defined as 'differences among biological entities'. Consequently, a *range* of biological resources is a manifestation of the *differences* among biological entities, and this, of course, is biodiversity itself. To the extent that a range of biological resources is valuable, then that value is directly attributable to biodiversity.

Why is a range of resources valuable? I assume it is self-evident that, in general, a greater abundance and variety of resources is more valuable than fewer or less varied resources because the former allows more scope for serving purposes that people want. This is true for actual (i.e. currently used) resources.

A more interesting issue is the value of a range of *potential* resources. Many arguments supporting the conservation of biodiversity are based on the value of potential resources. There are two basic arguments here. The first is obvious: 'increments in diversity increase the likelihood of benefits to man' (Norton 1986: 117). The emphasis here is on the discovery of *new* resources. The possibility of discovering new medicines, new foodstuffs, new industrial raw materials, and many other types of commodities, is often cited as one of the strongest arguments in favour of preserving species and their genetic diversity (cf. Myers 1983). However, when species are viewed simply as potential commodities, then they must compete with other economic demands. There are costs associated with preserving potential resources, and the economic benefits of biodiversity-depleting development projects may outweigh these costs. Norton (1987: 124-127) refers to the potential commodity value of species as ‘Aunt Tillie’s Drawer argument’, referring by analogy to the compulsive collector who saves pieces of junk ‘in case I might need them someday’. Nevertheless, this value of biodiversity – the chance of discovering new resources – should not be underestimated.

The second value of a range of potential resources is less obvious: a range of potential biological resources is also required in order to maintain the current range of resources. Current biological resources, such as domesticated crops, are vulnerable to insect and disease pests and to adverse climatic conditions, as mentioned above. They are vulnerable primarily because they lack genetic diversity, and for the same reason, they rarely develop resistance or hardiness by natural selection (Oldfield 1984: 8). Consequently, an abundant supply of wild genetic resources is required in order to prevent the depletion of current resources. The greater the genetic diversity within these wild populations, the more likely it is that suitable genetic material will be found.

It should be noted that, for a number of technical reasons,biotechnology cannot reliably substitute for natural genetic variety (see generally: Baumann et al. 1996). In turn, the wild relatives of domestic crops are dependent on the communities and ecosystems of which they are a part. By extension, therefore, the diversity of species that are sympatric with the wild relatives of domestic crops are instrumentally valuable, as is the diversity of habitats required to support them.

2. Secondary level of biodiversity value: necessary preconditions for adaptive evolution in response to change.

Frankel and Soulé (1981: 79) point out that there are two principal axioms in evolutionary theory: (a) genetic variation is required for a population to adapt to changes in its environment, and (b) natural selection of organisms is the means by which such adaptation occurs. While Sober (1984: 23) and others emphasise that evolution occurs by ‘the natural selection of organisms’, as compared to the selection of species or other collective entities, the overall effect is to allow these taxa to evolve in response to change.

As discussed, domestic biological resources tend to be vulnerable to new pests or adverse conditions due to their lack of genetic diversity and a concomitant inability to adapt by natural selection. Conversely, wild relatives of domestic crops are usually better able to survive changing conditions precisely because of the diversity of individuals within these wild populations, which is largely a manifestation of their underlying genetic diversity. The genetic diversity of these wild relatives of domestic crops is therefore an essential *precondition* that enables them to adapt.

Perhaps the one constant in nature is that it continues to change, over many spatial and temporal scales, and not necessarily in predictable patterns (see generally: Botkin 1990). Some of these changes are human-induced. Examples include the current threats of ozone depletion and global warming. To the extent that current biological resources are dependent on wild resources (actual and potential), and these wild resources in turn are dependent on their *in situ* communities and habitats, then humans are dependent on the ability of these entities to adapt to inevitable environmental change. *Humans are vitally reliant, therefore, on nature's ability to adapt.* But since diversity itself (particularly genetic diversity) is a necessary precondition for adaptive evolution, this places humans in a state of obligant dependency on biodiversity.

3. Tertiary level of biodiversity value: necessary preconditions for the self-augmenting maintenance of biodiversity itself.

It has been suggested that diversity begets diversity by way of positive feedback mechanisms. With a focus on species, for example, Whittaker (1970: 103) argues that 'Species diversity is a self-augmenting evolutionary phenomenon; evolution of diversity makes possible further evolution of diversity'. The opposite might also be true: 'Diminutions in diversity affect the spiral in reverse. Losses in diversity beget further losses and the upward diversity spiral will be slowed and eventually reversed if natural and/or human-caused disturbances are severe and continued' (Norton 1986: 117).

Whittaker's hypothesis is controversial,[10] but three plausible explanations are worthy of note. The first suggests that disturbances, dispersal, and competition together serve as a diversity generator. Within ecological time frames, disturbances followed by successional stages create patchy landscapes, with measurable between-habitat diversity. But in turn, the colonisation and serial development of disturbed areas is dependent on a pool of nearby species that are able to disperse to, and compete within, the disturbed area throughout its successional stages.

> Thus the total diversity of an area provides the pool of competitors for niches in developing ecosystems. The larger the pool, the more likely it is that the system will evolve into a complex, highly interrelated system. A complex, highly interrelated system provides more niche opportunities for new species. (Norton 1986: 115)[11]

Conversely, if an area is sufficiently disturbed, or if the landscape is fragmented (see generally: Harris 1984; MacArthur and Wilson 1967; Wilcove et al. 1986), then for any one ecosystem or habitat fragment, access to a larger species pool is at least partially cut off and a self-diminishing diversity spiral begins. Thus Wilcox (1984: 642) writes: 'The reduction in habitat size which accompanies insularization will result in...the tendency for a process (extinction of a species) normally occurring on a geological time scale to condense to an ecological time scale.'

A second explanation suggests that diversity is self-augmenting by way of lengthening and tighter packing of niche axes with subsequent specialisation and speciation – all operating in 'evolutionary time':

> Consider...the niche space for a group of organisms in a community. Along each axis of that space the number of species tends to increase in evolutionary time as additional species enter the community, fit themselves in between other species along the axis, and increase the packing of species along axes. Species can also be added as specialists on marginal resources, and they can be added by the evolution of new resource gradients and species adapted to utilizing them... Considered for a given group of organisms, diversity increases through evolutionary time by the 'lengthening' of niche axes, and by the addition of new axes – by the 'expansion' and complication of the niche space. (Whittaker 1970: 103)

A third explanation, drawing heavily on chaos theory and the science of complexity, is perhaps the most intriguing. Kauffman (1995), for example, maintains that Darwinian natural selection is insufficient to explain the diversity found in biological entities. Self-organisation, he argues, has played a far greater role in diversity generation that previously thought possible. At 'supracritical' levels of diversity, 'diversity feeds on itself, driving itself forward' (Kauffman 1995: 114).

Regardless of the exlanations posited in the literature, the geological record provides strong evidence for the phenomenon of increasing diversity over time (Sepkoski 1984).

I have suggested that these three levels of biodiversity value can be arranged in a hierarchy. A hierarchical arrangement implies some sort of connection between the levels within the hierarchy. What sort of connection is implied here? Since the subject matter is about *values*, one perspective is to see the hierarchy as a series of instrumental values which culminates in the attainment of the highest level values, as is typical of value hierarchies. From this perspective,

(a) the self-augmenting phenomenon of biodiversity, or the prevention of a self-diminishing spiral (i.e. the tertiary level of biodiversity value), is instrumentally valuable for maintaining the preconditions for adaptive evolution;

(b) the preconditions of adaptive evolution (i.e. the secondary level of biodiversity value) are instrumentally valuable for maintaining the range of potential biological resources; and

(c) the range of potential biological resources (i.e. the primary level of biodiversity value) is instrumentally valuable both for maintaining the current biological goods and services upon which humanity is dependent, and for increasing the current range of biological resources.

This can be expressed symbolically as:

$$3^{\circ} \text{ value} \Rightarrow 2^{\circ} \text{ value} \Rightarrow 1^{\circ} \text{ value} \Rightarrow \text{current and new biological resources}$$

In short, biodiversity is a necessary precondition for biological resources; this is its value.[12]

This conception of the values of biodiversity carries a distinct advantage over the various lists of values that have been compiled in the literature. Most of these lists refer to economic, ecological, recreational, aesthetic, cultural and other categories of value. As I mentioned previously, the drawback with such lists is that they more accurately refer to biological resources, not biodiversity *per se*. I maintain that biodiversity can be distinguished from biological resources. Regardless of the differences among peoples' preferences, all people have at least some sort of interest in biological resources. After all, everyone's life is dependent on them. Consequently, when biodiversity is viewed as a necessary precondition for the continuing flow of biological resources, then it can be stated reasonably that it is generally in humanity's interests to maintain biodiversity.[13]

This conception of biodiversity transcends the problems that are inherent in the allocation of scarce resources among competing interests. To some extent, therefore, the conservation of biodiversity can be seen as a means for maintaining values that are universal and largely independent of the competition over scarce biological resources and land. Biodiversity is literally the *sine qua non* of renewable resource management.

IMPLICATIONS FOR LEGAL REFORM

If, as I have argued, biodiversity is a necessary precondition for the long term maintenance of biological resources, then two broad implications can be discerned. First, it behoves those of us in the present generation to preserve biodiversity. At the societal level, this is largely a prudential issue; we are likely to be better off in the long term by conserving biodiversity. Second, future generations are likely to be vitally dependent on the extent to which we in the present generation conserve biodiversity. This is an ethical issue. Identifying our obligations to future generations and clarifying cogent sustainability policies are closely parallel ideas. It is in this latter context that a new perspective on biodiversity values is needed.

Those land-use and land-management decisions that affect biodiversity are usually perceived in terms of trade-offs. The overall issue is seen as economic: scarce resources are to be distributed among persons in society, and human wants for resources are assumed to be unquenchable. From this perspective, conserving biodiversity usually means forgoing some opportunities for resource extraction. Or, to characterise the more frequent pattern, extracting resources often entails a loss of biodiversity. Either way, environmental decision-making is viewed as a problem of making appropriate trade-offs: a little less of this for a little more of that. Valuing biodiversity in terms of biological resources feeds this decision-making paradigm. By narrowly focusing on increments of biodiversity (i.e. a species here, an ecosystem there) and treating them *as if* they were biological resources alone, then it is possible to make trade-offs between biodiversity conservation and those resource extraction activities that deplete biodiversity.

Yet if biodiversity is more appropriately seen as a necessary precondition for the long term maintenance of biological resources, an entirely different decision-making paradigm emerges. Biodiversity can then be perceived as an essential environmental condition. Consider other essential environmental conditions: the rate of solar influx, the earth's orbit around the sun, and gravitational pull. We take them for granted and we need not concern ourselves with their conservation. Biodiversity is different precisely because humans now have the ability to change this environmental condition.

An essential environmental condition is not something to be traded-off against more attractive, short-term opportunities. If an environmental condition really is essential, then it needs to be maintained. Land-use and land-management decisions should be made with this constraint in mind. Put simply, this means that each generation needs to live within its ecological limits. Each generation should be free to make whatever environmental trade-offs are appropriate for promoting the public interest, provided that biodiversity is not depleted.[14] Or to express this as an ethical principle: *the conservation of biodiversity should take priority over any one generation's collective interests*.

Implementing this priority-of-biodiversity principle in law is more difficult.[15] The purpose of western governments is to promote the public interest, and the public interest is usually interpreted as the collective interests of extant individuals within the relevant government's jurisdiction. But the priority-of-biodiversity principle suggests a constraint on the public interest and therefore implies a limit on governmental authority.

In constitutional democracies, limits on state authority are recognised in one area only: constitutionally entrenched civil rights and freedoms. These rights and freedoms are the individual's safeguard against a 'tyranny of the majority'. Borovoy expresses the system this way:

> Majority rule is democracy's safeguard against minority dictatorship. And the fundamental rights such as freedom of speech, freedom of assembly, and due process of law are democracy's safeguard against majority rule itself from becoming a dictatorship. (Borovoy 1988: 200)

There is a connection between this self-limiting feature of constitutional democracies and the conservation of biodiversity. Valuing biodiversity as a necessary precondition for the long term maintenance of biological resources allows us to see biodiversity not as one more value to be traded-off against competing values, but rather as an essential environmental condition. Fulfilling our obligations to future generations therefore implies that no one government should permit itself to be persuaded by contemporary collective desires for resource extraction to the extent that biodiversity would be depleted. But since the *purpose* of any one government is precisely to promote these contemporary collective desires, the conservation of biodiversity needs to be placed beyond the immediate reach of governmental discretion. The legal mechanism in constitutional democracies is to limit state authority itself by constitutional decree. Constitutions prescribe the legitimate jurisdiction of state authority. Government actions in violation of constitutional limits are *ultra vires* – literally 'beyond jurisdiction'.

In effect, there is a strong parallel between the individual in contemporary societies and future generations: both need to be protected against a 'tyranny of the majority'.[16] Limits to state authority are required in both cases. In the specific case of biodiversity conservation, constitutional limits to state authority are needed in order to prevent the present generation from exerting the equivalent of a 'tyranny of the majority' over future generations by way of pre-emptive environmental decisions.

NOTES

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[1] This article focuses exclusively on anthropocentric (i.e. human-centered) values. Yet nothing in this article is intended to undermine either the validity or importance of possible intrinsic values in nature. The entire subdiscipline of environmental ethics is seeking both to articulate and justify these values, and the journal *Environmental Ethics* is a primary vehicle for expressing current thought in this arena. Nonetheless, as a *political* premise, the assertion of intrinsic values in nature is problematic. Scherer (1990: 4) expresses the problem this way: '[E]nvironmental ethicists have at most produced a *theory of value*. They have not produced a *theory of action* inferable from the former....Important as it has been, their work has also shown its own shortcoming, for they have made painfully clear the difficulty of *inferring from the value of [nature]* to *how humans ought to act*.'
[2] Obviously, biodiversity needs to be conserved worldwide, regardless of the type of governance in any one country. This article, however, discusses only those legal reforms that are required in western constitutional democracies.
[3] Patil and Taillie (1982a) refer to diversity as a 'multidimensional' concept, by which I assume they mean a *polytypic* or *cluster* concept.

[4] A distinction is sometimes drawn between species richness which refers to the number of species in a given number of individuals or unit of biomass, and species density, which refers to the number of species per unit of area (Hurlbert 1971: 581). For the purposes of this discussion, either interpretation is applicable.
[5] While structure, function, and processes are important attributes of biodiversity, they are not essential for the definition of biodiversity. Given the specific composition of, say, an ecosystem, then structure, functions, and any attending processes cannot help but co-exist. In technical terms, structure, functions, and processes are *supervenient* on composition. Also, many biological entities are more abstract than simple physical entities. Examples are: species, other taxa, and gradients of change within ecosystems. Most of these are also polytypic concepts (see note 3).
[6] Williams et al. (1991) suggest a similar definition, but more narrowly confined to differences among species.
[7] Cf. Ehrenfeld 1976, 1981, 1988; Ehrlich and Ehrlich 1981; Fitter 1986; Hanemann 1988; Hoffman 1991; Livingston 1981; Lovejoy 1986; McMinn 1991; McNeely 1988; McNeely et al. 1990; McPherson 1985; Myers 1979, 1983; Norse 1990; Norton 1985, 1986, 1987; Office of Technology Assessment 1988; Oldfield 1984; Orians and Kunin 1985; R. and C. Prescott-Allen 1982, 1986; Primack 1993; Randall 1985, 1988, 1991; Rolston 1985, 1988, 1989; Soulé 1985; and WRI/IUCN/UNEP 1991.
[8] Another major problem, which cannot be discussed in detail here, is that a simple list of values presupposes that one value can be traded off against another in order to obtain the highest aggregate of value from nature in general or from any one area of land in particular. In short, a utilitarian decision-making philosophy is implied. Yet, if the conclusions of this article are correct, then biodiversity conservation must be preserved as an overarching principle for all land and resource use. A *lexicographic* ordering is implied for environmental decision-making.
[9] These three categories are not mutually exclusive. It is possible for one species to be a resource, a potential resource, and have contributory value – all at the same time. Take the dominant tree species in a temperate coniferous forest for example. It could be a valuable timber resource (or aesthetic resource); it might also yield new products and therefore is a potential resource; and finally, its dominant presence contributes to the well-being of other species, some of which may, in turn, be resources or potential resources.
[10] See Rosenzweig (1995) for review.
[11] See generally Ricklefs and Schluter (1993) for more discussion.
[12] A parallel argument can be made, and has been made, between the concept of *wildness* and resources. Birch (1990: 9) argues that 'although it [wildness] is at the heart of finding utility values in the first place, wildness itself cannot plausibly be assigned any utility value because it spawns much, very much, that is just plain disutility. It is for this reason that it is so puzzling, to the point of unintelligibility, to try to construe wildness (or wilderness) as a resource...To take the manifestation of wildness for the thing itself is to commit a category mistake.' Rolston (1983: 181-207) presents a similar argument, and states that 'wildness itself is of *intrinsic* value as the generating source [of resources]'. Oelschlaeger (1991: 1) discusses 'wild nature as the *source* of human existence'. See also Snyder (1990).
[13] By emphasising biodiversity as a necessary precondition for the maintenance of biological resources, I am not suggesting that it is a sufficient condition. A number of social and political conditions, for example, may also be necessary (see especially Kaplan 1994). *Caring for the Earth: a strategy for sustainable living* (IUCN/UNEP/WWF 1991:

9) lists nine principles for sustainable resource use. Several of these could be restated as necessary conditions.

[14] At a more practical level, not every gene, every individual organism, nor even every ecosystem can be preserved – nor would it be desirable to do so if possible. For management purposes, a unit of conservation must be identified. Here I am assuming that the biological species concept is an appropriate unit of conservation, meaning that every species should be conserved. This is a contentious point, but see Wilson (1992: 37-38) for comment on this issue. I should also hasten to add that I have a *wide* conception of species in mind: conserving a species entails the conservation of many other aspects of biodiversity, including, for example, a sufficient of genetic amplitude, a sufficient number of locally-adapted populations over each species' natural range, along with suitable biotic and abiotic habitat conditions. For obvious reasons, this cannot be fully articulated here.

[15] See note number 2.

[16] While the term 'tyranny of the majority' is usually interpreted literally in the sense of a majority outnumbering a minority, the term can also apply to a minority exercising unjust power over the interests of *disadvantaged* groups, even if the latter constitute a majority. South Africa's apartheid regime is an example in the recent past. The issue at stake here is the exercise of power, not numbers of people *per se*. For the topic at hand, it is likely that the number of people in the near future will outnumber extant individuals, despite the current rate of biodiversity loss. So in this case I am referring to the ability of the present generation to exercise power over future generations by way of unjustly usurping the ability of the environment to support them, and this is one form of tyranny of the majority.

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