

I Biodiversity and the Environmentalist Agenda

I.1 INTRODUCTION

Edward (E.O.) Wilson, Harvard Emeritus Professor of Entomology and great popularizer of the term ‘biodiversity,’ eloquently said (2006, p. 91):

The human hammer having fallen, the sixth mass extinction has begun. This spasm of permanent loss is expected, if it is not abated, to reach the end-of-Mesozoic level by the end of the century. We will then enter what poets and scientists alike may choose to call the Eremozoic Era – The Age of Loneliness.

Supposing that Wilson is correct, why should we care? In this book we will examine a number of commonly given reasons for why biodiversity ought to be conserved. These reasons can be divided into two types: instrumental and intrinsic value reasons. Before we can begin our examination, we need to do a bit of ‘housekeeping.’ In Section 1.2 we will take on the important, but difficult, task of discussing what biodiversity might be, and how we plan to treat the term in this book. It may come as a surprise to many, but biodiversity is not one thing, and it certainly is not well defined. In Section 1.3, we will set the scene by considering why some people think we are running out of biodiversity. Are we, as Wilson suggests, in the midst of the 6th mass extinction? What sorts of evidence is presented in support of this claim? Our next task, in Section 1.4, will be to attempt to define, for lack of a better term, ‘the environmentalist agenda.’ Environmentalism comprises a large and varied set of personal and collective values and policies, about which there may be much disagreement. We lay out what we think many environmentalists want when it comes to conserving biodiversity. The agenda will be important as we will assess the implications of the

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reasons given for conserving biodiversity against the agenda itself, to see how far any particular defense gets the environmentalist in achieving her goals. Finally, in the latter half of this chapter (Sections 1.5–1.6), we introduce the notion of ‘intrinsic value’ and we provide a taxonomy of positions in environmental ethics.

I.2 WHAT DO WE MEAN BY ‘BIODIVERSITY’?

‘Biodiversity’ is one of those words that have taken on meaning beyond that envisaged by the people who originally coined the term. ‘Ecology’ and ‘ecosystem’ are two other notable examples. The common perception is that the term ‘biodiversity’ owes its origin to E.O. Wilson (1988), although the progenitor ‘biological diversity’ had been around for some years before the contraction. At the time, ‘biodiversity’ referred vaguely, and simply, to *the diversity of life*, whatever that means. Within professional ecological and conservation biology circles, ‘biodiversity’ often refers to total diversity at three levels of ecological organization: genes, species, and ecosystems. Indeed, this is the definition adopted by the United Nation’s Convention on Biological Diversity (CBD), signed as part of the Rio Summit in 1992:

“Biological diversity” means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

This definition has the advantage of being inclusive of all manner of life forms, regardless of the level or scale at which they might be identified. Future scientific developments might one day identify new forms of biodiversity – for example, at micro-organismal or intra-genomic scales. The CBD definition provides a sufficiently broad umbrella to capture such new forms of biodiversity, in addition to the more familiar ones. However, such generality comes at the price of conceptual precision. Arguably, an adequate definition of biodiversity ought to facilitate the comparison and ranking of regions. Indeed, policy makers and

conservation managers often face difficult decisions about how to strategically invest limited conservation resources. The CBD definition, for all its flexibility, offers little guidance on this front. The problem becomes acute when diversity at one level or scale trades off against diversity at some other level. It is easy to imagine cases where an investment that maximizes within-species genetic diversity, say, requires sacrifices in the number of species or distinct habitats that are simultaneously conserved. For any environmental organization whose mandate is simply to maximize biodiversity, the CBD definition potentially generates conflicting courses of action.

A related concern arises even when the focus is restricted to a specific level of the biological hierarchy. For example, conservation biologists often focus on *species richness* as a useful measure of biodiversity (i.e. the number of distinct species in a given region). But difficult trade-offs can arise even here. Consider two habitats that are equal in species richness. Perhaps one is a marine habitat containing 20 species of pacific rockfish (*Sebastes*). The other is also a marine habitat with only 5 rockfish species, but 5 species of sculpin and 10 species of invertebrates. Does one region contain more biodiversity? Intuitively, the answer seems obvious. The second habitat, containing both invertebrate and vertebrate species, is the more diverse region. The implication of this argument is that species richness alone cannot serve as a definition of biodiversity – even though it is often used as a convenient proxy for measuring it. Notice that this same thought experiment can be run with any number of different properties besides phylogenetic distance:¹ morphological diversity, diversity in ecological roles, diversity of ecosystem functions, metabolic diversity, or diversity in developmental mechanisms, to name but a few. One can imagine holding all other factors constant while varying just one of these properties and the result will be a corresponding change in the amount of biodiversity that one intuitively identifies among two otherwise identical regions. We recognize that, in practice, two regions are unlikely to vary along just

¹ See e.g. Vellend et al. (2011): 194–207.

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one of these dimensions. However, the point of the thought experiment is to show that any number of biologically salient properties might be taken to contribute to differences in total biodiversity among regions. The CBD definition offers no instruction whatsoever on how to rank the importance of these potentially contributing factors.

Such concerns have motivated various attempts to sharpen the definition of biodiversity. One general strategy for redefining biodiversity is the reductionist approach. Reductionists propose to define biodiversity in terms of one core property or a limited set of properties whose relationships are clearly defined. For example, philosophers James Maclaurin and Kim Sterelny (2008) review a wide range of scientific contexts in which biodiversity plays some important role. These include a number of different projects in evolutionary biology, ecology, and conservation biology. Maclaurin and Sterelny argue that, in most of these cases, species richness is an adequate definition of biodiversity. Occasionally, this definition needs to be qualified by some secondary factor, such as the phylogenetic distance among species or the diversity of ecological roles that they occupy. But, generally speaking, species richness is the core property that most scientists are tracking when they investigate the biological significance of biodiversity, or so it is argued.

A second general strategy for defining biodiversity is the pluralist approach. According to this view, no core property or limited set of properties is picked out by the various uses of this term. Instead, there are many distinct properties or property clusters being identified on different occasions. A reasonable objective for pluralism is to disambiguate 'biodiversity' into several sub-concepts. For example, one sense of biodiversity might apply to comparisons of aquatic systems. A different biodiversity concept might apply to micro-organisms, and so on. Part of the challenge for pluralism, however, lies in selecting the appropriate goals for this categorization schema. For example, the philosopher and conservation biologist Sahotra Sarkar, and conservation biologist Chris Margules, maintain that the biodiversity concept is inherently bound up with the practices of conservation biologists. According to Sarkar and Margules (2002), the precise goals of conservation biology tend to

vary from one conservation project to the next: one day it might be preventing the intrusion of an invasive species, the next day the goal might be preventing the extinction of a precious subspecies, and on yet another occasion the goal might be to conserve a diversity of habitats. This openness of conservation objectives makes it impossible, Sarkar and Margules argue, to identify a limited set of biodiversity definitions that are suitable to all conservation aims. This predicament leads Sarkar and Margules to conclude that 'biodiversity' should be defined operationally as whatever property a given group of conservationists happen to be interested in maximizing on a given occasion.

Taking a step back from these debates, we suspect that many lay persons and non-experts would find it surprising that there is no scientifically agreed upon definition of biodiversity. In public debates about conservation, environmentalists often appeal to the notion of biodiversity as a way of lending scientific credibility to their agenda. Regions are characterized as a conservation priority simply because they contain 'high levels of biodiversity.' Such uses of the term give the impression that one is talking about a scientifically established property whose definition and quantification is beyond reproach. In fact, this is far from true. To be clear, in saying that biodiversity admits of no clear scientific definition we are not suggesting that environmentalists' arguments are therefore lacking in substance. On any given occasion it is usually possible to identify which properties of a biological system are threatened by a particular course of action. Perhaps the important lesson is that we environmentalists need to be as clear as possible in our use of this term. Otherwise, we risk committing the 'fallacy of equivocation.'² For example, suppose that it has been demonstrated that one form of biodiversity (e.g. within-species genetic diversity) is valuable because it buffers against extinction. It would be mistaken to infer that other forms of

² This logical fallacy occurs when one employs a word that has two or more meanings, but glosses over the distinction in order to confuse the listener as to the true meaning. For example: "Doctors know a lot about medicine. We are doctors. Therefore we know a lot about medicine." This looks like a logical inference, but 'doctor' might mean a medical doctor, or a PhD (doctor of philosophy). The first sentence uses the former meaning, whereas, in our case, the second sentence means the latter.

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biodiversity (e.g. species richness or habitat heterogeneity) are likewise valuable for the same reason. The same fact might not apply to other forms of biodiversity. Species richness does not buffer against extinction in any obvious way. Nor does habitat heterogeneity have this effect, generally speaking. This is one of the problems that can arise when subtly distinct concepts are associated with the same term: one can easily slide from saying something true to something false, often without notice.

What, then, do we authors mean by 'biodiversity'? The problem with providing a clear definition that we can stick to throughout this book is that we are unlikely to find one that enjoys universal approval. An alternative approach would be to look at what legislation and actual conservation projects seek as goals, and to use those to derive a de facto definition. However, this sort of investigation would take us beyond the scope of our current discussion, the aim of which is to assess the various reasons for valuing biodiversity, however it might be defined. We have thus made an effort to be clear about how we are using this term in the chapters that follow, highlighting occasions when alternate definitions of biodiversity might make a difference to its valuation.

1.3 WHY THINK THE EARTH IS RUNNING OUT OF BIODIVERSITY?

In the 3.5 billion years since life evolved on this planet, biologists estimate that approximately 4 billion species have evolved, and about 3.96 billion have gone extinct. This amounts to approximately 99% of all species that have ever existed (Barnosky et al., 2011). This means that, to a first approximation, about one species has gone extinct every year. As long as that extinction rate is balanced by a similar speciation rate, the number of species currently extant on the planet remains constant. Of course, neither extinction rates nor speciation rates have been constant over time. There have been exactly five periods in the past where extinction rates were much higher than the 'background' rate of extinction. These higher extinction rates were sustained long enough to result in so-called mass extinctions. Such mass extinction events occurred a long time ago (see Table 1.1), the last one approximately 65 million years ago.

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Table 1.1 *Past mass extinction events*

The **Ordovician Event** ended ~443 Myr ago; within 3.3 to 1.9 Myr 57% of genera were lost, an estimated 86% of species.

The **Devonian Event** ended ~359 Myr ago; within 29 to 2 Myr 35% of genera were lost, an estimated 75% of species.

The **Permian Event** ended ~251 Myr ago; within 2.8 Myr to 160 Kyr 56% of genera were lost, an estimated 96% of species.

The **Triassic Event** ended ~200 Myr ago; within 8.3 Myr to 600 Kyr 47% of genera were lost, an estimated 80% of species.

The **Cretaceous Event** ended ~65 Myr ago; within 2.5 Myr to less than a year 40% of genera were lost, an estimated 76% of species.

Redrawn from Barnosky et al. (2011).

Myr = million years, Kyr = thousand years.

Not only were these events a long time ago, but they happened over long periods of time (with the possible exception of the Cretaceous Event). For example, the Triassic Event occurred over a period from 600,000 years to 8,300,000 years. To put that in perspective, the entire history of our species (*Homo sapiens*) is around 300,000 years. Mass extinction events are variously defined, but, roughly speaking, they are times when the Earth loses >75% of its species in a 'geologically short period of time.'

Current extinction rates are said to be 1,000 to 10,000 times higher than the background rate of extinction, leading some to declare that we are in the midst of a 'sixth mass extinction event' (e.g. Barnosky et al., 2011). This suggestion has inspired grave concern among many environmentalists. Such numbers are indeed alarming, but it is important to understand how they are derived.

1.3.1 *How Do Scientists Estimate the Background Rates of Extinction?*

This is an important question because the lower the estimate of this rate, the worse current extinction rates look. First, the background

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rates are estimated from the fossil record. This already makes such an estimate problematic since not all species fossilize. Second, the notion of a 'species' used in the fossil record is different than that commonly used in contemporary taxonomy. The fossil record uses the notion of a 'morphospecies'; if two fossils look similar, then they are described as being the same species. In modern taxonomy we have many examples of two (or more!) species looking similar but actually being classified as different. These are sometimes called 'cryptic species.' And third, the fossil record can usually only be resolved to the level of genus or sometimes family, rather than to species. To get a number of species, scientists take estimates of the number of species per genus (or family) from well-resolved groups, such as mammals and birds, and apply them to other groups, such as marine invertebrates. Finally, extinction rates estimated from the fossil record are often estimated over very different time scales (millions of years) than are contemporary extinction rates (tens to hundreds of years).

Using these admittedly somewhat problematic methods, common estimates range from 0.1 to 1 extinction per 10,000 species per 100 years. Ten thousand species times 100 years gives something called a 'million species-years.' Historically, estimates of the background rate of extinction have ranged from 0.1 E/MSY (extinctions per million species-years) to 1 E/MSY. Past estimates of background extinction rates were usually based on marine invertebrate species (Raup, 1991), which may persist longer than terrestrial species (Ceballos et al., 2015). Anthony Barnosky and colleagues (2011) used a more complete mammalian fossil record to estimate the background rate of extinction at approximately 1.8 E/MSY. Note that this estimate is between 1.8 and 18 times higher than that previously used.

1.3.2 *How Do Scientists Estimate Contemporary Extinction Rates?*

The International Union for Conservation of Nature (IUCN) is the definitive source of information for contemporary extinctions and

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extinction threats. According to the current database (see Table 1.2) approximately 20% of the species that have been evaluated are either extinct, extinct in the wild, critically endangered, or endangered (according to the IUCN definitions of these terms). Assuming that all of the endangered or worse-off species will go extinct in the near future, and assuming that this relative extinction rate carries on unabated for a few thousand years, then Barnosky et al. (2011) estimate that the global extinction rate will approximately equal the 75% definition used for a mass extinction event³.

More recently, Gerardo Ceballos and colleagues (2015) looked at just the vertebrates. They estimated that extinction rates varied from 8 to 100 times higher than a very conservative background rate of extinction of 2 E/MSY (rounded up from Barnosky et al., 2011). An estimate of 100 E/MSY, coupled with the very important assumption that speciation rates change very little (certainly a contested assumption), gives a 1% decline every 100 years. If unchanged for about 14,000 years, we would achieve the 75% species loss required for the 6th Mass Extinction event (McGill et al., 2015).

There are obviously lots of data problems and assumptions necessary to arrive at this conclusion, for estimating even contemporary extinction rates is difficult. One reason even our contemporary extinction rate estimates are crude is that we don't actually know how many species there are currently extant on the Earth. There are currently about 1.5 million species identified, and we are advancing that number by about 20,000 species a year (Costello et al., 2013). The total number of non-microbial species has been estimated to be somewhere between 2 and 100 million. More recently Mark Costello and colleagues (2013) estimate that the number of non-microbial species is between 2 and 8 million, and assess that larger previous estimates "now seem highly unlikely." One of Costello's coauthors, Robert May, has remarked on many occasions that we know more about the number of stars in the universe than we know about the number of species on the Earth. That

³ Note that there is a lot more to Barnosky et al.'s calculation than presented here, but that is roughly one way that they arrive at this conclusion.

Table 1.2 *Threats to biodiversity*

	Extinct	Extinct in the Wild	Critically Endangered	Endangered	Vulnerable
Animalia	731	32	2524	3740	5613
Annelida (segmented worms)	1		1	2	1
Arthropoda (insects, arachnids, myriapods, and crustaceans)	81	2	370	550	1,024
Chordata (mammals, fish, amphibians, reptiles and birds; salps and sea squirts; and lancelets)	337	16	1,566	2,649	3,498
Cnidaria (sea anemones, corals, jellyfish)				28	204