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Of Ethics and Ecosystems: A Bifocal Perspective on Biodiversity Conservation

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Honors Thesis

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Acknowledgments:

I would like to dedicate this work to all those who have devoted their lives and careers to the preservation of our planet's natural diversity and the struggle against those who, through ignorance or personal interest, have put this great biological wealth in jeopardy. I would also like to thank my family, friends, and loved ones for their support and counsel throughout my academic career. I give my special gratitude to William Gleason sensei, my mentor in the martial arts, for providing the spiritual and intellectual roots by which my academic studies have flourished. I am equally indebted to the faculty of the Hispanic Studies, Environmental Studies, Chemistry, and Biology departments of Connecticut College for the challenging coursework and inspiring academic passion they have offered. I owe greatest gratitude to my thesis advisor, Prof. Derek Turner, without whom this work would scarcely have been possible, and to my second reader, Prof. Robert Askins for his invaluable assistance in verifying the scientific accuracy of concepts upon which the work was based.

Introduction

Starting with the 17th-century extinction of the Dodo (R*aphus cucullatus)*, continuing to the disappearance of the passenger pigeon (*Ectopistes migratorius)* in the 1800's, Thylacene (*Thylacinus cynocephalus)* a century later and the loss of the Chinese River Dolphin (*Lipotes vexillifer)* only eight years ago, the human race has become increasingly aware of its capacity to influence the natural world and, unfortunately, its ability to irreversibly destroy other lineages with which it shares its existence on earth. The catastrophic loss of species diversity by means of anthropogenic extinction has become a subject of growing concern for human beings in the last century, and the extent of its urgency continues to be unveiled.

E.O. Wilson (2002) describes the disastrous effects of human beings on natural systems, explaining that the arrival of people has resulted in massive extinction events in every area newly-colonized by the species. It is only today that societies are beginning to understand the damage our actions have caused to the surrounding environment, and the statistics are mind-numbing.

The IUCN red list, perhaps the foremost source of information on biodiversity loss, provides frighteningly concrete evidence of this crisis. Of all known species, 21% of mammals, 12% of birds, 30% of amphibians are to some degree endangered or at risk of endangerment or extinction. Of those species evaluated by the IUCN, 28% of reptiles, 37% of freshwater fish 35% of invertebrates and 70% of plants are also at risk. A total of over 11,000 species are currently classified as at risk of extinction (IUCN Red List, 2008-10). Estimating a rate of extinction of between one- and ten-thousand species per million for the present and coming decades, Wilson clearly conveys the grim truth that “at least a fifth of the species of plants and animals [on earth] would be gone or committed to early extinction by 2030, and half by the end of the century” (Wilson, 2002, pp. 102). Many contemporary authors also claim that human beings are the cause of the 6^{th} mass extinction in known evolutionary history, equating anthropogenic effects to the asteroid impact which wiped out the dinosaurs (Leakey and Lewin, 1996; Sarkar, 2005). Indeed, as Sahotra Sarkar carefully concluded, the human race has entered a biodiversity crisis of its own making (Sarkar, 2005).

In the face of this crisis conservation biology, a “science of necessity” was formed; an odd amalgam of social movement and scientific study dedicated to the preservation of Earth’s vanishing natural heritage. Indeed, conservation biology represents the “intersection of science, applied science, and politics” (MacLaurin and Sterelny, 2004, pp. 5) in the effort to conserve biological diversity. The difficulty with the discipline of conservation biology is that it “requires an unprecedented mix of biology and ethics” (Rolston, 2003, pp. 206) which necessitates the cooperation and coordination of scientists, politicians, philosophers, and the general public alike. The many intellectual parties involved with biodiversity conservation have resulted in widely disparate and incongruous action in conservation initiatives, yielding inconsistent support to endangered biological phenomena.

Thus, in the process of clamoring to preserve the planet’s immense wealth of biodiversity, human beings have created an unstructured and largely subjective system of ethics, policy, and research by which conservation measures are developed and carried out. Conservation is managed independently by dozens of governments and thousands of organizations worldwide in equally numerous ways and by equally numerous ethical and scientific standards. Consequently, efforts to preserve biological variety are left disorganized and insufficient, and the biodiversity crisis is poorly addressed.

As James MacLaurin and Kim Sterelny put it, “From the beginning, there has been potentially troubling ambiguity in thinking about biodiversity in conservation biology” (MacLaurin and Sterelny, 2004, pp. 2). The sort of ambiguity created by initial human ignorance to the nature and value of biodiversity has left the field of conservation biology unprincipled and without a concrete framework for cooperation. Even now, many philosophical and ethical issues regarding biodiversity and its conservation have yet to be addressed. As Bryan Norton admitted, “there remain important differences regarding how much we should do, what we should do, and even what is of ultimate value” (Norton, pp. 110). Among the various issues on which conservationists differ, three questions surface which form the root of nearly every biodiversity debate: What *is* biodiversity? Why should we preserve it, and what value does it have? And lastly, but perhaps most importantly: How can we preserve it?

The main objective of this work is to address these questions and attempt to find universally applicable answers that clarify the goals of conservation biology in order to encourage consistency and unification of future conservation efforts. In the following three sections, each of these questions will be confronted with respect to a variety of stances and opinions from various authors in the fields of biology and environmental philosophy. Using this multidisciplinary approach, I will provide the precursor to a principled framework by which a global conservation ethic can be unified in both action and direction. Keeping in mind the numerous academic disciplines involved in the science of conservation biology, it follows that any attempt to answer major theoretical problems in the field must include a combination of scientific and philosophical thought. This bifocal perspective will allow the strengths of each discipline to forge a clear and structured conceptual framework lacking neither practicality nor logical or ethical soundness.

The three central questions around which this work is based will be addressed in logical order. It makes sense that, before tackling issues like the value of diversity or how to conserve it, one must have a clear concept of what is meant by diversity. Thus, the first section of this work, “What is Biodiversity?” sets out to conceptualize the somewhat abstract notion of biodiversity and form a concrete definition by which conservationists can define what exactly it is that they value and wish to preserve. A review of biodiversity definitions will accompany a growing and exhaustive list of components which make up the sort of phenomena which create biological variation, resulting ultimately in an inclusive list of biodiversity components and the manner in which they contribute to the variety and future stability of natural systems.

The second section, “Why Conserve Biodiversity?” addresses the myriad ethical issues surrounding biodiversity conservation, primarily the question of justifying biodiversity conservation. In this section I outline a set of adequacy conditions by which a conservation ethic can be assessed for its efficacy and soundness, and proceed to examine the most prominent conservation ethics practiced today. Within this examination, I describe the strengths and weaknesses of various common conservation ethics, and propose the use of a practical-pluralist ethic based on the application of these ethics in contexts where their particular strengths are best applied.

In the final section of “Of Ethics and Ecosystems”, I shall confront the rather daunting question of *how* exactly human beings should go about conserving biodiversity. Given the practical nature of this question, an exhaustive response would be unattainable for a project of this scale, so I take a more focused approach in the examination of a case study. By reviewing the successes and failures of the Republic of Costa Rica—one of the world’s “greenest” countries—I highlight a number of common conservation issues confronted within the country and the solutions with which they are addressed. Additionally, I review the implications of the previous two sections—particularly a more inclusive and multifaceted definition of biodiversity and a practical-pluralist conservation ethic—for conservation practices today and how they might be successfully implemented in future actions. The section thus culminates with a list of suggestions and ideas to improve biodiversity conservation at all levels, be they political, social, cultural, or scientific.

It is through the conclusions of these three sections that I hope to provide the basic outline for a larger conservation framework. The conclusions reached throughout this work are intended not for speculation but for practical application. Thus, it is my intention that they form the precursor to a global conservation ethic or standard which may bring greater efficacy and consistency to biodiversity conservation initiatives worldwide.

With these goals in mind, I encourage the reader to explore the observations and arguments presented in the following pages and reflect on how they might be applied to the growing number of conservation efforts throughout the world. Thus, in an effort to provide satisfactory and practical answers to some of the most challenging questions facing the field of conservation biology, I would like to start from scratch by exploring the concept of biodiversity itself.

Section I: What is Biodiversity?

I.1 The Subjectivity of Biodiversity

Among the many daunting problems facing the biodiversity conservation movement is a deceptively simple question which, if left unanswered, dooms the entire field of thought to eternal speculation. This question, of course, is the first obstacle encountered in the arduous path toward a reliable and reasonable conservation policy: put bluntly, what is biodiversity? As explained in MacLaurin and Sterelny's aptly-named *What is Biodiversity?*, biodiversity conservation is plagued by a “troubling ambiguity in thinking” (MacLaurin and Sterelny, 2008 pp. 2) which cripples the practicality of a discipline founded on urgent necessity. Vastly disparate definitions of biodiversity have been used for myriad purposes in conservation biology, ranging from the strict “species count” definition to Sahotra Sarkar's liberal “biologically interesting phenomena” (Sarkar, 2002).

Needless to say, if biologists and philosophers of biology are unable to characterize a specific target of conservation, it is unlikely that policymakers with more pragmatic demands will be capable of identifying clear goals for conservation initiatives. A simplistic definition like species count may be immensely useful from a practical point of view, but does not present a complete picture. On the other hand, an all-inclusive definition leaves no aspect of nature unprotected, but would be virtually impossible to put into practice. Before a conservation ethic or policy can be formed, it must be clear what exactly is being valued and why. This section will focus on the challenge of defining biodiversity, with the particular interest of finding a balance between practicality and reality to encompass as many valuable aspects of biological systems as possible.

The concept of biodiversity is undoubtedly an abstract one. As such, it will be somewhat difficult to define subjectively, but more importantly, nearly impossible to define objectively. While the issue of actual measurement of biodiversity (and thus the objective, scientific definition) will be confronted in part III of this text, our current goal is more theoretical. The idea is to present in clear terms the dimensions and properties of a multifaceted concept and thus outline a target for conservation efforts. This abstract notion of biodiversity, as mentioned before, is difficult to represent clearly in words. The UN conference on Environment and Development (1992) defined biodiversity as

"the variability among living organisms from all sources including... 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."

A few key issues are immediately apparent in this definition that will be central to the interests of this section. First, the word "variability", the keystone of the entire description, which implies immediately that disparity among biota is crucial to biodiversity. Needless to say, this is also implied by the "diversity" which makes up most of the concept's name. Thus, any parameters outlined to make up biodiversity are recognized for the differences between them. Plurality is evidently an important aspect of a biodiversity definition, as evident in the repeated listing of subjects above, including multiple settings in which biodiversity can be found and forms which it can take. Taking from this definition its most basic elements, one comes to the conclusion that a definition of biodiversity must recognize differences, and recognize these differences in a variety of ecological and evolutionary contexts.

What arises from this analysis is a clearer view of the problem to be addressed in this section, the “units and differences problem” (MacLaurin and Sterelny, 2008) which asks specifically *which* aspects of the natural world are important enough to be considered “Biodiversity” (with a capitol “B”) and how the differences found within those aspects can be measured. Many would agree that the pluralist approach of policymakers in the UN clause shown above is certainly a good start; in fact, according to MacLaurin and Sterelny, it is unlikely “that anyone really thinks there is a single natural property of a biological system that captures all its biologically relevant diversity” (MacLaurin and Sterelny, 2008, pp. 7). With this in mind, I begin this section by rejecting the possibility of a single metric of biodiversity. How, then, will this problem be approached?

I.2 A Piecemeal Approach

Thinking logically, when one is faced with a concept which cannot be encompassed as a whole, one must view the sum of its parts. With biodiversity, however, it would be difficult to quantify the “sum” of all factors contributing to a system's diversity. The best option, then, is to encompass as much of the concept as possible, a “next-best-thing” approach. MacLaurin and Sterelny (2008) take a similar approach by characterizing several biodiversity “surrogates” defined as “readily identifiable and measurable features of biological systems.” These surrogates serve as biodiversity indices which, given their practical accessibility, are more manageable than the intangible concept of biodiversity but still give information about its condition.

Many of these surrogates, notably species or ecosystem richness, provide at best only partial representations of the full scale of biological phenomena found in nature. As a result, in the creation of a working definition of biodiversity, it may be worthwhile to combine various surrogates and create a sort of "multifaceted" biodiversity concept. In the course of this section, I will combine the concept of surrogates with the pluralist idea of gathering many separate biodiversity metrics to form a definition of biodiversity which represents the great majority of biological phenomena.

By accumulating a sum of "parts" which in one way or another represent biological variation, one can achieve greater proximity to a hypothetically exact biodiversity concept. Because one cannot quantify the quality "B", representing all things humans find valuable and worthy of conservation in biological systems, it may be easier to approach piecemeal through the inclusion of a variety of component phenomena. A mathematical analogy serves well to describe this approach. Anyone familiar with the basics of calculus may recall the idea of Riemann sums; the premise of which is, when calculating the area under a curve (an otherwise incalculable value), a mathematician creates a number of measurable, rectangular boxes beneath the curve which touch it on one corner and thus account for *most* of the space in a specific area beneath the curve. Summing the area of several of these rectangles will give a fairly accurate estimation of the area under the curve. Increasing the number of rectangles, one increases the accuracy of the estimation. For the purposes of estimating another impossible-to-quantify concept, in this case biodiversity, it seems wise to take a similar approach, using biodiversity surrogates as our rectangles, and summing these values to obtain a reliable (though not exact) picture of our goal. Such a method, however, requires a certain attitude to avoid misuse. It must be clearly understood that the sum of our surrogate-rectangles is *not* the actual property B or the area under our biodiversity curve, but an estimation of that quantity. Thus, in the case of policymaking and measurement (section III), studies with this method as a conceptual framework must not treat it as an absolute, but as a “best-guess”.

In this way, a “workable” definition of biodiversity is acquired without denying that many more unknown factors may be involved. The value of this intermediate view is not only that it combines the advantages of two opposing approaches to biodiversity but that it uses a scientific mindset of acting on what appears to be proven without assuming the possession of an absolute truth. We have thus accomplished, at least in theory, a framework for defining biodiversity which matches our initial goals. It retains practical applicability while refraining from the assumption that all possible aspects of biological diversity are included within its parameters. Maintaining this trajectory, we may move on to the selection of factors which will sum to a representation of biodiversity.

I.3 Species Diversity

The most obvious (and according to some, most important) element of biodiversity is the concept of species richness. Usually measured as a simple “species-count” within the particular region or ecosystem in question, species richness is considered the most quantifiable and concrete component of biodiversity. This makes sense from a broad perspective; when one thinks of differences between organisms, taxonomic differences are usually the first to come to mind. It is without question, then, that great value is placed on species as an element of biodiversity. In fact, the importance of taxonomic diversity was recognized before the broader concept of biodiversity, easily apparent in the early legislation of the Endangered Species Act. The goal of the act, of course, was to preserve species diversity by protecting endangered species from extinction. If not only hundreds of conservation organizations but also the United States government are promoting the preservation of species diversity, it seems indisputable that species are an essential component of biodiversity. In fact, the first thing to come to mind at the mention of biodiversity is a species-count; many ecologists use species richness as a dependable measure of biodiversity and ecosystem health (Vane-wright et al, 1991). The apparent concreteness of species richness makes it a seductive candidate as a biodiversity surrogate, but does his quantifiability hold true under closer scrutiny? More specifically, are species a “natural kind”? Do they provide an absolute measure of one type of diversity?

MacLaurin and Sterelny's *What is Biodiversity?* provides an exceptional analysis of the concept of species in its second chapter, appropriately titled “Species: a Modest Proposal”. The chapter begins by presenting a few “chinks in the armor” in the customary biological species definition, which defines species as genetically isolated populations which are incapable of interbreeding. The authors cite a number of exceptions and potential problems for this definition, including the presence of “intermediate” populations; genetically distinct groups that can interbreed and produce viable offspring. Such organisms exhibit a form of valuable diversity in their genetics and would by one definition be called separate species, but because they can produce fertile offspring, would not warrant such distinction by the widely recognized biological species concept. How should such factors be analyzed from a conservation point of view? Which definition would—or even should—be used? This example plants seeds of skepticism in our former faith in species as viewed through a biological lens.

MacLaurin and Sterelny, however, are interested in an even broader investigation of species. After all, given the previous line of thinking, does it not follow that there are different definitions of species? The authors present a vast abundance of definitions and perspectives on species, and ask reasonably “are there reasonable prospects... of a consensus view of the nature of species?” (MacLaurin and Sterelny, 2008, pp. 29) Needless to say, if this were not the case, previous assumptions about the utility of species richness in biodiversity measurement would be questionable; biodiversity conservation would be without its most trusted surrogate. The nearly-ubiquitous utility of the species concept in the biological sciences warrants an effort to justify its application to conservation issues.

MacLaurin and Sterelny continue systematically, listing common species definitions from diverse standpoints. The list includes at least seven distinct perspectives, including typological, phenetic, biological, ecological, cohesion, evolutionary, and cladistic species. A specific flaw or gap is found in each, and a few of these will be reviewed briefly below.

Typological species, or species determined by a fixed set of characteristics, are likely the most pedestrian of species definitions. These species are identifiable by certain individual characteristics and are "locked", so to speak, within that identity by those characteristics. This conceptualization makes the assertion that individual species have an "essence" which determines what they are (and are not). Thus, according to the typological species concept, species themselves are a "natural kind" which is readily identifiable and distinguishable. According to MacLaurin and Sterelny, because typological species are bound by these strict sets of criteria, they fail to account for a fundamental tenet of modern biology: that species change over time. In other words, typological species, by definition, imply that species do not change over time (MacLaurin and Sterelny, 2008), a view which conflicts with the theory of evolution and likely the reality of most conservation situations. The reality of this criticism is obvious; in attempting to preserve a particular species, are human beings willing to prevent the creation of another by interrupting the evolutionary process?

Ecological species, defined by their niches or "roles" within a particular ecosystem, are explained to be unrealistic because a species can perform a variety of functions depending on the ecosystem in which they live. In the words of the authors, "species do not have niches. Instead, they are ensembles of populations, each with its own niche" (MacLaurin and Sterelny, 2008 pp. 38). This criticism seems valid; it is not difficult to imagine that an omnivorous rodent might function as a primary consumer in one ecosystem and an insect-predator in another. The argument against ecological species is that a species' relationship with its environment (in its geology and climate) is far too complex to be glossed over by something as simple as a unique niche for each species.

MacLaurin and Sterelny continue reviewing and rebutting various definitions of species, outlining specific (and often shared) weaknesses in these conceptualizations, before presenting an approach which they claim avoids such shortcomings. The idea is outwardly much simpler than those previously discussed, though its derivation is somewhat complicated. The classification that the authors present is the idea of “phenomenological species”, defined as “recognizable, reidentifiable clusters of organisms” or more implicitly as those “which make field guides possible” (MacLaurin and Sterelny, 2008 pp 40). From this standpoint, phenomenological species are a general and inclusive definition based more on appearances than on any form of genetic or phylogenetic isolation. The idea stems from the fact that the environmental effects on isolated populations (smaller parts of a larger “metapopulation” now isolated from the whole) can impose different selective pressures on these populations, eventually giving rise to a new species. In this way, the largely abiotic factors of the surrounding environment can release what the authors call the “evolutionary brake” on evolutionary change which metapopulation dynamics (interbreeding) impose on the genesis of genetically distinct groups. The surface-changes of populations separated in this way are simple phenotype change, and as the authors state, “Speciation is not required for phenotype change... but it is often required to make such changes permanent” (MacLaurin and Sterelny, 2008 pp. 39). The authors instead focus on the process by which populations of changing phenotypes become isolated by geologic factors and are lead to undergo speciation. Phenomenological species are thus those brought about by this general process, referred to as a “life cycle” of a species. By this definition, any subpopulation that bears certain recognizable differences and is to a significant extent reproductively isolated from nearby populations is considered a distinct species. In this way, even subpopulations which show some distinct "promise" of becoming separate species are recognized as well as well-established species.

MacLaurin and Sterelny explain that "phenomenological species richness captures a crucial dimension of biodiversity" and that "the phenomenological species richness of a region is, in an important sense, a catalogue both of phenotypic variety and of the potential evolutionary resources available in that region."(MacLaurin and Sterelny, 2008 pp. 40). The idea of phenomenological species is, not unlike my approach to biodiversity, considered a "best bet" option and not an absolute solution. For instance, it is mentioned that these species "do not represent equal amounts of evolutionary information and evolutionary potential" (MacLaurin and Sterelny, 2008 pp. 40) between different lineages. Thus, under the inclusive definition of phenomenological species, different recognized species represent different levels of genetic divergence and thus are not all created "equal". The strength of phenomenological species, by contrast, is that they embrace the process of evolution by including any independently-evolving lineage rather than only those isolated by more specific factors like genetic isolation or ecological function. This species definition also allows for greater flexibility in the classification of microbes and other asexual organisms, to which the concept of interbreeding does not readily apply. In such cases, the OTU's (Operational Taxonomic Units) used to classify many microbes based on genetic differences act identically to a phenomenological species definition, providing the same opportunity for practical application.

Is species richness, then, a shoe-in to any list of surrogates for biodiversity? Bryan Norton argues that this is not necessarily the case. Admitting that species are easy to identify and have a basis in biological facts, Norton calls the concept of species classification and conservation "atomistic" and argues that they make an inherent assumption that natural phenomena are largely static (Norton, 2003). There is validity to his point; one of the principle tenets of modern biology is the plasticity of species and their ability to form from genetic differences among individuals and individual populations. Thus, to improve the accuracy of our definition of biodiversity, potential sources of new species (fitting the working definition of *phenomenological* species) must also be considered. Returning to the analogy of Riemann sums, these potential sources act as additional “rectangles” along the curve of an abstract concept of biodiversity.

I.4 Morphological Diversity

The first of these to come to mind is what is known as disparity. Disparity is roughly defined as the morphological or phenotypic variation between individual organisms in a population or community. While species are viewed as “objective units in nature” or “the atoms of diversity” (MacLaurin and Sterelny, 2008, pp. 42) morphology makes up a larger-scale difference not completely encompassed by most definitions of species. Where species often reflect distinct and recognizable genetic variation involving isolation and separation, disparity describes variability in *expression* of a particular set of genes and smaller scales of variation among individuals of a population. In other words, it is the outward expression of genetic variability, but not requiring division into isolated populations. This sort of disparity occurs as a result of different gene expressions of individuals within a population, as well as more minute, individual- or pedigree-based genetic differences. Morphological disparity is measured thus by the number of distinct phenotypes (for example fur color, antennae length, leaf shape) in a population of the same species.

For example, a population of goldfish in a pond with both black-spotted and pure-gold fish consists of only one species. However, if certain selective pressures abounded, say, predation by a visual predator, brighter orange fish might be eaten more readily than speckled or darker fish with better camouflage. Eventually, the population would lose its brighter fish, and even inactive genes for gold or bright phenotypes carried by speckled or darker adults would eventually be selected out of the population. This would soon result in a new phenomenological species. It is not difficult to stretch this example to other organisms. Thus, disparity between individuals in a population is a valuable addition to a definition of biodiversity because it can lead to speciation. It thus acts as a "key ingredient" in the evolutionary process, the underlying process responsible for biological variation. As an additional source of speciation and thus biological variation, it forms a crucial addition to a growing definition of biodiversity.

While—unlike species richness—morphological disparity seems very hard to measure, it is still considered a relevant and valuable part of biodiversity. Reliable methodology for the measurement of morphological disparity are discussed thoroughly by MacLaurin and Sterelny but will be reviewed in part III of this work.

I.5 Developmental Diversity

Adhering to a causal investigation of sources of biological variation, it makes sense not only to investigate sources of species diversity like morphological disparity, but also the sources of those sources. Differences in organism development—among species or individuals of a single population—are the principle sources of phenotypic disparity. It follows that if certain genetic or environmental differences in an organism affect its development, phenotypic disparity of individuals will occur within populations. It thus seems conceivable, at least with respect to the pluralist and inclusive definition formation under way, that developmental differences may also be an important source of biological variation, be they caused by genetic or environmental differences. Nonetheless, a closer look at the relevance and importance of this concept is necessary to warrant its inclusion.

In Chapter 5 of their work, “What is Biodiversity?” MacLaurin and Sterelny focus on development and its contribution to the concept of biodiversity. Development is viewed as an additional factor in morphological disparity, the utility of which lies in “supplementing a phylogenetically informed species richness measure of biodiversity with a tractable and principled concept of morphological diversity” (MacLaurin and Sterelny, 2008, pp. 85). Development serves this general purpose as a way of creating a “tractable and principled” concept of disparity. “The developmental system of lineage”, say MacLaurin and Sterelny, “determines those aspects of phenotype that can vary independently...” (MacLaurin and Sterelny, 2008, pp. 85) and thus is a key factor in determining disparity or even assessing its potential to arise. As discussed earlier, developmental differences play a distinct role in determining phenotypic variation. Furthermore, organism development is often used in distinguishing the taxonomic relatedness of species. The question remains, however, how exactly this quality of variation can be observed.

MacLaurin and Sterelny introduce the concept of “evolutionary plasticity” as a tool to conceptualize developmental differences. Evolutionary plasticity is the ability of a species or lineage of organisms to have phenotypic variety; the type which may lead either to greater resilience of the population to environmental changes or eventual divergence and speciation—both properties of great relevance to biodiversity. This concept is the framework by which developmental differences are added to the growing definition of biodiversity. Plasticity is an “elemental resource”, a value of an organism or species which predicts its ability to have greater variety in its population and thus change and adapt to a changing environment. Taking a broad perspective, it is not hard to imagine that phenotypic disparity increases the ability of a population or species to change and adapt, as species richness may for an ecosystem. Likewise, developmental diversity makes morphological differences more frequent and thus promotes the same benefits of diversity up the causal chain.

In order for a population to have plasticity, at least three things are needed according to MacLaurin and Sterelny. First, variety must be added to the population through "genetic novelties" (MacLaurin and Sterelny, 2008, pp. 88). These can come in the form of a population structure which features crossbreeding, mutations, or any other source of genetic variation. Next, there must be some factor by which the variation can be accumulated. The authors explain how moderate environments with few selective pressures can "store" plasticity, "preserving genetic variation that would otherwise be eliminated from the gene pool" (MacLaurin and Sterelny, 2008, pp. 90). In this way, genes which are not expressed due to lack of necessity add to variation and plasticity by not affecting the phenotype of an individual in a negative way, while those which are expressed but are also harmless in the context of the current environment provide the same contribution to diversity. The last important point is the use of these genetic variations in the developmental processes of an organism, thereby tying variation to how the organism will grow and mature. At this point, differences in organism development are the results of genetic differences, and a new conceptual bridge can be drawn.

The key connection sprouting from developmental biology is that "lineages are evolutionarily plastic because organisms are developmentally plastic" (MacLaurin and Sterelny, 2008, pp. 91). In other words, the variation in development of organisms can lead to morphological variety and even eventually speciation. At this point, MacLaurin and Sterelny hit the core of their argument. Organisms, seen as "developmental mosaics", have parts and aspects which develop independently of one another. This, using the aforementioned point of linking evolutionary with developmental plasticity, means that individual aspects or body parts of a lineage of organisms can evolve, and hence that greater developmental variation leads to better "evolvability". In other words, phenotypic differences in organisms—likely due to developmental differences—are subject to change, thus providing a mechanism for speciation.

This concept is no doubt strikingly important for any definition of biodiversity, because it outlines clearly the role of both disparity and developmental diversity in both the changing state of species and the possibility of creating new ones. It will also later be seen that developmental biology provides the principles for selecting dimensions to examine in investigations attempting to measure disparity and thus makes the process far simpler and more effective.

I.6 Behavioral Diversity

Moving further and further from the traditional surrogate of species richness, I am motivated to stretch for sources of variation even further removed. One source rarely considered is the possibility of behavioral differences among individuals or subpopulations within a species. Not unlike other surrogates added to this patchwork definition of biodiversity, behavioral variation can influence developmental and morphological disparity between organisms, conceivably playing a role in the eventual divergence of new species. Thus, behavioral differences—specifically those which are independent of genetic factors—present a unique and powerful influence over the evolutionary process. In fact, this idea is a major point in the study of animal behavior, in which the adaptive effects of organism behaviors are studied.

Before behavioral variation can be considered as a separate and therefore necessary component to the definition of biodiversity being formed, it must be understood to be distinct from the genetic diversity accounted for by other components like species and developmental differences. Though indeed many behaviors are known to be genetically determined, those which are important for conservation are those *not* included in and dependent upon an organism's genome, but instead those which are independent and therefore perpetuated only by learning and cultural transmission, constituting a form of biological information separate from genetic diversity.

It is not unthinkable that learned behaviors or tendencies might eventually affect genetic aspects of a population including development and physiology, perhaps leading to divergence given sufficient time; as a hypothetical example, consider a species of cat which develops a penchant for following a pack of canids and scavenging the remains of their kill. The cat's body would develop differently within its lifetime, accounting for a switch from solitary hunting to scavenging for food. It might have a leaner build and lower metabolism for greater resistance to starvation, while the lifestyles of its conspecifics necessitate bursts of movement and power for attacking and killing prey. If remarkably successful, this cat might pass on these behaviors to its offspring through cultural transmission, resulting in a subpopulation with behaviors entirely different from those of the rest of the species. Developmental and physiological characteristics would arise as selected by the demands of this new lifestyle. This subpopulation, due to changes in physiology and development brought on by this new behavior or by the advent of some geographic barrier from other populations, might eventually form a new phenomenological species.

Indeed, evidence of this process has surfaced throughout the field of animal behavior. Recent research on a number of taxa illustrates the concrete link between behavior and lifestyle, tacking behavior as another way in which organisms adapt to their surroundings and thus introduce further biological variation. One recent example is a study on Japanese macaques (*Macaca fuscata*), in which frequency of thermoregulative behaviors (like huddling and sunbathing) were observed to change with seasonal temperature fluctuations (Hanya et al, 2007).

Even more convincing are the various subpopulations of killer whales whose divergent behavior has some taxonomists wondering if they should be called separate species. Various killer whale populations have been observed which display vastly disparate behaviors for feeding on equally divergent prey: great whales, seals and smaller sea mammals, and large fish (Schrope, 2007). Orcas have also been observed hunting in behaviorally complex ways, “drowning” sharks at the water's surface and washing seals from icebergs with waves generated by their flukes (Schrope, 2007). At least two distinct subpopulations, like those hypothetically discussed in the earlier example of the wild cat, have been established for Orcas, including one which feeds almost exclusively on mammals, and another which feeds almost exclusively on fish. Though it is still debated whether these populations represent isolated “sibling species” (distinct species which only appear similar) or simply subpopulations, the vast differences in their behavior provide a telling example. Interestingly enough, behavioral differences as large as the use (or non-use) of echolocation are observed between these populations. While both subpopulations have the ability to echolocate, those which hunt mammals do not echolocate or communicate verbally while hunting to avoid alerting their prey, which have the ability to hear echolocation vocalizations. Meanwhile, orcas who hunt fish which are deaf to their echolocation find and track their prey using echolocation (Barrett-Lenard et al, 1996). In this way, though physiologies are nearly the same (the mammal-eating “transient” whales have not *lost* their ability to echolocate), behaviors account for a huge difference in role and impact on the environment and thus account for substantial variation.

An even more extreme case of the biological variation arising from behavior is found in tool use. Specific subpopulations of both chimpanzees and dolphins have been observed using tools for foraging and problem solving in the wild. Chimpanzees have been observed using sticks to extract ants and termites from the mounds, while a population of bottlenose dolphins near Shark Bay, Australia are often seen using sponges to protect their rostrums from sea urchins during benthic foraging (Jackson, 1942; Smolker et al, 1997). Furthermore, this tool-use appears to be a *tradition* in these subpopulations, meaning that it is not conveyed genetically but passed down through imitation from adult to offspring (Krützen et al, 2005; Sugiyama, 1997). With this in mind, it is clearer that preservation of genetic components of biological diversity already included in our definition would not preserve these unique behaviors; they exist only within the community of organisms whose culture preserves them through cultural transmission. On an intuitive basis, one can imagine how the complex cognitive abilities of human beings may have developed the same way, eventually leading to a genetic change.

It is also worth mentioning that behavioral diversity represents a unique form of biological information in and of itself. While the potential to change genetic information in the form of changing selective pressures on an organism is indeed important, it should be noted that the value of unique, non-genetic behaviors stretches beyond this potential. The fact that behavioral diversity is a form of information independent from the physical, organic aspect of evolution makes it all the more valuable, leading to adaptively-important change in a community of organisms that is completely independent of their genetic makeup. Thus, though a population of chimpanzees adept at using tools has certainly not yet become a unique species, the behavioral adaptation shared in its culture constitutes a large part of its adaptation for survival. Would it pay to exclude such a step in the evolutionary process from a definition of biodiversity?

Despite the convincing case made by numerous examples of behavior, a few key factors and criticisms with regard to behavioral variation must be taken into account before it can dependably be included in a definition of biodiversity. First, to avoid redundancy, behavioral differences must, like the cultural traditions among Shark Bay dolphins and various subpopulations of chimpanzees, be independent of genetic factors already being accounted for. Naturally, bioreductivist thinkers may deny the inclusion of behavioral diversity in biodiversity by attributing it solely to genetic and developmental differences, the likes of which were already included in earlier portions of the growing definition. This may indeed be the case with some organisms, in which behavioral differences can be accounted for by genetic differences, but not for species such as chimpanzees, dolphins, and killer whales which exhibit learned behavior and trends of cultural transmission. With this in mind, it should be added that only *certain* types of behavioral diversity should be included in an inclusive biodiversity definition to avoid redundancy.

Second, they must be readily transmittable between individuals. Needless to say, if only a single organism has the ability to perform a certain behavior, no matter what the importance or effect of this action, it will die with the organism. Thus, in order for a behavior to be a evolutionarily valuable source of biological variation, it must be an *ongoing* source of variation, and must be transferred from parent to offspring or more widely among organisms in a population. Adding the above stipulation of separating behaviors from genetic differences, such a behavior must be taught to the offspring or learned through passive observation. This requirement may exclude certain organisms, notably particularly asocial ones or those which do not interact (through rearing or other social means) with their offspring. Additionally, any organisms which cannot "learn" (arguably many plant and fungal species) or have low cognitive complexity may also be excluded. Thus, behavioral diversity only acts as a source of variation in certain select species.

At this point in the ongoing pursuit of an inclusive and accurate approximation for biodiversity, it is evident that the "source of a source" method of deriving additional sources of biological variation is exhausted. Recognizing the evolutionary links between various components of natural variety—for example, that disparity can lead to speciation, and that behavioral changes can lead to developmental changes—I have been able to "derive" new candidates for addition to the growing biodiversity concept formed in this section. However, further derivation seems problematic. There is no readily-discernible "agent" by which new behaviors come to exist, unlike the way that changes in development can gradually lead to changes in phenotype, and so on. Thus, for the reminder of the section, I will focus on another component of biodiversity at a different "end" of this causal chain.

I.7 The Case for Ecological Diversity

Returning to where it all started, the study of species richness (and diversity), I revisit the criticisms of this surrogate posed by Bryan Norton. In his 2003 work, “Searching for Sustainability: Interdisciplinary Essays in the Philosophy of Conservation Biology” Norton addresses what he calls the “scale problem” in conservation biology. The problem lies in the fact that, according to Norton, the attention of conservation biology has been too narrow. He explains that a gradual broadening of our lens of conservation (from individual organism to species, from species to taxa, from taxa to ecosystems) is the correct course of action, and that at present we are emerging from the second of three phases which he calls the biodiversity phase (Norton, 2003).

According to Norton, “the biodiversity phase represented a distinct advance in conceptualization because of the introduction of multiple layers of diversity and the emphasis on varied dynamics and habitats as well as species” (Norton, 2003, pp. 114). The biodiversity phase is explained to be the prominence of thinking not unlike that which this work is founded upon; that there are *multiple* factors in nature which necessitate preservation, beyond a simple species count. Additionally, it is a certain focus on processes in nature, not just static elements (Norton, 2003). The problem with this method, however, is that it focuses perhaps *too* much on processes and not enough on the elements currently present.

Norton argues that though this perspective is a good one, it still presents a narrow scope which must be widened further to what he calls the “sustainability of ecosystem health” program supposedly in use today and destined for use in the future. By this perspective, the efforts by conservationists up to the current decade have been too narrowly focused on “small” scale conservation. Norton's perspective “argues that policies to protect biological diversity must monitor and protect larger ecological units, such as ecological systems” (Norton, 2003, pp. 115). This perspective stems from the observed correlation between ecosystem health and species abundance, thus implying “that saving species may eventually play a less-central role in biodiversity policy” (Norton, 2003, pp. 121). Norton’s argument is essentially a holistic one, implying that the health of an ecosystem can provide us with the “whole picture” which represents all (or most) other components of biodiversity and thus bypasses the growing pluralist definition being assembled in this work. Needless to say, this is a desirable end, as each additional component of biodiversity necessitates further measurement and evaluation for application in the policy-making world. A simpler definition would make life quite a bit easier. Such practical matters of measurement and application will be discussed in greater depth in the third section of this work.

My disagreement with Norton's view is minor, and mainly nominal in nature. Put simply, it is my argument that what Norton presents in his work, rather than a new approach to biodiversity, is a strong case for the inclusion of ecosystems and their “health” in the patchwork, frankensteinian approximation of biodiversity being formed in this work. Unless only in name, I argue that conservation biology has not escaped the “biodiversity phase”, but may be simply expanding and adding to the definition of that ideal it works to preserve. Of course, in both acknowledging the importance of ecosystem health and management of ecosystems and denying the fact that they are an all-inclusive representation of biodiversity; I am taking an intermediate stand on the holist view of the environment. Specifically put, it is my opinion that holist arguments regarding biological phenomena are commonly correct but not entirely sufficient; thus ecosystems and ecosystem health are a valuable *component* of biodiversity, but cannot account for it as a whole. A noteworthy examination of the role of ecosystems in biodiversity is given in MacLaurin and Sterelny's *What is Biodiversity?* which, up until the recent discussion of behavioral variation, has closely matched the growing biodiversity definition established in this work.

MacLaurin and Sterelny (2008) gauge the potential of ecosystems and the communities which inhabit them as surrogates for biodiversity. Their idea is to investigate the possibility that communities present an additional dimension of biodiversity that should be taken into account in conservation. Like in other chapters, a question has been confronted by the authors, and they set out with the apparent intent to provide a working answer to it. However, unlike previous chapters, they seem to be getting tired of this process, and fail to really prove or disprove the idea presented above. Instead, they provide a "framework for investigation" (MacLaurin and Sterelny, 2008, pp. 130) which, though frustratingly ambiguous, sets the stage for the explorative purposes of this work, and will be used as a "launching pad" for the pursuit of a more decisive conclusion.

Their analysis is framed around three main problems which must be overcome to include ecosystems as a distinct source of biological variation. The first of these will be called the "coherence" problem, and questions the very existence of biological communities. The second, named in this work the "holism" problem investigates the possibility of communities having any distinct properties not included in the sum of their parts (and thus in the components of biodiversity already included). Lastly, the "boundaries problem" poses a logical objection to the idea of ecosystems and communities. The boundaries problem argues that because distinct lines cannot be drawn where one ecosystem ends and another begins, that ecosystems may not existence as objective units. If they do not exist thus, is it possible to consider them independent sources of biological diversity like individual organisms? Needless to say, if ecosystems don't exist in the same way, diversity between ecosystems cannot be attributed to the ecosystems themselves and they may not be properly recognized as sources of biological variation.

In defining communities, the authors are quick to present a dichotomy that draws into limbo all efforts to include ecosystems and communities in conservation. This divide is over the nature of biological communities and forms the basis for the "coherence" problem. According to the authors, there are two possibilities explaining the nature of biological communities as seen in nature. These are outlined as follows: the first is the "assemblage of indifference"; the "individualist" point of view, which states that species do not affect one another but instead form phenomenological communities simply because of abiotic factors like climate conditions. By this view, what are viewed as "communities" are simply overlapping zones of species distribution due to common aspects of their respective tolerances for abiotic conditions. The opposing view, and the one most in line with an ecosystem-health or holist point of view, is that communities are "organized local systems" which are regulated internally by species interactions. Each species affects the other within the ecosystem and thus the aspect to be valued is the cohesive whole and not simply the patchwork of species which seem to be overlapping. This idea of a community is explicit about the uniqueness and importance of communities due to the biotic interactions occurring within them, and that an ecosystem has value and characteristics of diversity independent of the biodiversity within it.

MacLaurin and Sterelny present a number of justifications supporting both hypotheses, and seem ambivalent throughout the chapter whether ecosystems hold independent value as sources of biological variation or if they are simply phenomena illustrated by the summation of their parts. Frequently, they seem to be convinced that the "organized local systems" explanation is true, with statements like "we can infer from the qualitative stability of communities that they are networks of biological interaction…" (MacLaurin and Sterelny, 2008, pp. 118) and "organisms do not just eat, breed, and die. They reorganize [and subsequently effect] their environment" (MacLaurin and Sterelny, 2008, pp. 116). Despite this, they insist that we "cannot assume that persisting communities are internally regulated." (MacLaurin and Sterelny, 2008, pp.

118) and fail once more to make a stand on the subject. The authors provide some brief objections to the more holist argument on the grounds that there is little observational evidence of the competitive exclusion principle, and that in some cases competition is hardly observed at all.

MacLaurin and Sterelny later address a second potential problem with the uniqueness of communities as a component of biodiversity, the existence of characteristics of the community separate from (but not independent of) the individuals which make up the community. Emergent properties are essentially properties of an ecosystem that are the result of the ecosystem itself and not the total actions of its members. It is the biological acknowledgment of the idea that "the whole is greater than the sum of its parts". The existence of such properties is closely tied to the nature of communities as "organized local systems" rather than as "assemblages of indifference", and would certainly suggest that communities do exist as more than simple overlaps of distribution. A number of examples of emergent properties are provided, including ecosystem stability (due to varied tolerance and functional redundancy) and ecosystem services, noting that "There is a near-consensus in ecology that, in some measure, there is a positive relationship between diversity and stability" (MacLaurin and Sterelny, 2008, pp.122). However, once more, MacLaurin and Sterelny refrain from decisiveness and explain that "to establish an emergent property of hypothesis, the covariation between the emergent property and its apparent effect must be robust" (MacLaurin and Sterelny, 2008, pp. 123). Apparently, the observations of ecosystem services and increased ecosystem stability found as a general trend in the field of ecology are insufficiently robust to prove the existence of these emergent properties. Their hesitation lies in the idea that empirical evidence may theoretically be difficult to obtain for some systems given that productivity rates must be assessed for individuals in field data collection, and that ecosystem success and stability may not directly reflect individual success. Thus, MacLaurin and Sterelny argue, there is insufficient empirical data to prove that ecosystems involve more than the summation of the organisms within them.

Another factor relevant to the dichotomy which plagues the use of ecosystems in conservation is the concept of “boundaries”. If communities were “organized local systems” they must feature distinct boundaries where one organized local system ends and another begins. The individualist theory would not necessitate such organization and delineation. They introduce a hypothesis by Richard Lewins and Richard Lewontin which says that strong versus weak interactions between organisms can be determined through comparison, and that boundaries should be formed by the presence or absence of stronger interactions. With such a system, it is claimed that communities will be “roughly spatially identifiable” (MacLaurin and Sterelny, 2008, pp. 126). MacLaurin and Sterelny explain that such a view “presuppose[s] that patterns of interaction are clumped,” (MacLaurin and Sterelny, 2008, pp. 126) and that organisms within those communities interact more strongly with one another than other organisms outside their clump. The authors seem unclear as to whether this form of boundary is realistic and observable. They reference a potential mechanism for the formation of bounded “patches” of habitats based on examples in which organisms modify their environments and create potential niches for themselves and other organisms, but make no definitive assertion to support or refute the existence of ecosystems and community boundaries (MacLaurin and Sterelny, 2008).

By the end of their discussion, MacLaurin and Sterelny have made no claim regarding the existence of ecosystems and communities and their importance (or lack thereof) as components of biodiversity. Instead, they present three clear obstacles which any conceptualization of ecosystems must overcome before they can be considered a source of biological variation independent of the myriad factors which compose them. Before engaging further investigation of the nature of ecosystems, these obstacles must be challenged. To confront both the “coherence” problem and “emergent properties” problem, I would like to examine a few examples of biogenic ecosystems.

While it can be argued that all ecosystems are in some form biogenic (and though this claim would support my argument even more strongly, it shall not be made here), certain specific examples of biogenic ecosystems—those that are formed by the actions and modifications of specific organisms, and thus cannot exist without them—are powerful enough to challenge the aforementioned objections regarding the more widely-held understanding of the nature of ecosystems. Biogenic ecosystems, by definition, prove a level of coherence in an ecosystem by showing the importance of interactions between certain organisms. All biogenic ecosystems by necessity depend on the relationships between several distinct forms of life in order to exist in the first place. Needless to say, if coral polyps were absent from a reef system, the reef system and the thousands of species and millions of organisms associated with it would cease to exist. Ignoring for now the widespread effects on other ecosystems associated with the absence of reef systems, at the very least all biological phenomena contained within the reef are either absent or severely degraded if the reef itself is absent. Thus, a coral reef cannot be a "community of indifference", because the algal symbionts, peppermint shrimp, sea anemones, various fish larvae, and countless other species which can survive only in the environmental context of a coral reef can live *only* in a coral reef; their overlap is not simply due environmental tolerances, but a salient necessity for their mutual existence.

One would be hard-pressed to argue that such biogenic ecosystems are communities of indifference. However, MacLaurin and Sterelny argue that because there is little to no evidence for such intense interdependence in other ecosystems, it is doubtful that communities and ecosystems (as distinct units of complex interdependence and interaction) exist. The first flaw in the coherence problem is thus that it assumes that because of certain apparent exceptions, communities cannot exist anywhere. Though I will not deny that certain exceptions may exist, I will assert that communities and ecosystems are certainly real biological phenomena, though their tangibility may vary substantially. I refer here to a principle of ecology neglected by MacLaurin and Sterelny's analysis, the intermediate disturbance hypothesis.

This hypothesis states that as environmental stresses intensify, competitive interactions decrease, and vice-versa (Connell 1975, 1978). Using this hypothesis as a framework, we can understand why certain ecosystems appear to be more closely-knit communities than others, especially if (as implied by MacLaurin and Sterelny) competitive interaction is the main criterion used for identification. In habitats with extreme conditions (extremely high or low temperature, salinity, precipitation, etc.) competitive interactions lose much of their importance because few organism populations can ever reach a high enough density to compete with one another or other species. Thus, in such physically stressful environments, the coherence of a community is decreased. It is not impossible, then, that under an extreme (let us say at the North or South Pole, or in geyser vents) conditions, communities of indifference may exist, but between these and coral reefs are a multitude of “shades of gray” in which the realism and appearance of communities increases steadily. It may be, then, that the strength and coherence of communities, as well as their inclusion as a distinct aspect of biodiversity, changes with nature of the ecosystem itself. Deserts and other high-stress ecosystems with poor species interaction may have most of their biodiversity “invested” solely in species and other sources of variation, while a coral reef as a whole has a more distinct component of variation invested simply in the larger web of interactions it represents. This is not to say that some ecosystems hold no importance as ecosystems in and of themselves; it must also be noted that MacLaurin and Sterelny neglect to mention certain inevitable interactions between organisms, including symbiotic relationships and predator-prey interactions, which are present in *all* systems and thus at least show some evidence of emergent properties amongst ecosystems.

If it is clear at least that ecosystems do exist, though along a gradient of prominence, it must also be established that these ecosystems have certain salient properties beyond the sum of their “parts”. My opposition to this “problem” lies in essentially the same discussion as for biogenic ecosystems. A coral reef is more than the sum of its species, because none of these individual parts could survive independently from one another. In order for these parts to be considered distinct from one another, they should have some considerable degree of independence, but this is not the case. If corals are missing, none of their legions of dependent species can survive. If coral grazers and resident filter-feeders are absent, corals will die due to slow growth, excess of dead tissue, and sedimentation which kills the symbiotic algae from which they draw a large portion of their energy.

Beyond that, as mentioned briefly earlier, there exist certain clear effects (I will not stretch to call these “benefits”, though the arguments supporting this are strong) of a reef's presence which impact other non-adjacent systems. For example, coral reefs break waves and often protect coves by substantially reducing wave-stress in which many species (and ecosystems) intolerable of such stresses could not otherwise survive. The existence of the coral reef, then, independent of the abundant life within it, has other effects on the world which would not be present if the ecosystem as a whole were was not present. Furthermore, certain migratory fish species have young which can only survive in the shelter of a reef. Without this shelter, the fish would not grow to adulthood and have certain interactions in other ecosystems (at times across the ocean) and therefore exert additional effects independent of the presence of the species contained in the reef. If one is unwilling to accept these more literal emergent properties, there are also more conceptual forms which might be easier for nonscientists to understand.

In ascribing conceptual emergent properties to ecosystems, I will touch briefly on the field of biodiversity conservation, a subject to be explained in greater depth in part III of this work. In attempting to preserve a species, if the species is the only thing valued, an area from which that endangered species has been extirpated is not a target for conservation. Because the species is not present there, and only non-endangered species inhabit the area, it is of no concern to conservation biologists. However, there is an important connection between this area and the endangered species which is being valued (what type of value, or how much exactly that is will be an issue discussed in section II of this work). The area is still a *habitat* for this endangered species, a collective set of conditions each of which is necessary to form a zone where the endangered species can live. Thus, the area is attributed value for its potential to hold this endangered species. From a practical standpoint, this is almost an intuitive idea, but it presents certain underlying implications valuable to the current discussion. If an ecosystem is to be valued or recognized as a *habitat* for a particular species, and thus recognized to have certain characteristics which make it a habitat, one cannot simply attribute these characteristics to a small portion of the biodiversity components within the system. Because these components are largely connected and each needed to maintain the other, the property of being a *habitat* lies not in a few choice species but in the entire *system* which provides those conditions.

The third major problem with communities investigated by MacLaurin and Sterelny is the “boundary” problem, which regards the idea that “if communities are ecological systems with casually salient properties, then, presumably, they have objective boundaries too” (MacLaurin and Sterelny, 2008, pp. 124). In other words, there must be “a zone after which we stop counting, as addition to diversity *there* makes no difference to the extent of buffering *here*” (MacLaurin and Sterelny, 2008, pp. 124). As was mentioned earlier, the authors concede that abiotic, physical conditions do not need to change markedly across ecosystem borders, nor must it be clear which ecosystems or communities certain populations belong to. Basing their analysis on the assertion by Richard Lewontin and Richard Levins that communities are defined by the differences between relatively “strong” and “weak” interactions, MacLaurin and Sterelny present only one criterion for an ecosystem's borders: the “clumping” of interactions. The root of the problem stems from the lack of consistent empirical or logical evidence for this clumping.

My argument concerning the boundary problem is similar to that for other obstacles to the notion of communities and ecosystems; simply because one factor is not immediately apparent and consistently so between all ecosystems does not mean it does not exist. There are some ecosystems—once again, biogenic and highly competitive ecosystems are great examples—for which boundaries are inherently obvious. The strong interactions between coral and various coral-reliant species end where coral stop growing, where the proper substrate for the ecosystem ends. Though various species who affect the reef may leave it and enter other communities and ecosystems regularly, being affected by organisms there, the interactions of these species with those in both ecosystems are likely weaker, thus still enabling the rough designation of a "boundary" by the definition of Lewontin and Levins. It must be carefully noted that there will be exceptions to this rule; if nothing else is clear from texts in the philosophy of biology, it is that the natural world and disciplines which study it are constant sources of exceptions.

As before, my way of accounting for the inconsistency of ecosystems in their clarity and distinctness is to place them on a continuum regarding the factors discussed above. Some ecosystems (like my biogenic examples) are particularly distinct; their boundaries end when a specific set of species stops appearing and can be delineated directly. Other ecosystems, usually those with high abiotic stresses that prevent equilibrium conditions and competitive or mutualistic interaction among species, lack complex (or as complex) webs of interaction and may have much more subtle communities that are difficult to distinguish. At the same time, there are communities and ecosystems that are distinct sources of biological variation in the strength and complexity of their interactions, have clearer boundaries, more obvious (and often important) ecosystem services, and stronger and more numerous strong interactions between more other sources of biodiversity like species. Not all ecosystems are created equal. Some contribute more and some less to biological diversity independent of the phenomena they contain, and those that contribute more will be more important targets for conservation in addition to the components of biodiversity which exist within them (IE the species and their respective populations).

From a practical standpoint, such a model is quite useful. Not only does it explain the vast differences in “problem” characteristics observable between different communities, but it enables a distinction between ecosystems which would benefit immensely from Norton's “ecosystem health” approach to conservation and those for which individual species would benefit more from independent conservation measures. In light of the habitat issue raised before, it is logical that organisms which need a specific ecosystem to survive are those who need clearly bounded and interaction-heavy ecosystems; these species have more obvious collective properties and more prominent organism interactions. If an endangered species lived in an environment in which it had few specific interactions but many more general and weaker ones with a variety of organisms, one specific set of these organisms would not only be difficult to recognize but would be less important for the conservation of that species. It would always have another set to rely on, another area to shift its biological “weight”.

Thus, while I will not make the ecologically troubling assertion that ecosystems are not sources of biological variation or aspects of nature which should be valued independently of the diversity they contain, I will certainly concede that not all ecosystems have *equal* value as sources of biodiversity. In other words, all ecosystems fall within a spectrum whose endpoints are defined by two (purely theoretical) ecosystem types. On the far left (this side was chosen arbitrarily) is a “community of indifference” in its purest state, in which the ecosystem itself has no independent value as a source of biodiversity, having no emergent properties, very unclear boundaries for conservation, and little to no deterministic species interaction which necessitates explanation beyond shared distribution. On the right side of the spectrum is the ideological holist community whose value as a biodiversity source is completely independent of its members. The ecosystem has obvious physical boundaries and all species within it rely so heavily upon one another that their distribution is solely based on shared presence and the establishment of habitat. The ecosystem exhibits a number of valuable and easily distinguishable emergent properties such as ecosystem services and providing habitat for an immense number of species which are absolutely incapable of surviving without the whole ecosystem. I hypothesize that all ecosystems fall between these extremes, and thus for the purpose of identifying biodiversity, ecosystems are a matter of degree. Their contribution to biodiversity (and as will be asserted, subsequently their value) varies between ecosystems.

I.8 An Inclusive Biodiversity Definition

By this point an inclusive and multifaceted approach to defining biodiversity has been completed. Starting with the “calculus analogy”, the most fundamental source of biological variation, species, was included after some specification, followed by several of its “derivatives” (I use the term only in analogy), including morphology, development, and behavior. Finally, a new model for defining the biodiversity of ecosystems was presented which acknowledges them as a variable source of biodiversity with degrees of value (again, a term used lightly) independent of their parts. In this way, it is clear that the term biodiversity represents a great variety of natural phenomena which are identifiable, measurable, and unique to different degrees. While species are assessed according to taxonomic or phylogenetic distinctness and ecosystems by their coherence, phenotypic plasticity creates developmental variety distinct from other sources. Behavioral and morphological differences, in addition to developmental variation, account for the biodiversity observed within species not included in the customary “species count” evaluations of biodiversity. The result of these observations is the formation of an inclusive definition of biodiversity, one which encompasses the myriad natural phenomena both incorporated in and influencing the continued process of evolution.

While it is indeed a great step forward to formulate a well-informed and inclusive account of all that we value in the earth's biota, one great uncertainty remains which until the present—to avoid complication—has been avoided. That is, the subsequent question to our current claim, “This is valuable to us.” How valuable? Needless to say, while a formalized definition of biodiversity is a great conceptual resource, before it can have any practical application the *value* of concepts defined must be clarified, starting first with a surprisingly formidable stumbling block for conservation biologists: Why conserve biodiversity?

Section II: Why Conserve Biodiversity?

II.1 The Intuitive Consensus

While it is helpful to have a concept of what exactly human beings value as biodiversity, and just how far such a definition goes, there is still a major logical gap between a definition of biodiversity and the application of appropriate conservation measures. A justification for biodiversity conservation is needed; specifically, a compelling answer to the question “*Why* conserve biodiversity?” The question is surprisingly difficult to confront. Indeed, what sort of value does biodiversity hold, and how does this compare to the prioritization of certain social and economic issues? What sort of obligations on a moral or ethical basis do human beings hold concerning the components of biological variety outlined earlier, and where do these obligations come from? According to Sahotra Sarkar, “to get such an obligation” toward biodiversity and the environment, “we have to analyze carefully the nature of our relation to the environment. For instance...whether the environment embodies some set of values that requires us to refrain from harming it” (Sarkar, 2005, pp. 6). For many people, it is intuitively clear that such value exists.

As Bryan Norton explains, "Any discussion of the value of biological diversity should start with the recognition of the breadth of consensus favoring the protection of biological resources" (Norton, 2003, pp. 116). The problem for biodiversity conservationists is thus not an issue of agreeing that such values and the obligations that come with them exist, but how exactly those values are attributed.

Fortunately, there is no shortage of ethical systems being applied to this problem. Strategies range from the existence of intrinsic values to the interests of future generations and nearly all conceivable possibilities in between, not to mention appeals to ecosystem services and the potential to alter human preferences. In fact, the number is so great that any account of biodiversity ethics usually starts with a "Goldilocks" approach to the subject, reviewing briefly each main category of valuation and eventually settling on one which is "just right". Though this section will follow this trend to some extent, it should be clearly stated that the goal of this work is for practical application, and that ethics will be chosen on this basis. Consequently, it is not in my interest to denounce or devalue any particular ethical framework, only to review the criticisms each has received and compare their practical advantages and disadvantages with others.

II.2 Adequacy Conditions for a Biodiversity Conservation Ethic

Before one can make a consistent analysis of a set of conservation ethics, a framework for analysis must be provided by which these ethics can be assessed. A set of criteria would be useful by which to compare and contrast the ethical consequences and conclusions characteristic of different perspectives. In his 2005 work, "Biodiversity and Environmental Philosophy", Sahotra Sarkar provides a stringent set of conditions that must be met before a conservation ethic can be considered acceptable. While it is not my interest to "rank" conservation ethics and make any normative claims regarding how other human beings should interact with the world around them, I believe Sarkar's “Adequacy Conditions for a Conservationist Ethic” provide a solid foundation for analysis. These conditions will be reviewed in depth to set the stage for an investigation of prominent approaches to conservation ethics.

Early in the text, Sarkar selects six conditions which serve as the basis for his analysis of various contemporary conservation ethics. The first of these conditions, called the generality condition, is directly related to part I of this work. According to Sarkar, in order to satisfy this condition, an ethic should attribute value “to biodiversity in general, in all its complexity” (Sarkar, 2005, pp. 48). The importance of this condition is intuitive, if not rational by definition. If biodiversity consists of the components of natural systems which humans value (including their variation), then, naturally, at least *some* value should be attributed to each of these components as they occur in a natural system. This condition makes no assertions as to how much value should be attributed to various components of biodiversity, only that some should. This leaves some much-needed flexibility for the formation of an ethic according to such a complex definition of biodiversity. For the purposes of this work, the only alteration to this condition shall be that the definition of biodiversity in use is that presented in section I of this work, and not that adopted by Sarkar.

This condition forms the foundation of any biodiversity ethic and forms the first of two parts of the “objective” of biodiversity conservation, simply the preservation of endangered biological phenomena. A second condition, however, is necessary in order to ensure this objective is met. Even if all components of biodiversity are attributed some value, it does not mean that they will be conserved as a result.

The second condition, the “moral force condition” concerns the ethical obligations involved with the value mentioned above. In order to satisfy this condition, an ethic must “produce an obligation to attempt to conserve all biodiversity” (Sarkar, 2005, pp. 49), necessitating human action and management to some degree. Thus, not only must value be attributed to components of biodiversity, but when these components and their value are threatened, an ethic must create cause for action. This condition, too, has clear priority in an ethic and is difficult to dispute. Components of biodiversity which human beings value must be protected when threatened, so policies must generate an obligation to protect those phenomena that are valued. A conservation ethic is thus not practically useful unless it generates the need for "real-world" action distinct from conceptual recognition of value. This condition is naturally an integral part of a working conservation ethic and for the analysis of this work will be considered the most important.

Sarkar's "collectivity" condition states that a conservation ethic must have some holist element, attributing value not only to individual organisms but to the broader taxonomic groups of which they are part and the ecosystems and habitats which they support and are supported by. According to Sarkar, a conservation ethic must "attribute value to other higher-level entities along both the structural and taxonomic hierarchies" (Sarkar, 2005, pp. 49). Thus, Sarkar makes a clear stand on the holist vs. individualist debate mentioned in part I, and couples a holist framework to the ideal conservation ethic. In the context of the definition of biodiversity constructed in part I, it should also be noted that the generality condition mentioned earlier may partly overlap this condition by attributing value to ecosystems and larger structural units. Higher taxonomic units, however, are uniquely covered by this condition.

It should be noted that the attribution of value to taxonomic and ecological units larger than individual organisms is a heavily debated subject. Though it was generally established in part I that these larger units will be given value, this condition is given secondary importance given that its fundamental concepts are not universally accepted.

The logic behind this condition seems to be sourced in the precautionary principle, with the idea that though some value cannot be readily attributed to some biological phenomena (higher taxonomic units like families, for instance), this does not imply that such value may not exist. While there is uncertainty regarding the value of higher taxonomic classes, Sarkar seems to assert that a good ethic still gives them value. Due to these uncertainties, the importance of this condition for the purposes of this work is diminished with relation to higher classes. In relation to ecosystems and habitats, its purpose may already be served by the first condition.

Touching upon the idea of taxonomic classes once more, Sarkar adds the “All-taxa” condition, which requires that an ethic attribute value to all species and classes, not simply charismatic species. Needless to say, this sort of condition is a necessary one, as conservation measures and effort toward the preservation of charismatic megafauna are notoriously greater than those toward less appealing species (to use a famous example, the snail darter). The all-taxa definition requires that an ethic provide solid justification for the preferential “treatment” of one species or taxa over another. Presumably, this sort of justification involves some comparison in the value attributed in previous conditions by some scientific of philosophical model. This question is addressed in Sarkar's next adequacy condition.

The next condition is one of considerable practical concern. The “priority-setting” condition requires that an ethic provide some framework for the prioritization of species and other components of biodiversity in relation to one another. For conservation measures, such a framework is essential. Naturally, resources for conservation efforts are limited and thus must be focused toward the biological phenomena of greatest value or of the most urgent need of conservation management. Without such a priority-setting framework, an ethic would prevent the effective preservation of valuable biological phenomena and thus fail its primary objective. Due to the practical emphasis of this work, this condition will be considered important and stressed in subsequent ethical analysis.

Sarkar's sixth and final condition is also the one he considers the least important. What he calls the “non-anthropocentrism” condition predictably requires that a conservation ethic allows the “attribution of value without reference to parochial human interests” (Sarkar, 2005, pp., 50). It is understandable why such a priority would be considered less important. If the main objective of the ethic is still to properly conserve endangered biological phenomena, it seems reasonable to say that this objective may be independent of the justification used for action. The requisite conclusion for this logic is that if humans are the source of justification for biodiversity conservation, the necessity for conservation is only present as long as humans are, too.

While this may seem initially problematic, when taking a broad enough ecological perspective on the relationships between biological phenomena and the biosphere as a whole, this relationship would be maintained unless humans were completely absent from earth. Thinking logically and environmentally, this absence would also eliminate the anthropogenic risk of extinction, the type of problem upon which conservation measures focus.

With this in mind, the non-anthropocentric condition is also treated with secondary importance. Based on the assumption that conservation should combat only anthropogenic biodiversity loss (thus avoiding “species hoarding”), anthropogenic problems will only arise in the presence of humans, and when that presence is removed (from *all* interactions, thus the entire biosphere) the necessity for action dissipates. Thus, for the purposes of this work, an anthropocentric ethic is still considered acceptable as long as it obeys the above conditions, especially the satisfaction of the moral force and generality conditions. It should be noted that this argument does not by any means discredit or disprove non-anthropocentric ethics, but provides some rationale that the interests of anthropocentric and non-anthropocentric ethics may overlap to a large degree, and that differences between them may be considered trivial for the practical purposes of this work.

That being said, the non-anthropocentric condition is certainly not an unwanted condition for an ethic; many thinkers insist that an anthropocentric view is immoral and unethical. Thus, if an ethic could possibly satisfy the arguments of these thinkers, it would certainly add to the value and applicability of the ethic.

In light of the practical focus of this work, I would like to introduce an additional adequacy condition, one that is relevant to the application of an ethic. What I will call the “comprehensibility” condition, which states that in order to be effective, a conservation ethic must be readily understandable for the average person. Additionally, an ethic must be effective in small-scale conservation decisions of the sort that nearly all human beings make on a daily if not hourly basis. Such decisions occur frequently and in huge numbers, the majority of the time independently of federal law or its enforcement. For example, whether to buy products that may be harvested, produced, or disposed of unsustainably, whether to use fire to clear a plot of land at the risk of burning nearby forest, or whether to throw back an endangered fish when caught. This sort of decisions are frequently not governed by federal conservation laws, inconsistently regulated between political boundaries, or insufficiently enforced. The “comprehensibility” condition thus necessitates that an ethic allow all (if not the vast majority of) people to have an intuitive understanding of a conservation ethic and have the ability to apply it when the need arises. It should be noted that whether or not people are *obligated* to obey this ethic will depend on the satisfaction of the “moral force” condition explained earlier. Due to the increasing number of conservation decisions, conscious or otherwise, being made by human beings on a daily basis and the relatively poor enforcement of environmental laws in certain parts of the world, this adequacy condition is given importance secondary only to the generality and moral force conditions.

For the following investigation of contemporary conservation ethics, the primary criteria for a working ethic will be called the "core" adequacy conditions, namely the generality and moral force conditions. The prioritization and comprehensibility conditions are placed in the category of "practical" adequacy conditions. The all-taxa and collectivity conditions are considered subsets of the generality condition that simply specify ways in which it should include particular components of biodiversity. The non-anthropocentric condition will be considered unessential but still beneficial. These three conditions will form the "secondary" adequacy condition group for their diminished importance with regard to the purposes of this analysis. Using this framework for assessment, I will review the most prominent ethical systems in conservation biology and attempt to outline those which show the most promise for application.

II.3 Intrinsic Value Ethics

Since the time when Aldo Leopold's "Land Ethic" sparked interest and discussion of our philosophical relationship to the environment, appeals to the intrinsic value of natural phenomena have been immensely popular. Before this, many spiritual and religious philosophies attributed such value to natural phenomena. Sahotra Sarkar explains that ethics of intrinsic value claim that an entity, rather than a quality, has value, and thus attribute such value irrespective of any instrumental or other quality of the entity (Sarkar, 2005). He further classifies intrinsic value systems as being one of two types. The first is a system in which value is attributed to an entity without comparison to anything else; this sort of intrinsic value is directly opposed to extrinsic value, or any value emerging from a relation to another entity. The second type is a system in which an entity is valued without regarding it as a means to any sort of end, but instead as an end in and of itself. This Kantian perspective is of course the opposite of instrumental value systems in which an entity receives its value because of its potential use to others.

Holmes Rolston III (1989) presents an environmental ethic built on the foundation of intrinsic value. Rolston's ethic represents what Sarkar defined as the first “type” of intrinsic value ethic, focusing on the value of entities (in this case, species) independent of the existence of any other entities. Rolston supports his position that all species have such inalienable and intrinsic value by making an analogy with the human ethic, arguing that in the same way people have a duty not to end one-another’s lives, it is also our responsibility not to end the unique lineage of a species. In Rolston's words, “Humans have learned some intraspecific altruism. The challenge now is to learn interspecific altruism” (Rolston, 1989, pp. 208). Rolston argues that as greater processes related to forms of life, species have intrinsic value beyond their use to an ecosystem or any human needs. Citing a variety of species including the Beggars tick, a pesky plant family with adhesive seeds of which one particular species is endangered, Rolston makes it clear that though all species may not have instrumental value, there is still some value present that humans, as ethically concerned organisms, cannot ignore.

Rolston's arguments for the existence of this value are focused less on distinct proof (after all, this would be difficult if not impossible) but in criticizing opposing views. Rolston explains that anthropocentric perspectives are “submoral and fundamentally exploitative” and insists that ethical systems are “about partners with entwined destinies” (Rolston, 1989, pp. 208). In this way, Rolston illustrates his view that anthropocentric ethics are inherently immoral and opposing to our own moral standards toward one another. “Morality,” he explains, “is needed whenever the vulnerable must be protected from the powerful” (Rolston, 1989, pp. 211). Certainly, this statement applies to the current interaction of humans and the rest of the biosphere.

Rolston addresses another criticism of intrinsic value with regard to species, one which could also be posed toward any of the other myriad components of biodiversity outlined earlier. "Perhaps species do not exist" (Rolston, 1989, pp. 209) Rolston muses, facing the problem that moral obligations cannot exist toward phenomena that are nonexistent. Here, he makes an argument similar to my own in the first section of this work regarding ecosystems and habitats; while the boundaries are not always clear and while classification is always different, species, like geological phenomena, are "phenomena objectively there to be mapped" (Rolston, 1989, pp. 210) and thus unquestionably exist, despite uncertainty of *how* they exist. From there, he makes the simple step of asserting that certain duties exist to these phenomena, explaining that, though there is no moral "contract" between humans and other species, the same duties apply regardless of a pen-and-paper agreement. Because of our position of power, it is our duty to ensure that our actions do not cause undue harm to biological phenomena, regardless of their value to us.

In fact, Rolston extends this morality, explaining that the question "Ought species X to exist?" is simply "a single increment in the collective question 'ought life on Earth to exist?'" (Rolston, 1989, pp. 212) to which the (hopefully) obvious answer is yes. Thus, with each anthropogenic extinction, human beings are essentially conceding that there is no value to life itself; by failing to attribute value to a larger unit of life, we are essentially arguing that there may be no value to the larger whole. The extinction of a species, Rolston argues, is a form of "superkilling", which is either equally or more morally deplorable because it extinguishes not only a single life form but an evolutionary trajectory of forms. He asserts that modern human beings are faced with a unique situation as the first "superkillers" on earth. With the technological and numeric potential to remove entire forms of life from the biosphere and thus the ability to commit superkilling, a new and more sensitive ethic is required of humans in the 20th century. "If," Rolston concludes, "in this world of uncertain moral convictions, it makes any sense to claim that one ought not to kill individuals without justification, it makes more sense to claim that one ought not to superkill the species, without superjustification" (Rolston, 1989, pp. 213). Thus, a greater form of justification is needed to risk the extinction of an entire species than would be needed to risk the lives of the individuals making up that species.

Rolston also extends this ethic to ecosystems, insisting that the goal of conservation is "not [simply] the preservation of species but of species in the system that we desire" (Rolston, 1989, pp. 216). Naturally, if species and the forms of life which make them up are being valued, the ecosystems which they form and on which they depend are additionally important; these ecosystems are part of the evolutionary process in which these species are involved and form the support network which allows them to continue. Using this logic, it may also be reasonable to extend this ethic of intrinsic value to other components of biodiversity. This extrapolation requires the acceptance of on a few assumptions, however, notably that the arguments made in the first part of this work regarding what phenomena contribute to biodiversity are true. If agreement has been reached regarding which elements characterize biological variety, the ethic of intrinsic value can be extended to some degree to all of these components with respect to their contributions. It is, however, unclear how far this sort of "life ethic" can be extended and how *much* intrinsic value will be attributed to different components of biodiversity.

Rolston makes an initially convincing case for the attribution of absolute value to other forms of life and possibly other biological phenomena related to the perpetuation of life. It is difficult to argue against such value when considering the "paradox that the single moral species acts only in its collective self interest toward all the rest" (Rolston, 1989, pp. 212). Indeed, there is an intuitive pull to this concept which makes it difficult to deny. However, it remains to be seen how this value system satisfies the adequacy conditions outlined earlier for an effective conservation ethic.

As mentioned above, it may be possible to extend Rolston's more sensitive ethic of intrinsic value to other components of biodiversity, because, as established in part I, these components all make some contribution to the variation and perpetuation of life in the biosphere. In this way, while it was initially directed only toward species, Rolston's ethic to prevent the “superkilling” of biological phenomena on a greater scale than simple individuals can be transformed into a “life ethic” which encompasses all recognized components of biodiversity. It may thus satisfy the first adequacy condition, which necessitates that it attributes value to all aspects of biodiversity which are desirable to value. By definition, it satisfies the “non-anthropocentrism” condition, though this does not make any significant contribution to its practical application. Additionally, it would conceivably satisfy the all-taxa condition by attributing such intrinsic value to *all* natural phenomena, regardless of their appeal to humans or other uses. The collectivity condition is addressed by Rolston's extension of the ethic to ecosystems and larger taxonomic classes, which will be valued as larger units of the “life” which is given intrinsic value. The moral force condition of this rather powerful ethic is undoubtedly satisfied; no human being wants to be classified as a “superkiller”. Rolston makes it clear that the same duties and obligations we normally assign to other human beings also apply to other forms of life, what he calls a “biologically sounder ethic, though it revises what was formerly thought logically permissible or ethically binding” (Rolston, 1989, pp. 215). Additionally, the comprehensibility condition is satisfied by the simple extension of the “moral circle” used in Rolston's ethic. There is no need for excessive contemplation, simply the understanding that humans have a great capacity to destroy other forms of life, and that morality and ethical consideration naturally arise in such situations. This thought process is likely intuitive to a great number of people.

The main problem(s) with this ethic arise in response to its objective measurement. While it is clear that value will be attributed to all aspects of biodiversity, it is very difficult to say *how* *much*. The ethic contains no conceivable method of prioritization, and thus would be virtually impossible to implement in a legal setting. Besides that, there is little *logical* basis for this extension of morals. While it does, indeed, obey virtually the same logic as the “golden rule” perspective on human ethics, it would be very difficult to convince lawmakers that such an extension is necessary. As other authors have admitted, such ethics of intrinsic value are “little help in policy matters” (MacLaurin and Sterelny, 2008, pp. 118) and pose “important difficulties for those who seek to integrate environmental ethics with scientific practice” (MacLaurin and Sterelny, 2008, pp. 150). Indeed, though there is intuitive draw to ethics like Rolston's, it is not necessarily enough to prove its own case; thus it is a difficult “feeling” to justify, and even harder to really apply.

A number of potentially problematic situations come to mind with respect to this difficulty. Any comparative dilemma, for instance, where the value of one species needed to be weighed against the other, would be immensely difficult, like deciding whether to save one baby versus another from a burning building. Some concrete method of prioritizing species is necessary to enable the use of such an ethic, or else it does little but reinforce the already commonly-held suspicion that it is better to prevent the loss of a species than to promote it. Additionally, this type of approach presents interesting implications for other types of “biodiversity”, for instance, man-made biodiversity in the form of livestock or other domestic breeds. Are certain duties due to milk cows to avoid the “superkilling” of one unique bloodline, or will value somehow be diminished for certain types of species? It seems strange to consider preserving a population that humans themselves “created” in the first place. Without proper prioritization, it is impossible to justify the decision to conserve a specific coral reef or prevent the loss of a new color of pansies. Though the intuitive appeal of this approach is undeniable, it is clear that its lack of logically-binding justification makes implementation difficult.

This is not to say that there have not been more logically-based justifications for the attribution of intrinsic value. Sahotra Sarkar reviews a number of these systems in the third chapter of *Biodiversity and Environmental Philosophy: An Introduction*, though he finds all of them unsatisfactory according to the adequacy conditions outlined earlier.

For example, appeals to the value of sentient beings are considered unacceptable because it fails the collectivity and all-taxa conditions. Naturally, some organisms might not be considered sentient—for example a bacterium or plant—and these would be excluded from ethical consideration. Perhaps even more troublesome, aspects of biodiversity outlined in the first section of this work that are non-sentient (essentially everything aside from individual organisms) would also be outside of ethical consideration. This sort of justification would thus fail to accomplish its objective of preserving what we consider valuable biological phenomena. Additionally, issues like the culling of particular species to avoid the destruction of habitats or extinction of other species become problematic, because prioritization of values (unless measured simply in number of sentient lives saved) is also virtually impossible.

Other attempts to logically justify intrinsic value ethics, such as Paul Taylor's "Respect for Nature" ethic stem from appeals to interests or a "will-to-live" in an attempt to attribute intrinsic value to the *interests* of organisms, thus eliminating the issue of sentience (Taylor, 1986). In order to have intrinsic value, an organism must simply have some form of "preference" in that it behaves a certain way, preferring certain conditions over others. However, not only is it incredibly hard to quantify and attribute a "will-to-live" or "will-to-reproduce", but again it requires a logical stretch to assign such interests to non-organismal components of biodiversity, such as higher taxonomic classes, types of behavior, ecosystems, and so on. Thus, the collectivity condition is again left unsatisfied, and these logical attempts at assigning intrinsic value to biological phenomena are largely unsuccessful.

From the preceding analysis, it seems likely that logical justifications for the attribution of intrinsic value are largely fruitless and unsatisfactory for the formation of a biodiversity ethic. In fact, the only somewhat acceptable perspective on this ethic would be Rolston's rather intuitive understanding that human beings require a more sensitive ethic now that they are capable of causing much greater destruction to the biosphere. Again, ignoring the need for rational justification and purely logical thought, there is great moral pull to the argument that the purpose of morality is to intervene where the weak must be protected from the strong, and that in our current position of immense strength, human beings may indeed have need for an ethic which can encourage such morality. While admittedly useless for policymaking and large-scale decisions, there does seem to be some value in this form of ethic. As Sahotra Sarkar explains, intrinsic value ethics are “endorsed on the grounds that [they] will lead to a better attitude on our part in our interactions with other living forms” (Sarkar, 2005, pp. 58), and not necessarily for governments to create and enforce laws. According to Sarkar, the idea “that a new attitude toward the nonhuman world, an attitude different form the one we customarily display, would better safeguard biodiversity and environmental health, is almost certainly correct” (Sarkar, 2005, pp. 59). The point Sarkar makes here is an important one considering the importance and utility of intrinsic value arguments. While they may be of little use for decisions as a governmental level, they encourage a more careful and morally-bound attitude toward the natural world on the part of every human being who encounters them, and thus can contribute to conservation on a broader, “grass-roots” scale. It is not hard to imagine how an ethical, intuitive justification for conservation might appeal more to an uneducated or scientifically apathetic individual, while complicated logical explanations citing utilitarian and biological benefits of biodiversity might fall short. Thus, while an ethic of intrinsic value does not belong in the field of lawmaking, it certainly has its place in the future of conservation.

II.4 Demand Value Ethics: The Anthropocentric Approach

The second large category of conservation ethic is composed of all those which attempt to attribute value to biological phenomena relative to their importance to other organisms or interest groups. These ethics include the anthropocentric justifications for conservation often decried as base and immoral by intrinsic value conservationists. Naturally, this category of instrumental and extrinsic value is the polar opposite of ethical systems discussed earlier, and focuses on the use of more rational rather than intuitive concepts to support its claims.

In their discussion of ethics in *What is Biodiversity?* James MacLaurin and Kim Sterelny describe such utilitarian attempts at attributing value as "demand value". According to the authors, demand value systems stem from "theories that tie the moral worth of an action to its effects on the maximization of minimization of some natural property" (MacLaurin and Sterelny, 2008, pp. 151), notably happiness, pleasure, or "well-being" or the minimization of negative properties like unhappiness. These are measured by the interests of various groups in the subject at hand, in this case any organism benefited by the biological phenomena valued as biodiversity. The obvious issue with such values is what the authors call the "aggregation problem" (MacLaurin and Sterelny, 2008, pp. 152), which essentially poses the question "valuable to whom?" The idea of demand value results in a "weighing of interests" between individuals that can lead to the question of *which* demands are worth appeasing and which aren't. Naturally, a squirrel has different demands than a dairy farmer, and the subsequent conflict of interests therein would be difficult to account for from a conservation standpoint. It would be difficult to satisfy many of our earlier-outlined adequacy conditions without being clear which sort of interests were being given value. Specific interest groups must be identified in order to enable the use of demand value arguments for conservation.

To avoid the aggregation problem, many philosophers refer to a specific set of interests, notably *human* interests. These anthropocentric arguments focus on economic, social, and even spiritual benefits which components of biodiversity can provide to humans. With regard to such ethics, "the values involved in protecting biodiversity are fully represented in an accounting of the welfare of humans in the present and in the future" (Norton, 2003, pp. 117). Thus, components of biodiversity are valued for their properties as *resources* for human use. In "Searching for Sustainability: Interdisciplinary Essays in the Philosophy of Conservation Biology" Bryan Norton insists that "Protection of biological diversity can be justified because of the many ways in which species and ecosystems provide services that we would otherwise have to supply. In general, anthropocentric justifications easily satisfy the moral force condition by showing the utility of a biological phenomenon directly to human beings, which would place conservation directly in their best interest. The priority-setting condition may also be satisfied, given the human ability to attribute monetary and economic value to most resources and benefits. "Willingness to pay" surveys are commonly used to attribute this type of value to phenomena which are not readily monetarized. In this way, biological phenomena could be valued by the monetary worth of the services or benefits they provide, and prioritized in order of value. The comprehensibility condition is also easily satisfied, because the logic to conserve something that benefits oneself is relatively straight-forward.

Issues arise when faced with the generality condition (and its specific sub-conditions, the collectivity and all-taxa condition), as it is not clear how distinct values can be attributed to each and every part of a broad and inclusive definition of biodiversity. The possibility arises that a species or ecosystem characteristic exists that no one can directly benefit from in a utilitarian fashion. This possibility fails to satisfy the all-taxa condition, which states that *all* species (and other biological phenomena), even those which are not particularly charismatic or immediately useful, be attributed value. Needless to say, a "worthless" species would be indefensible from the perspective of demand value. The problem here is that demand value “does not tie to diversity per se. Rather, it ties [value] to specific uses” (MacLaurin and Sterelny, 2008, pp. 153). One attempt to resolve these collectivity conditions is through the citation of the diversity-stability hypothesis.

The diversity-stability hypothesis is usually the first intuitively satisfactory move for the creation of an anthropocentric conservation ethic which satisfies the generality condition. This hypothesis links biodiversity (in all its forms) to the stability of a specific ecosystem or collective body (be it a population or biome). In so doing, it places value on all aspects of biodiversity by stressing that each of these aspects is at least somewhat important to the stability of the ecosystem. Also keeping in mind that the biosphere itself depends on the contributions of many ecosystems and populations through ecosystem services and other functions, it follows that each component of biodiversity has some value given its contribution to the perpetuation of these services.

The diversity-stability hypothesis, at its very simplest, relies on the ecological concept of functional redundancy. Functional redundancy is the phenomenon when a single ecosystem (or community) has more than one member that can fulfill a particular role or niche. Thus, if conditions change that make it difficult for one species to survive, other species can fill in their place and make sure the role is still fulfilled. Diversity thus provides additional functional redundancy. The idea, then, is that this additional functional redundancy makes ecosystems and subsequently the entire biosphere more stable and capable of continuing in the face of change.

In the last few decades, the diversity-stability hypothesis and the ethical conclusions which can be drawn from it have come under attack in the works of several different authors. These researchers showed that certain cases existed in which diversity decreased stability. Though initially this seems to be an insurmountable defeat of this line of thinking, this is not necessarily the case. As MacLaurin and Sterelny explain, one of the main critics of the hypothesis researcher, Robert May (1973) identified biodiversity only as species richness, and thus excluded the vast majority of other components discussed in part I of this work (MacLaurin and Sterelny, 2008). Additionally, fault may be found in May's definition of stability, which referenced only population size; specifically, the population size of individual species involved in the ecosystem (MacLaurin and Sterelny, 2008). Naturally, given the explanation of functional redundancy above, the diversity-stability hypothesis makes no reference to the stability of individual populations; in fact by definition it functions to *account* for such natural fluctuations. More specifically, the concept of ecosystem stability is not that populations will remain constant, but that the effects of one fluctuating population on its environment will be buffered by another population with different characteristics and thus different population fluctuations under the same conditions.

In the same study, the stability of ecosystem services is found to increase. Other researchers, notably David Tilman argue that these properties are what become more stable in more diverse communities, and that more diverse communities are more productive (MacLaurin and Sterelny, 2008, pp. 122). Much of the research done in this area, however, was based entirely on plants (Tilman 1996, 1999, Tilman et al. 2005) and may not apply as easily to more complex animal and plant-animal relationships.

Sahotra Sarkar is equally skeptical of the formation of an ethic around the diversity-stability hypothesis, explaining that other authors “have produced equally compelling empirical evidence that richness is inversely coordinated with stability, interpreted as resilience and resistance.” While again, as with the case of Tilman and May, the definitions used for this research may be criticized, it is clear that opinions vary greatly as to the utility of the diversity-stability hypothesis.

Thus, though according to some there is a near-consensus that the positive relationship between diversity and stability exists (Hooper et al., 2005), the subject is still “hot”. Subsequently, some authors eschew its use in conservation ethics entirely due to the criticisms it has received and the uncertainty behind it. Both Sarkar and MacLaurin and Sterelny chose to abandon the diversity-stability hypothesis in the formation of their conservation ethics and, interestingly enough, end up making similar ethical appeals in the process. The ethics created by these authors form a third category in which ethics are based on appeals to the precautionary principle or the somewhat abstract idea of “prudence”.

II.5 Precautionary Ethics

In *Biodiversity and Environmental Philosophy: An Introduction* Sahotra Sarkar (2005) addresses the concept of “transformative values”, which attribute a sort of intellectual value to biodiversity. According to Sarkar, biological phenomena have transformative value because they have the ability to change a human being's perspective or preferences. In other words, rather than having direct demand value, biological phenomena hold value in the *potential* to change such demand values. Sarkar presents two types of transformative values, direct and indirect. Direct transformative values are attributed to phenomena which can bring about a change of demand values, while indirect transformative value is attributed to those which can lead to other events that transform demand values. (Sarkar, 2005) In this way, direct transformation value stems simply from the experience of a certain phenomena, while indirect value is brought about by its potential intellectual contributions.

Biodiversity is thus being valued for its intellectual appeal and only that. In Sarkar's words, “the best argument for the conservation of biodiversity remains its intellectual promise”

(Sarkar, 2005, pp. 85). Value is thus due to objects which can change our intellectual points of view and the values which come from them.

The most obvious—and potentially most challenging opposition to this type of argument is the “directionality problem”, which addresses the possibility of *negative* transformative value. After all, if value is simply being placed on the changes in value a biological phenomenon can bring about, it is not specified that this change must be a good thing. It would make little sense to attribute value to a negative experience with biodiversity. Hypothetically speaking, we would not want to value a species or behavior of some organism that was so incredibly unpleasant it induces undesirable changes in human values; for instance causing them to stop valuing their own or other human lives. Sarkar's initial response to this objection is to claim that such negative experiences are highly unlikely, and that a component of biodiversity “is much more likely to have positive than negative transformative value” (Sarkar, 2005, pp. 98). Accepting that this may not be the most convincing answer—indeed, for some it may not be convincing at all—Sarkar adds that “the most convincing argument in response to the directionality problem is based on the indirect transformation of demand values that biodiversity generates through its contributions to science” (Sarkar, 2005, pp. 99). In this way, the potential for new scientific discovery and understanding as a result of biodiversity research is considered the most promising source of value for components of biodiversity. Thus, as biological phenomena are employed as subjects of research or sources of inspiration for further intellectual understanding, they create an indirect benefit to human beings. According to Sarkar, the only potential negative change resulting from knowledge of biodiversity would be further discoveries of agents of biological warfare. It is thus much more likely that scientific research on components of biodiversity would be beneficial than harmful. As Sarkar explains, “Given how much we have yet to learn about the variety of life on Earth, biodiversity studies have more potential in this way than probably any other field” (Sarkar, 2005, pp. 103). Through this line of thinking, it is evident that while the viability of direct transformative value is certainly crippled by the directionality problem, indirect transformative value may still maintain some utility through its connections to science and other forms of intellectual development.

James MacLaurin and Kim Sterelny ultimately make a similar argument for the attribution of value to biodiversity, referring to what they call the “Option value Option”. This idea of value stems from the concept that a thing’s value is in the options (or freedoms) it can provide in the future. Thus, something is valued not just for its use in the present, but for the possibilities of its future value; option value becomes a way for humans to “hedge their bets” when it comes to biodiversity resulting in an ethical system which “links utility much more closely to diversity” (MacLaurin and Sterelny, 2008, pp. 154). This “option value” is not at all unlike Sarkar's indirect form of transformational value, which attributes value to phenomena whose presence can lead to discoveries or experiences which change our preferences. In fact, the authors add that the future preferences of human beings are one of the most important unknown factors in the evaluation of biodiversity, and are the point at which “the option value approach connects to the transformative value approach” (MacLaurin and Sterelny, 2008, pp. 156).

MacLaurin and Sterelny base their approach on two possibilities; the first, “that species (or for that matter ecosystems) that are not of value to us at present may become valuable at some later time”, and the second, that “as our knowledge improves… we will come to discover new ways in which species can be valuable” (MacLaurin and Sterelny, 2008, pp. 154). As with Sarkar's indirect transformative value, components of biodiversity are not being valued for their present utility, but for the *potential* they may possess for future utility or in the future ability to change our preferences for utility altogether. Economically speaking, option value could be defined as “the additional amount a person would pay for some amenity over and above its current value..to maintain the option of having that amenity available for the future...” (van Kooten and Bulte 2000, as taken from MacLaurin and Sterelny, 2008, pp. 154).

The sort of “bet-hedging” and precautionary arguments put forth by Sarkar and MacLaurin and Sterelny seem viable when considering the adequacy conditions to be used in this analysis. As MacLaurin and Sterelny admit, “the crucial point about option value is that it makes diversity valuable” (MacLaurin and Sterelny, 2008, pp. 154). In other words, this ethic may simply be constructed because it satisfies certain adequacy conditions, notably the generality condition, effectively. Indeed, it is clear that the generality condition is met, not to mention the collectivity condition, as no currently-known utility of any species or phenomena is required. The all-taxa condition is a bit harder to apply, though again it is not unthinkable that option value could be applied to higher taxonomic classes. The moral force argument is largely satisfied by the anthropocentric focus of the ethic. In fact, the only conditions on which these ethics seem to fall short are the non-anthropocentric and the comprehensibility condition. It is clear that the ethic is anthropocentric, and thus would not satisfy the first of these two conditions. Second, the logic behind its development, though in many ways quite sound, may well be outside the grasp of a large portion of the human population, or else so complex that it could not adequately be applied in practical, day-to-day situations in which little time for deliberation is permitted. Furthermore, educating the public on such an ethic would be highly problematic and time-consuming.

While the concept of a precautionary ethic seems initially straightforward, it is easy to become mired in the conceptual twists and turns employed by proponents of precautionary ethics in the effort to overcome logical opposition like the directionality problem. Thus, if precautionary ethics were to be taught in an environmental education format, they would either need to ignore glaring issues like the directionality problem altogether, or include excessive explanation and reasoning in order to prove the somewhat convoluted logic reinforcing such an ethic.

Furthermore, additional criticisms to these ethics exist which draw attention to their potential failings. MacLaurin and Sterelny address a substantial problem with the idea put forth by Eliot Sober in his work “Philosophical Problems for Environmentalism”. This “ubiquity problem", according to Elliot Sober, lies in the fact that option value seems to be "turning ignorance of value into reason for action" (Sober, 1986, as taken from MacLaurin and Sterelny, 2005, pp. 156).

Amongst his varied criticisms of common environmental arguments, Eliot Sober (1986) addresses transformative value and other precautionary arguments with a critical focus. As mentioned earlier, Sober's powerful objection to the use of precautionary ethics is that a logical "jump" is made from a position of ignorance or uncertainty to a point at which a decision is made. Ignorance, Sober rather rationally argues, is not reason for action. In his words, "If we literally do not know what consequences the extinction of this or that species may bring, then we should take seriously the possibility that the extinction may be beneficial as well as the possibility that it may be deleterious"(Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 176). In other words, the mere uncertainty of an outcome associated with a particular action does not present justification for action. The logic of this criticism forces proponents of precautionary ethics to take a step back and temper the claims of this point of view.

MacLaurin and Sterelny's response to Sober's problem is that some knowledge should be gathered for option valuation; in other words, we "need to be knowledgeable enough to ignore very remote possibilities" and be "ignorant, but not too ignorant" (MacLaurin and Sterelny, 2008, pp. 156). This "partial ignorance", they argue, is what makes option value work; conservation scientists can place value on a large number of aspects of biodiversity based on limited (but convincing) knowledge of the sciences without having to place value on positively anything and everything that might possibly have value at some point in time. The emphasis of this ethic is thus on *probabilities*, meaning circumstances which, according to our knowledge, are likely (or probable) to occur, as opposed to *possibilities* which are any circumstances which might possibly occur. It is evident that there must be some cutoff, then, at which the value of a species (or the circumstances or preferences leading such value) becomes probable rather than simply possible.

Naturally, this would be when current research points in this direction more strongly than knowledge to the contrary. This hypothetical "cutoff probability" may thus lie just above a half-and-half chance. If human beings are surer that benefits will come from valuing a species than they are that harm will come from it, it makes logical sense to attribute some value therein. How *much* value, for that matter, may simply depend on how convinced human beings are of the potential benefits versus the potential costs.

It should be noted that this version of a precautionary ethic is *not* equivalent to the sort of probability-to-value calculations by which demand values of uncertain outcomes are determined, for instance, those in which a 50% chance of gaining $100 is valued at $50. If the probabilities of certain beneficial effects of species conservation were known, there would be no issue regarding the evaluation of species. In the case of option value, no real probability is known; the uncertainty still exists, but certain indications, logical or intuitive, suggest that a desirable outcome is more probably than an undesirable one. I, for one, would hesitate to blame the ethicist who encouraged the conservation of great whales even if in centuries to come great whales were the cause of some great human catastrophe. The undesirable effect of conservation in such a case seems unlikely, and thus the potential benefits outweigh these costs.

While this amendment to the option value option eliminates a good deal of its logical issues, it should be noted that it causes precautionary ethics to lose a key advantage over demand values; the satisfaction of the collectivity condition. Though they have maintained the satisfaction of the prioritization condition and have been made more convincing and logically sound, precautionary ethics lose out on inclusiveness. Because value can only be attributed to biological phenomena that human beings believe will have some value or the potential to change preferences in the future, certain hypothetical species, *especially* those about which humans are particularly ignorant, are not attributed value. Thus, precautionary ethics, not unlike demand value ethics, sacrifice some inclusiveness for practicality and logical soundness. In contrast to demand value ethics, precautionary ethics are substantially more inclusive, which is reasonable. A major disadvantage, however, as mentioned earlier, is that precautionary ethics are difficult to conceptualize and, given more recent modifications regarding probable circumstances, require substantial research to be effective.

II.6 Further Ethical Considerations for Conservation

Having addressed the three main categories of biodiversity evaluation—intrinsic, demand, and precautionary—and their respective advantages and disadvantages, it makes sense to discuss additional considerations for a biodiversity ethic that do not necessarily fall into any of these three specific categories.

In his essay "Philosophical Problems for Environmentalism", Eliot Sober (1986) reveals a powerful concern for biodiversity ethics while relating a common ethical argument for intrinsic biodiversity ethics to arguments regarding abortion. What Sober calls "slippery slope" arguments state that, because no line can be drawn in situations of "degree" (like species extinction) where many increments stand between one state and another, each increment must be given the value or priority of the entire state change to prevent the change from occurring, or else they may simply encourage the mindset that they have no value at all. With regard to environmentalism, Sober explains that "if it is the *wholesale* impoverishment of the biosphere that matters, one would apparently have to concede that each extinction matters a little, but only a little..." but if species are valued this way, people may be "inviting the wholesale impoverishment that would be an unambiguous disaster" (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 177). Thus, with these arguments in mind, allowing the extinction of a single species permits the extinction of the next, and so on, thus eventually leading to the catastrophic results of ecosystem failure.

Sober likens this mindset to arguments used in the abortion debate; interestingly enough, ones which serve both sides. Anti-abortionists, for example, argue that because infanticide is considered extremely unethical, and no distinct line can be drawn between a fertilized egg and a 9-month old where it is or is not considered as valuable as an infant or newborn, abortion at any age must be equally unethical. Thus, it must be unethical to kill a zygote at any stage of development in order to prevent the sort of thinking that permits infanticide. At the same time, such arguments are used to justify abortion, with the logic that because it is permissible to abort a zygote or a fertilized egg, and no clear defining line can be drawn between that egg and a fetus at advanced stages of development, abortion should be permissible at any age.

Both of these "slippery slope" arguments, as explained by Sober, rely on the fact that there is "no place to draw the line", but, he argues, "the fact that you cannot draw a line does not force you to say that two alleged categories collapse into one" (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 178). Sober thus argues that situations of degree (including abortion, species extinction, and the loss of other biological phenomena) require a different way of thinking. Regarding species loss, Sober explains that "Since the biological differences are ones of degree, not kind, one may want to adopt the position that the moral differences are likewise matters of degree" (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 178). In this regard, while it can be granted that all species (and other components of biodiversity) have some value, this value increases with their rarity; as more and more species go extinct from human action, greater and greater justification will be needed to warrant further human-caused extinctions. According to Sober, "This means that one can value diversity without being obliged to take the somewhat exaggerated position that each species [or component of biodiversity], no matter how many there are, is terribly precious in virtue of its contribution to that diversity" (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 179).

This sort of thinking eventually leads to the framework of a separate environmentalist ethic, one which may apply quite well to biodiversity conservation. Sober's aesthetic ethic is explained through a comparison of biological phenomena to works of art and the way we value them. As Sober explains, “our attachments are to objects and people as they really are, not just to the experiences they facilitate” (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 189). In terms of art and biological phenomena, this means that what people value in these things is not simply their instrumental value as a provider of certain experiences, but in some actual connection humans make with those phenomena. This sort of thinking forms a new justification for a sort of intrinsic value ethic based on aesthetics. Though it seems almost intrinsic, it should be noted that this sort of value is *not* independent of the “valuer”; while some concept of an object or concept’s connection to a human being (it’s “genuineness”) is being valued, the connection being valued cannot exist unless both the object and the “valuer” exist.

Continuing to draw parallels between components of biodiversity and artwork, Sober also asserts that an aesthetic evaluation would promote the evaluation of higher organizational levels of biodiversity including ecosystems and larger taxonomic classes. He introduces the idea that works of art are valued not just in substance but in *context*. Just as a work of art is valued more in its original setting, an endangered species would be additionally valued in the context of its habitat. As Sober explains, “This leads to the more holistic position that preserving ecosystems, and not simply preserving certain member species, is of primary importance” (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 189). By this logic, aesthetic value can be attributed to all organizational levels of biological phenomena, thus satisfying the collectivity adequacy condition.

Sober next addresses his earlier ideas with regard to matters of degree, explaining that in a system of aesthetic value, rarity is also an important quality. By this logic, “A work of art may have enhanced value simply because there are very few other works by the same artist,” (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 190), and subsequently, when “viewed as aesthetic objects, rare organisms may be valuable because they are rare” (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 189). In this way, Sober's aesthetic ethic makes use of his earlier assertion regarding matters of degree, and thus resolves the problem of using “slippery slope” arguments, which often reduce the value of biodiversity to either purely intrinsic or purely instrumental, and opens an avenue for species prioritization based on their rarity.

Focusing more keenly on the adequacy conditions outlined at the beginning of this section, it is evident that Sober's aesthetic value ethic is indeed a successful candidate as a conservation ethic. The generality condition is satisfied, because aesthetic appreciation has no real limit to *what* exactly can be valued. The only constraints on the inclusivity of this ethic would be in the aesthetic desires of those who hold it; naturally it would be desirable that through environmental education human beings find all biological phenomena aesthetically valuable. It is thus conceivable that all components of biodiversity outlined earlier could be valued in this sense. The collectivity condition is also thoroughly satisfied, because as Eliot explained, often what is aesthetically valuable about pieces of art is their *context*, and thus the surrounding phenomena of larger organizational levels are also to be valued as related to certain especially valued phenomena. In this regard, the entire ecosystem and community understood to relate to a specific endangered species would be given equivalent or near-equivalent value to the species itself. At the same time, the individuals that make up that species would also be valued. In this way, the aesthetic value ethic serves to attribute value to all organizational levels, not simply species or individuals. The all-taxa condition is initially concerning, as human beings clearly tend to place more value on the aesthetics of charismatic species, but, as Sober explains, what is truly valued is the object (or phenomenon), and not the experience it gives. Therefore, as with works of art that are not necessarily “charismatic”, aesthetic value is attributable. As mentioned earlier, the priority-setting condition is satisfied by the evaluation of rarity in the aesthetic value ethic, which necessitates increasingly great justification for allowing a phenomenon to become “extinct” as it becomes rarer.

The ethic fails the “non-anthropocentrism” adequacy condition, though, given its minimal importance, this is a negligible shortcoming. The aesthetic value ethic encounters the majority of its problems when confronted with the comprehensibility condition, and for a number of reasons. From the very beginning, its name may pose a problem, suggesting at first that a sort of hollow valuation of species simply as objects of viewing pleasure. This sort of misinterpretation creates the sort of reflexive opposition aesthetic value ethics commonly encounter from the rest of the environmental community. Sober hypothesizes that environmentalists may “feel that aesthetic concerns are frivolous” or “antithetical to a proper regard for the wilderness” (Sober, 1986, as taken from Schmidz and Willott, 2002, pp. 191), and though he assures readers that such responses are unfounded, their prominence as an immediate reaction remains. In this way, without additional explanation and analysis, this ethic loses much of its intuitive pull.

II.7 Is there no “Just Right”?

The preceding review of ethical values ascribed to various components of biodiversity should provide the reader with a thorough and organized account of the sort of options available to conservationists in justifying their efforts and the respective advantages and disadvantages involved with each. It is evident that no “one ethic” has been constructed which flawlessly accomplishes all the goals of a conservation ethic while additionally satisfying conditions of adequacy and rational criticism. Instead of one grand or universal solution, conservationists are faced with a set of ethical tools which are appropriate for separate contexts and appeal to different interest groups.

Intrinsic value ethics are perhaps the easiest to understand of common conservation ethics, with almost spiritual implications regarding morality and obligations toward other forms of life. The intuitive appeal of these arguments makes them practical for application in "grass-roots" movements and in non-legal sectors of conservation. A lack of purely rational justification and prioritization makes these somewhat cruder ethics difficult for the implementation of conservation legislation and largely unconvincing to cynical or self-interested individuals.

Demand-value ethics or anthropocentric ethics tend to be the most practical and commonly cited, with strong intuitive pull and logical soundness. Their main weakness lies in the uncertainty in scientific knowledge regarding biodiversity and the ways it benefits human beings, particularly regarding the diversity-stability hypothesis. Demand-value ethics are easy to understand and difficult to argue against, though they may fall short in attributing value to all aspects of biodiversity. A distinct reliance on scientific research is a key hindrance to these ethics, and one upon which their future success will depend.

Precautionary ethics have some reasonable intuitive appeal and escape the weaknesses of demand value ethics with their reliance on complete information and research. These ethics bridge the gap between the satisfaction of human interests and the uncertainty involved with the benefits of certain components of biodiversity to the rest of the biosphere. In the process, however, they expose new vulnerabilities, including problems of directionality. Additionally, precautionary ethics may be particularly difficult to conceptualize and may be inaccessible to uneducated individuals or those who must make conservation decisions within a limited amount of time or with limited available information. For this reason, such ethics may be inappropriate for some educational purposes and for encouragement of environmental stewardship in societies with poor education systems.

An aesthetic value ethic avoids claims of instrumental value to human beings and instead values a sort of "connection" between human beings and the authentic objects that they value. Aesthetic value also eliminates the reliance on the heavily disputed diversity-stability hypothesis and avoids the directionality issues of precautionary arguments. Such an ethic provides a rational explanation for why rare species, though possibly less influential on their environment, should still be preserved. In so doing, aesthetic value ethics satisfy the generality and all-taxa conditions, and with the additional necessity to conserve "context" as well as the object of value, also satisfy the collectivity condition. The moral force condition, by contrast, may not be satisfied, as many human beings see aesthetic interests as frivolous or unimportant. Additionally, such ethics may not distinguish the value of components of biodiversity above cultural artifacts, which could pose substantial obstacles for conservation.

Thus, amidst the sometimes overwhelming wealth of ethics available to the conservationist, it seems there is no particular ethic that is "just right". Though I will not deny the possibility that such an understanding or relationship with the natural world exists which might form a perfect ethic, I will assert that this "perfect ethic" has yet to be found. For this reason, as mentioned earlier, the utility in the preceding analysis is not in a "ranking" of the best to the worst available ethics, but to highlight the particular strengths and weaknesses of each. With this information, a given ethic may be more effectively applied to a context in which it is particularly effective or useful.

II.8 A Pluralist Conservation Ethic

The ethical approach which arises from this perspective on biodiversity ethics is certainly a pluralist one; to consider a variety of ethics appropriate for a variety of contexts, one must concede that there is no overriding "master ethic" which governs them all. According to Andrew Light (2003), a "master ethic" is not feasible in an environmental ethic "either (1) theoretically, because the sources of value in nature are too diverse to account for in any single value theory or (2), practically, because an environmental ethics sufficient to motivate enough people to extend moral consideration to the nonhuman natural world would have to appeal to a broader range of intuitions about the value of nature than is found in the work of any single approach to environmental ethics" (Light, 2003). My adherence to a pluralist ethic is motivated by the latter reasoning. While I do not necessarily believe that no "master ethic" exists or can exist, I do believe that human knowledge of natural systems is insufficient to create such an ethic. For that reason, not unlike my approach to a similar problem in part I, I propose a "next-best-thing" approach with the interest of finding a workable solution to a problem in which time is of the essence. Thus, I make the case here for a "practical pluralist" perspective on biodiversity ethics, not denying that some great "divine ethic" may exist, but taking the responsibly humble and cautious stance that the human race may yet to have discovered such an ethic. As Andrew Light put it, "we literally do not have the time to await agreement all the way down," (Light, 2003); ethical systems are needed *now* to provide a rational framework for conservation, and it is clear that certain ethics fit some situations better than others.

Thus, "as long as our different moral frameworks are oriented toward the same environmental priorities, we can ignore <u>for the time being</u> many of the issues of the truth about which reason for valuing nature is actually right" (Light, 2003). As explained in the beginning of this section, it was never my intention to label one ethic as right and another as wrong; it is instead to propose a practically effective ethic involving a mixture of the preceding perspectives. Naturally, this strongly pluralist perspective is not without its opposition. There is considerable controversy in philosophy between monist and pluralist perspectives, and in the final paragraphs of this section I will briefly defend this pluralist perspective as it relates to the application of conservation ethics.

J. Baird Callicott (2003) takes a formidable stand against pluralist ethics which is well worth mentioning in this section. Attacking the customary definition of pluralism, which explains that an agent may shift from one set of ethics to another where certain ethics are more appropriate, Callicott explains that such thinking leads to a sort of “moral promiscuity” in which an agent will simply employ whatever ethic “gets the job done”. Such “moral promiscuity” could conceivably lead to the justification of horrible acts (Callicott, 2003).

Andrew Light’s response to this objection is one regarding specifics. While pluralism in its purest form may indeed create the possibility of moral pluralism, *practical* pluralism, by contrast, employs pluralism only by necessity and not as a standard; it thus acknowledges the superiority of a “master ethic” if such a thing were to exist, but makes do in its absence. As Light puts it, “the practical pluralist does not necessarily advocate the need for a single agent to shift from one moral theory to another based on the relationship at hand, but rather encourages the articulation of a diversity of moral arguments for the same end” (Light, 2003, pp. 236). It is evident that the practical pluralist employs a pluralist perspective cautiously; such is the approach with my suggestion of a pluralist biodiversity ethic. Especially with the overwhelming consensus in favor of some form of biodiversity conservation, I am confident that the use of a pluralist ethic will not lead to the justification of deplorable action. This is not to say that a pluralist approach does not have its problems.

The most prominent stumbling-block of any pluralist ethic is the idea of “contradictory indications”. Naturally, if ethics are different, in certain situations they may differ in what sort of action they prescribe. In a biodiversity conservation context, the use of multiple ethics may conceivably create several different courses of action regarding a single set of circumstances. For example, assume that the only population of a certain distinct subspecies of jewelweed lived in the same meadow in which a children’s hospital was to be built. Option-value thinkers would suppose that the value of saving hundreds of youngsters from injury and disease would outweigh the potential genetic value held in a rare subspecies of an otherwise fairly common plant, while intrinsic value thinkers may have a more complicated situation weighing one form of life against the other. Demand value conservationists, by contrast, would have little predicament at all. Thus, which ethic, if any, is to be given priority, and how will such conflicts be resolved? As Callicott explains, “attempting to act upon inconsistent or mutually contradictory ethical principles results in frustration of action altogether or in actions that are either incoherent or mutually cancelling” (Callicott, 2003, pp. 208). It is clear from this line of thinking that inconsistencies pose a threat to the viability of pluralist ethics.

Referring once more to the overwhelming consensus regarding biodiversity conservation, I first make the simple argument that such cases of blatant disagreement will be for the most part rare, and certainly not impossible to resolve through legal mediation. After all, conflicts of interests are an everyday part of the real world which policymakers and activists alike continually encounter. The possibility of conflict and argumentation has been present in all political and ethical systems; to forbid or intentionally prevent such issues would bear great resemblance to a dictatorship.

Conceding still that a consistent system for conflict settlement is necessary, I believe that—until a more universally applicable conservation ethic is found—ethical decisions within this pluralist framework should be settled as similar decisions are today: by the government or courts. More specifically, because I have suggested that particular ethics are especially appropriate for certain contexts, I assert that ethical decisions made within these contexts should be bound by those ethics, and each “context” should have use of whatever authority is normally vested in it. Because precautionary and demand value ethics are apparently the most logically sound and practically applicable methods of evaluation, it makes sense that they be put to use in governments, and thus that government action in conservation be according to such ethics. By contrast, intrinsic value or aesthetic value ethics, far less appropriate for policymaking but more intuitively appealing and easy to understand, are better employed in environmental education and on cultural grounds, especially for those who lack the philosophical and statistical training to make complex assessments involved with precautionary ethics. This sort of attitude toward intrinsic evaluation of natural phenomena is often congruous with a respect for native cultural or religious views necessary for positive interaction.

Following the way most societies are organized today, precautionary ethics would thus have some priority, as government powers are generally responsible for policymaking, though the larger public, likely more disposed to intrinsic value ethics, would have the ability to contest decisions and influence policy. Thus, my idea for a pluralist ethic is to have ethics employed where they are most fit, and then allow decisions to be made the way they are in similar ethical debates where disagreements arise.

In this way, I propose here the use of a pluralist biodiversity ethic with the intention of providing well-rounded justification for conservation management and providing an ethical framework for the great diversity of ethical relationships humans have with an even greater diversity of biological phenomena. This approach is not intended to be an end-all solution to biodiversity ethics, but a step in the right direction, a best possible approach to utilize until something more fitting is available. As with other issues in conservation biology, human beings do not necessarily have the time to await theoretical perfection before acting to save biological variety. Instead, like with our growing definition of biodiversity, adaptive management must be guided by adaptive ethical frameworks.

The perspectives formed in the preceding two sections are again largely meaningless without application to real-world conservation situations. As is often said, conservation biology is a “science of necessity”, and thus values practical application as much as theoretical understanding. In the third and final section of this text, the real-world implications of earlier theoretical arguments will be explained and suggested for application in conservation biology.

Section III: How to Preserve Biodiversity?

III.1 Applying Theory under Uncertainty

While theoretical challenges like defining biodiversity and justifying its conservation are integral parts of any effort to conserve natural phenomena, such answers—difficult as they are to attain—are not enough to resolve issues of global conservation. Naturally, practical issues—from planning to application—must also come into play if philosophical and ethical understanding will be put into practice. As Bryan Norton put it, "the problem is that the brilliant theoretical insights of Leopold have proven frightfully difficult to operationalize" (Norton, 2003, pp. 114). From a practical standpoint, no amount of correct thinking and logical or spiritual acumen will manifest actual change unless properly applied. In regard to the previous two sections of this work, the words of Bruce Lee come to mind: "Knowing is not enough, one must apply. Willing is not enough, one must do."

Thus, though I have already provided a tentative outline for defining biodiversity and a practical-pluralist ethic to clarify the necessity and target(s) of conservation, a great "how" clause is left unanswered, and it follows that discussion should shift to how best to manifest this understanding in conservation measures in the future. Even if the justification of biodiversity conservation is not agreed upon, the general consensus remains in favor of conservation. As a “science of necessity”, “the protection of biological diversity must proceed” even “amidst considerable uncertainty” (Norton, 2003, pp. 126).

The third and final section of this work focuses on evaluating the conservation practices in use today and presenting suggestions based both on the concepts of the first two sections and on the work of other authors. Needless to say, the full range of conservation measures and practices employed worldwide is an enormous and varied study subject. To narrow the scope of analysis to a level appropriate for this work, a single case study will be employed as a focal point for criticism and an exemplar for future projects.

III.2 The Republic of Costa Rica: A Case Study in Conservation

The Republic of Costa Rica, a country with no military and an economy based largely on ecotourism, has a reputation as an environmental leader; it is ranked 3rd in the world by the 2010 Environmental Performance Index for its efforts to conserve its astounding natural heritage (Yale Center for Environmental Law & Policy 2010). Often considered the “greenest country in the world”, Costa Rica makes good use of the wealth of biological phenomena in a territory roughly the size of Virginia, with income from ecotourism exceeding that of all exports combined since the late 1990's (ICT 2006). By 1999, revenue from tourism composed 9% of the nation's GDP, about $950 million. In its tiny landmass, Costa Rica is thought to contain about 5% of the world's known species, with at least 500,000 identified species (INBio Website, 2010). In addition, over 25% of the national territory falls under some form of legal protection for conservation purposes (INBio Website, 2010). Costa Rica makes an ideal case study for an investigation of conservation policy and action, referred to “as an example of a country that has wholeheartedly embraced sustainable development with protected areas as the centerpiece” (Brandon, 2004, pp. 299).

Indeed, the country has shown a long-standing commitment to environmental and conservation issues, evident in the myriad laws and government agencies it has devoted to such purposes. In fact, the environment is included in the constitutional rights of its citizens (Salazar, 2004). The constitution of the Republic of Costa Rica lists amongst its priorities conservation and the protection of natural beauty, and grants all its citizens a right to “a healthy and ecologically balanced environment,” (GOCR 1984). In a more recent amendment, this statement asserts that “Every person has the right to a healthy and ecologically balanced environment. Therefore, he or she is justified in denouncing any act that infringes upon that right and claiming reparations for the damage caused” (GOCR 1994).

Over the last 30 years, the government of Costa Rica has also delegated environmental responsibility to a variety of organizations created often exclusively to address conservation issues. For example, in 1978 the National Parks Foundation was created, a group dedicated to the management, protection, and planning of the country's many national parks. Eight years later, the government designated a ministry intended to bring conservation policy to equal status with extractive policy (forestry, mining, agriculture, etc.), which brought these policy decisions to a single organization. MINAE (The Ministry of Environment and Energy), as it was called, worked to solve a problem common to most Latin American countries stemming from inconsistent government policy and low prioritization of environmental issues (Brandon, 2004; Rudel and Roper 1996, 1997). Over the next three years, SINAC (The National System of Conservation Areas) was established as a conservation-focused subset of MINAE, and INBio (National Biodiversity Institute) was formed to create a central authority to inventory the country's abundant biodiversity (Brandon, 2004). A more recent program started in 1996 established a number of market-based mechanisms encouraging conservation, including the elimination of subsidies toward activities which degraded the environment, and direction of revenue flow from users to providers of environmental services. In this way, the owner of a private reserve containing a mangrove ecosystem which improves water quality might receive payments taken from environmental taxes paid by a corporation which regularly deposits wastes in the same aquatic systems (Brandon, 2004). With such powerful legislation supporting environmental sustainability, and a multitude of ministries and organizations devoted to the conservation of biological phenomena, it is clear why Costa Rica might be lauded as an exemplary “green nation”. Predictably, though, and like any other country, Costa Rica has its problems, making it clear that even a country with this level of environmental commitment still has much room for improvement.

Given the prescriptive purpose of this section, greater emphasis will be placed on the environmental and conservation-related *problems* in Costa Rica than on its accomplishments. I would like to emphasize, however, that these shortcomings are not unique to Costa Rica and that they in no way belittle its respectable efforts toward biodiversity conservation and sustainability. Much can be learned from the successes and stumbling blocks of various conservation initiatives undertaken in Costa Rica over the last few decades, but the country’s massive accomplishments in conservation are far from negligible.

Perhaps the greatest problem with Costa Rica's seemingly unmatched commitment to conservation is summed up in a quote from the Ministers of the Environment World Forum (2000), which states that “there is an alarming discrepancy between commitments and action.” Though the strength of legislation described earlier seems absolute, it must be understood that, like any abstract idea, a law has no effect unless accurately followed; therein lies a large issue for Costa Rica. As Roxana Salazar (2004) eloquently explains, “In Costa Rica, environmental destruction is, at least in part, the product of poor interpretation and lack of enforcement of the laws, as well as the shortcomings in the laws and public policies themselves” (Salazar, 2004, pp. 281). Indeed, most critics of Costa Rica's environmental efforts cite poor implementation of admittedly aggressive and generally solid policy (Brandon, 2004). These critics and observers of the country’s environmental policy cite one issue with overwhelming unanimity: enforcement. “The most serious problems lie in enforcement,” explains Salazar, adding that various judicial boards all-too-often approve funding for projects which are detrimental to the surrounding environment (Salazar, 2004, pp. 282). Enforcement, says Salazar, is “hindered by a deficiency of clear policies, inadequate budgets and human resources, and lack of follow-up evaluation and verification mechanisms” (Salazar, 2004, pp. 281). The scientific ignorance of legal officials and local staff are also commonly bemoaned inhibitors to the proper implementation of Costa Rica's impressive policies (Bustos, 2004; Quesada & Stoner, 2004; Salazar, 2004).

Though it is clear that regulations are not being adequately implemented, the policies themselves are not without their shortcomings. According to Julio Alberto Bustos (2004), the government's tendency to pass green laws with little thought or consideration leads to an overabundance of conflicting and overlapping legislation which often muddles environmental issues beyond recognition (Bustos, 2004). In this way, issues can rarely be clearly resolved and questions of environmental and ethical justice are left largely unanswered. A statistic provided by MINAE states that, despite attempts at legal enforcement, amidst this tangle of legislation and weak enforcement more than 25% of all commercial wood harvested in Costa Rica is illegal. Bustos explains that the overwhelming impunity of violators of environmental law is due to the complex web of environmental organizations and officers (MINAE, the Office of the environmental Comptroller, the environmental Tribunal, the Environmental Prosecutor, etc.) through which information must be passed to bring criminals to justice. Communication and power distribution between these various parties is patchy and inconsistent, resulting in an overcomplicated and often ineffective legal system.

Environmental criminals, then, due either to apathy, ignorance, lack of enforcement or discombobulated judicial processes, go largely unpunished for their acts. This concept was clearly illustrated to me during my stay in Costa Rica, where streams running into the ocean from a banana plantation nearly five miles away often ran a slight silvery-blue with fertilizers and pesticides, and where a local man told me without hesitation that he regularly poached eggs of the endangered Hawksbill sea turtle (*Eretmochelys imbricata*) while helping his best friend—an employee for a local sea turtle conservation project—put up posters discouraging the consumption of turtle eggs.

Among the myriad problems arising from the poor enforcement and the structure of Costa Rica's environmental policies, even ecotourism, usually reputed as the ultimate, mutually-beneficial environmental solution combining economic and environmental benefit, causes immense problems for conservation. In the case of the endangered sea turtle populations who rely on Costa Rica's two coasts for nesting grounds, ecotourism has become an enormous problem. Due to the incredible growth of the tourist industry, land development in Costa Rica increased by 600% from 1998 to 2008, and with a lack of proper infrastructure, 97% of sewage from these new developments runs untreated into rivers, streams, and eventually the ocean (Sherwood, 2008). Resulting algal blooms smother offshore coral reefs and the incredible biodiversity they support, not to mention the source of revenue which brought tourist operations there in the first place. At the same time, sea turtle nesting sites are constricted by rising storm surges and sea level due to global climate change and the gradual descent of tourist developments further and further onto Costa Rica's beaches. With shrunken nesting sites and high illegal poaching rates, the Pacific population of the endangered leatherback sea turtle (*Dermochelys coriacea*) has declined more than 97% since 1988 (Rosenthal, 2009).

The issue for ecotourism in Costa Rica appears to be not simply in practice but in mindset. Ecotourist enterprises have allowed the environment to be used in an exploitative fashion when they were intended to protect it. Many authors cite the increasing number of luxury resorts dotting the Pacific coast, which provide everything from swimming pools to golf courses for alleged ecotourists (Rosenthall, 2009; Sherwood, 2008,). Considering the ethical issues reviewed earlier in this book, it appears that demand-value ethics involved with ecotourism become harmful and exploitative when not tempered by a solid understanding of ecological principles and scientific research. What was originally intended to connect economic and environmental wellbeing has instead resulted in large-scale ecological degradation. As illustrated by the majestic and gigantic leatherbacks, when ecotourism runs unchecked, it destroys the very phenomena on which it thrives.

The troubling contrast between Costa Rica's reputation and actual condition have lead to substantial efforts toward rectifying the situation and conserving the biodiversity that is still so heavily threatened. For the last two decades, countless authors and researchers have been addressing the problem and putting forth their own suggestions based on varying experiences with conservation work. I will summarize a generalized list of suggestions for biodiversity conservation initiatives from the work of these authors and allow this to broaden to more universal guidelines as this section continues.

III.3 Data Collection and Inventorying

Paul Hanson (2004) explains that the first shortcomings in biodiversity conservation efforts arise in the collection of scientific data used in designation and assessment of conservation areas. Non-inclusive and biased inventories skew results and can “short-change” regions of the real value of their biological phenomena. If conservation decisions are being made upon false data, they are simply not fulfilling their purpose. As Hanson explains, “inventorying and monitoring have involved organisms that are relatively well-known—taxonomically—for example, vertebrates and vascular plants. Yet the poorly known groups of organisms... constitute the majority of the species” (Hanson, 2004, pp. 299). According to some researchers, it is these “taxonomically difficult” and generally less heavily studied groups—like insects, fungi, microbes, and some plants—that are often better indicators of environmental change (Hanson, 2004).

Hanson bemoans the decreased importance attributed to taxonomic research in developed countries, notable in the decreasing entrance of graduate students into such fields of study and funding cuts to natural history museums. Biological collections, he argues, are “every bit as valuable as their more dazzling counterparts in nuclear physics facilities,” (Hanson, 2004, pp. 299), in that they, too, hold potential value in the untold secrets they contain—an argument strongly based in the precautionary ethics explained in the previous section. This value, Hanson explains, is further increased in the field of conservation biology, where accurate assays of biodiversity (in this context, measured simply by abundance of species) are invaluable for conservation decisions.

INBio, Costa Rica's institute dedicated to biodiversity inventories, sets a good example for future conservation programs in other countries in both its successes and failures. Hanson (2004) reviews the methods employed by the various INBio research centers in Costa Rica and presents suggestions for their improvement. The institution is focused on cataloguing as many of the species present in Costa Rica as possible, and thus abides by a very narrow, almost traditional definition of Biodiversity—that is, as defined only by a species count. The chief mechanism by which surveys are carried out is through the work of “parataxonomists”, local people from villages adjacent to protected areas that are trained in data and specimen collection. The specimens brought in by parataxonomists are then identified, classified, and catalogued by trained technicians (Hanson, 2004; Janzen et al, 1993). Apparently, the method of employing local parataxonomists is very productive, and enabled INBio to collect massive amounts of data. As Hanson explains, “the team of parataxonomists in Guanacaste Conservation Area have produced more specimen-based information on host ranges of parasitoids than was previously known from all of tropical America” (Hanson, 2004, pp. 231).

While this form of data collection does enable rapid sampling on a large scale, it does have its shortcomings. Certain species are difficult to acquire or are particularly rare in certain areas and thus often not collected. In other cases, overzealous collecting can yield to oversampling of more common and easily acquired species. Even after specimens are acquired, it is often incredibly difficult to identify them accurately (even if the species has a name—many are yet nameless) without assistance from experts. All technicians and taxonomists in INBio research centers are either experts from foreign universities or trained by them. In this way, the programs rely heavily on training form outside professionals for expertise and do not have a large enough knowledge base to run independently. Naturally, this creates a huge demand for trained personnel and the money to afford further training and employment of trained personnel, not to mention access to scientific literature which might contribute to the feeble knowledge base (Hanson, 2004).

Beyond issues with staff, INBio experiences more concrete limitations on its biodiversity inventories. For example, Costa Rican law only requires that trees and vertebrates be included in environmental impact studies (Hanson, 2004). It is understandable how such a narrow scope might limit biodiversity assays, especially when around 300,000 of Costa Rica's 500,000 named species are thought to be insects (INBio website, 2010). Additionally, inventories are only carried out in national parks and protected areas, but not in private reserves and private property not set aside for conservation (Hanson, 2004; Herzog and Vaughan, 1998). This sort of inventorying gives a “patchy” and incomplete look at the country's biodiversity, and would fail to detect potential hotspots for conservation if they existed on property not currently being protected. From the standpoint of this paper, it is clear that even if expanded to include all taxa, the INBio approach to biodiversity inventories may still be too narrow a perspective. To provide an accurate and clear assessment of valuable biological phenomena, many more components must be studied, including behavior, disparity, community composition and entire ecosystems.

Even if INBio is forming an accurate portrayal of Costa Rica's biodiversity, Hanson argues that their discoveries are not adequately publicized. As Hanson explains, “the information obtained from inventories has to be made available for a variety of uses, notably scientific advancement, environmental education, and conservation management,” (Hanson, 2004, pp. 234). Though publications are produced, they are poorly distributed and do not effectively reach policymakers and conservation biologists in a reasonable timeframe. Needless to say, if information so painstakingly collected cannot be put to use for its intended purpose, further efforts at accurate data collection are useless.

It is clear that inventories are a crucial part of the conservation process. Without an accurate idea of what biodiversity is found and in what locations, human beings would be helpless to conserve components of biodiversity *in situ*. As the most widely practiced and practical method of data collection available, biodiversity inventories are certainly a critical part of any conservation plan. As Hanson explains, “the urgency of the current situation requires us to select areas that need protection on the basis of existing information and rapid biodiversity assessments” (Hanson, 2004, pp. 233). Biodiversity inventories are still the most efficient way to obtain such information. However, the accuracy of biodiversity inventories today leaves much to be desired. Most inventories are based only on species counts and occasionally classification of ecosystems. With regard to the definition of biodiversity established earlier, such criteria are understandably too narrow. While it is not unthinkable that surrogates and indicators for biodiversity may exist, inclusive assessments of biodiversity are still important and may even be required to identify such surrogates. While the participation of local employees and volunteers is a powerful tool, it must be reinforced with sufficient scientific knowledge and staff expertise. Thus, funding for hiring trained professionals and providing access to scientific journals is immensely important. Lastly, information gained from inventories must be distributed to both the public and other targets of interest so that it can properly be put to use in policy and management.

In addition to the suggestions presented by other authors for biodiversity inventorying, I would also like to address the implications of part I of this work to this issue. The type of biodiversity inventories described by Hanson—and being carried out around the world—focus almost exclusively on a species count. The first section of this work clearly indicates that such measurements—while they do encompass a very important part of the evolutionary process—do not assess biodiversity in the myriad forms by which it is defined. Thus, future biodiversity inventories should devote resources to a more inclusive study of biological systems, taking note not only of species count but other important and valued phenomena like ecosystems and morphological disparity.

While it is easy to criticize those who carry out modern biodiversity inventories, it is quickly obvious that the use of species-counts for inventorying is largely a matter of practicality; the measurement of other components of biodiversity is unclear and likely time-consuming. With this in mind, I concede, as do other authors, that when time and resources are especially scarce, species counts function as an acceptable—though far from ideal—surrogate. However, it will be necessary to provide some suggestions on how to measure the additional components that I argue should be taken into account.

Fortunately, many authors making similar arguments felt the same need to present constructive suggestions along with their criticisms of the common definition of biodiversity. These suggestions shall be summarized here in addition with my own. MacLaurin and Sterelny, for instance, suggest the addition of morphological and developmental diversity to biodiversity assessments, providing a surprising solution for the problem of quantifying such phenomena. The concept of a "morphospace", according to MacLaurin and Sterelny, "can represent patterns of phenotypic evolution independently or issues of phylogeny and species richness" (MacLaurin and Sterelny, 2005, pp. 82). A morphospace is a theoretical space which assigns individual dimensions to specific traits or characteristics to a set of organisms (MacLaurin and Sterelny, 2005). Each individual organism can thus be placed as a set of points or a shape within the space based on those characteristics, enabling a quantified comparison of organisms with the characteristics they share. MacLaurin and Sterelny hastily reject the concept of "global morphospaces" which compare all possible organisms, explaining that comparison of organisms which do not share certain traits would be largely ineffectual. Instead, they suggest the use of "partial morphospaces" to compare organisms within a population or species which share a set of common characteristics. In this way, morphospaces become a powerful analytical "tool" for assessing qualities of morphological disparity between subspecies or other smaller subpopulations of a larger taxonomic unit.

Some key questions regarding the use of morphospaces are left unanswered by this explanation. For example, *which* characteristics of a given species or population will be used? Of the conceivably infinite traits one could ascribe to a given organism, which are the most appropriate? MacLaurin and Sterelny explain that developmental differences play a key role in solving this problem. They maintain that the developmental traits of an organism provide the "principle" which can standardize and regulate an investigation of disparity through the use of morphospaces (MacLaurin and Sterelny, 2005). "The developmental system of lineage", explain MacLaurin and Sterelny, "determines those aspects of phenotype that can vary independently" (MacLaurin and Sterelny, 2005, pp. 85) and therefore provides insight into which characteristics deserve attention and comparison in a morphospace. With this in mind, it is clear that the morphospace is not a perfect solution to the issue of measuring phenotypic disparity, but a tool which, if properly used, can be of great use in this context.

Thus, by restricting the use of morphospaces to smaller taxonomic units in which comparable characteristics and structures exist and proposing the use of developmental differences to select targets of comparison, MacLaurin and Sterelny present what I consider a viable analytical system to quantify morphological and developmental variety in the natural world.

As mentioned in part I, the potential for developmental variation in a species or population is measured by its phenotypic plasticity. It follows that inventories of developmental variation should focus on the phenotypic plasticity of a particular species as an independent characteristic by which it contributes to the overall diversity of a system.

Behavioral variation, too, is an additional source of biological variety and thus a candidate for addition to biodiversity inventories. The concept of measuring and quantifying behaviors is one already—and rather thoroughly—addressed by the field of animal behavior. Observational techniques employed in this field prove more than sufficient in providing data regarding variations in organism behavior. Behavioral inventories for many species are already available, and the organizational formats they use would make their inclusion in biodiversity inventories relatively straightforward. Though the level of expertise for behavioral inventories is highly variable and dependent on the organisms being inventoried, I would argue that the amount of training necessary for this type of data collection would be roughly equivalent if not superficially greater than that required for specimen collection. Additionally, the use of video and sound recording technology may enable untrained staff to collect evidence of behaviors without the need to identify them. Knowledge of behaviors carries further benefits for conservation by allowing conservation strategies for certain organisms to be devised according to their respective behaviors.

The addition of ecosystems to accounts of biodiversity is hardly a novel concept, but still one worth mentioning in this review. The study of ecology provides a number of systems which categorize specific ecosystems and allow their accurate identification, for example by observation of organism interactions and relationships or by more obvious, physical boundaries like the edge of a pond. As explained in part I, the degree to which certain ecosystems are apparent as some whole greater than the sum of the interactions of species within them has great implications for its importance in conservation. In addition, more cohesive ecosystems exhibit “co-evolution”, in which distinct lineages within the community interact and influence one-another’s evolutionary trajectory through their relationships to one another. In the case of these more coherent systems, the preservation of species’ distinct evolutionary trajectory depends also on that of one or more other species within the community, warranting the protection of the entire community. Thus, the assessment of ecosystems in biodiversity inventories should focus on determining the “coherence” of the ecosystem and its value independent of the organisms within it. More obvious and coherent systems should be recognized as independent (though certainly parallel) targets for conservation, while systems formed by much weaker levels of interdependence need not be strongly recognized.

Sahotra Sarkar (2005) points out that advances in computer programming such as GIS are invaluable for questions of space delineation, and are thus a powerful tool for the quantification of ecosystem diversity in biological systems. Such programs enable a variety of values to be assigned to specific areas, with clear or “fuzzy” borders to indicate the strength of transition to one state or another. As a result, these programs represent perhaps the most promising method of measuring and describing ecosystems in biodiversity inventories.

III.4 Environmental Education and Public Exposure

Once biodiversity information has been both acquired and distributed for analysis, it is essential that the lessons learned in biodiversity studies are shared for application elsewhere. While government and private institutions have the most centralized and formal power to confront conservation issues, the public sector retains the greatest potential. As with my discussion of the “comprehensibility condition” in section II of this work, I continue to stress here the importance of public participation in conservation initiatives and direct, everyday interaction with the environment. Without the support of the public, a government is virtually helpless to implement environmental policy. Even if enforcement, a great missing link in today’s biodiversity legislation, is adequate, it can never be universal, and everyday decisions (like littering or use of pesticides) cannot be constantly monitored. A good system of conservation thus focuses not only on solid policy and enforcement but on education and dissemination of information to keep the public informed to environmental issues and how they can help.

Gordon S. Frankie and S. Bradleigh Vinson (2004) explain that environmental education is the solution to this problem. They define environmental education (abbreviated EE) as “the interdisciplinary process of developing a citizenry that is knowledgeable about the total environment—including both its natural and built aspects—and that has the capacity and the commitment to engage in inquiry, problem solving, decision making, and action that will assure environmental quality” (Frankie & Vinson, 2004, pp. 248). By this definition, especially where the term “commitment” is employed, it is evident that EE includes not only an informative but an ethical component. Though naturally environmental educators must be cautious of the idea of indoctrination or forced education, the idea of including environmental ethics in education is a crucial one for affecting the countless numbers of seemingly insignificant, everyday decisions made by the public in their interactions with the environment. It is in the application of ethics to EE that the previously established “comprehensibility condition” comes into play to a greater extent, where more easily understood ethics are more appropriate for public education given their greater accessibility.

Frankie and Vinson (2004) cite one particular case where this sort of education worked particularly well. In the late 1980s, problems with forest fires in the Lomas Barbudal Biological Reserve in the Tempisque Conservation Area of Costa Rica were exacerbating problems of exotic vegetation invasion and devastating local plant and animal species alike. Many local citizens used burning techniques to destroy "pest" plants on roadsides and fields, but often accidentally triggered wildfires, an unnatural phenomenon in local ecosystems. Residents of the local town of Bagaces were trained in firefighting techniques in conjunction with the formation of "Los Amigos de Lomas Barbudal", a locally-based conservation organization. Local firefighters worked to combat fires once they had started and educated park rangers and other local personnel with the help of the authors and professional firefighters from the U.S. Forest Service in California (Frankie & Vinson, 2004). Volunteers from a local high school were also enlisted, and regular workshops were held teaching methods of fire prevention and explaining the environmental damages caused by fires. Most importantly, in the early 1990's the authors started the Center for Conservation of Nature in Bagaces, which held regular meetings for discussion of environmental issues, offered EE seminars, and sponsored a library with books about the natural world for local children (Frankie & Vinson, 2004).

Though most of the conservation efforts initiated by Frankie and Vinson were met with great success, others showed room for improvement. A visitor center created at the Lomas Barbudal reserve flourished under outside financial support, but when left to its own devices it encountered financial problems. With some minimal assistance from the University of Costa Rica, the visitor's center was stabilized and was able to continue its work (Frankie and Vinson, 2004). The lesson to be taken from this experience is that EE projects will often, if not always, require outside support. Though this does not necessarily mean a great investment, it is clear that some continued assistance is necessary.

Among other advice for EE, the authors explain that "It is important to establish and maintain a variety of working and friendly relationships with local cooperators and leaders" to keep local participation high and encourage eventual increased autonomy (Frankie and Vinson, 2004, pp. 251). Furthermore, outsiders seeking to establish EE programs must "know their audience", and be conscious of cultural beliefs and traditions of local populations. With regard to outside assistance, Frankie and Vinson emphasize that "there is a need for more professional biologists to become involved in the process of transferring their biodiversity and conservation knowledge to audiences other than their own colleagues" (Frankie and Vinson, 2004, pp. 255).

Proceeding past the practical concerns of managing EE programs, it is immediately apparent that, aside from the informational portion, there is a prominent *ethical* element to environmental education. Referring to the practical-pluralist approach to conservation ethics outlined in part II, I would like to reiterate the utility of demand-value and intrinsic-value ethics in environmental education. While most government policies regarding conservation reflect a strong precautionary perspective, a knowledge of biological systems and the variety of indirect benefits they can provide are both essential to understand such ethics and often too complex to be conveyed outside an academic institution. In order to combat the aforementioned problems of enforcement in sectors where educational resources and government control are limited, a strong environmental or conservation ethic must be passed on to the populace. Changes in public school curriculum might be a bit much to ask, but environmental education programs might certainly want to consider placing greater emphasis on environmental ethics.

It is far more effective to provide human beings with their own conscious methods of ethical judgment than to try to prevent environmentally destructive behaviors through law enforcement and constant monitoring. Many religious and cultural traditions include some system of attributing intrinsic value to the natural world; support of this cultural perspective, rather than the introduction of potentially unconvincing or overwhelming academic ethics, would likely be a more effective method of ethical education. One particularly appropriate example of the relevance of local religious beliefs in conservation is that of the "ecological monks" working to conserve forests in Thailand. Buddhist monks throughout northern Thailand have been using the moral and practical guidelines of their religious beliefs to educate farmers and other landowners in ecologically sustainable land use, naturally encountering much greater success than foreign education movements (Darlington, 1998). Thus, by enforcing the intuitive appeal of intrinsic and short term demand-value ethics, conservationists can provide effective justification for conservation methods without the need for substantial academic education for those who are unwilling or unable to receive such an education.

The intuitive appeal of intrinsic and demand value ethics is likely due to their congruence with the traditional and cultural beliefs held by many societies. While many “eastern” and Native American religions tend to attribute intrinsic value to natural phenomena, most “western” schools of thought tend to focus on the instrumental (demand) value of the natural world. While I have no desire to rank one of these attitudes over the other, I will stress the appropriateness of a pluralist conservation ethic in environmental education in this context. A monist ethic would somehow need to reconcile the disparate cultural beliefs and traditions of a great many societies in order to acquire consistent cooperation in conservation efforts, while a pluralist ethic could tailor environmental education programs toward specific societies in ways which did minimally conflict with their traditional beliefs and practices. In this way, the conservation movement might garner greater support and achieve greater success in collaboration with the public.

It is clear that EE is an effective and powerful tool for the exchange of useful conservation knowledge between scientists and local populations. Frankie and Vinson do not exaggerate when they say that “EE is a necessity if [any] system of natural areas is to be conserved and protected for the future. There is both ignorance to dispel and the need for new information by technically competent professionals” (Frankie and Vinson, 2004, pp. 254). Environmental education presents a strong solution to the largely *human* problem in biodiversity conservation, targeting the ignorance and bias which results in ecologically harmful actions. Nonetheless, there are other tools for the effective communication of conservation ethics, practices, and rationale.

Gilda Aburto (2004) makes a case for a surprisingly unexpected ally for biodiversity conservation: the media. Citing John Muir, Rachel Carson, and the explosive growth of the internet, Aburto lauds the communicative power and efficiency of the media in its various forms. Adding a touch of desperation, the author explains that “Whereas yesterday pen and paper were sufficient to battle the ax, today chainsaws and tractors have given an advantage to the destroyers,” (Aburto, 2004, pp. 258) making it clear that the rate of biodiversity loss now far exceeds its former limits. “Biologists alone cannot stop this destruction,” Aburto writes, “only through communication can biologists transmit their much needed knowledge to the public, empowering it to act” (Aburto, 2004, pp. 258). This transmission must be both fast and powerful; the sluggish progression of scientific publication and communication between colleagues is not nearly sufficient. But, “by means of radio or television, information can literally circle the globe and reach millions in a very short time” (Aburto, 2004, pp. 258). In parallel with the “science of necessity” background of conservation biology, Aburto cites the severity of the problem as the main reason for media action. Without the sort of public exposure provided by the media, conservation initiatives will be left without sufficient support (be it in manpower, funds, or public opinion) to succeed.

To illustrate the importance of the media’s function, Aburto refers to the conservation of La Mula Creek, a forest of valuable timber located between two larger protected areas in the Guanacaste province of Costa Rica. The Costa Rican Institute of Agrarian Development (IDA) planned to clear-cut the area and divide it among local farmers who did not own land. While the adjacent town of Bagatzí and conservation scientists on their own had little effect in protesting the decision, when both parties began contacting the media and speaking with local journalists, their influence on the decision became more noticeable. Frequent correspondences with visiting journalists from throughout the country as well as letter-writing to authorities and a few publicized, formal studies by conservation biologists quickly turned the tide of the struggle and placed immense public pressure on the IDA. The institute instead donated the land to Costa Rica's Ministry of the Environment (MINAE), who declared it a protected region (Aburto, 2004, pp. 259).

With this success story in mind, Aburto's first suggestion is a partnership between journalists and conservation researchers. Scientists, she claims, are often too "shy" with their research and results, and are hesitant to publicize anything but fully analyzed data. In the media, however, the more important content is often simply what is being researched and why it requires such research. Thus, scientists should be in regular contact with media officials, providing frequent updates to the public regarding the nature and progress of their research and raising awareness to the conservation issues it confronts. Given the rate at which biodiversity (in its myriad forms, including habitats, unique and non-inheritable behaviors, etc.) is being lost, infrequent scientific publications, rarely comprehensible to the public, are insufficient to initiate the scale and strength of effort needed to preserve biological diversity. In this way, if scientists continue to be as conservative with their work as they have been until now, no matter how high-quality the information they gather, data will be "too late" to serve their intended purpose. Scientists are thus left in a precarious position: will they compromise their scientific reputation by publishing what may be viewed by others as sensationalist stories about their work, or wait to perfect their research, only to have failed the very purpose of that research in the first place?

The solution to this conundrum, says Aburto, lies in relationships with individuals who are more prone to public exposure like politicians and journalists. As Aburto explains, "experience has repeatedly shown that journalists can be very effective and, above all, swift when communicating important information presented to them by biologists" (Aburto, 2004, pp. 258). Politicians, meanwhile, thrive on media attention of any sort and are not prone to be shunned for citing information beyond the scope of scientific data. At the same time, they boast the sort of charisma and power needed to reach the media effectively (Aburto, 2004, pp. 259). Both of these parties function as “links” between scientists, public activists, the government, and the public, keeping the flow of information constant and fresh (Aburto, 2004, pp. 259). Through the incorporation of a journalist or political partner, data and research on conservation issues can be “translated” effectively to a format more easily understood by the public and transferred directly to the public knowledge base, where it can be effectively utilized by activists and governments alike.

Aburto also provides a number of suggestions for scientists and their associates for the publication of scientific information on conservation issues. First, stories published through these partnerships should be “humanized” to grant them comprehensibility and appeal to a wider audience. In order to be humanized, these stories should include not only the biological phenomena they strive to conserve, but also the human beings involved in the efforts. This sort of humanization is especially necessary for cases which do not involve charismatic megafauna, which require some additional component to attract public attention. Scientific publications are too often based solely on data and therefore less accessible to the public on a personal basis (Aburto, 2004). These partnerships should also strive to have *frequent* publications to maintain public interest and release new information as it becomes available; a steady stream of information in smaller amounts is more “digestible” than more infrequent and larger updates (Aburto, 2004).

It is also important to recognize that the variety of modes of communication now at any organization’s disposal is growing on a day-to-day-basis. While television and radio remain fantastic tools of communication, the growing powerhouse of the last twenty years is the internet. Networking and social sites like MySpace, Facebook, and Twitter, have acquired gigantic followings in the last decade, while with the growth of handheld computer and cell phone technologies, human beings are more and more capable of accessing the internet. In this way, it is growing easier than ever for conservationists to publicize their efforts and stories to the rest of the world; all that remains is to seize the opportunity.

Setting aside the more rarely discussed subjects of media attention and environmental education, I will shift at last to more concrete and well-established studies of conservation biology, particularly the management of wildlife and preserves. In their work “Threats to the Conservation of Tropical Dry Forest in Costa Rica”, Mauricio Quesada and Kathryn E. Stoner (2004) review the current state of conservation of an endangered ecosystem in the Tempisque and Guanacaste conservation areas of Costa Rica and make further suggestions for how these methods could be improved for future conservation initiatives. This case study will serve as a solid introduction to the final portion of this section which reviews the main challenges to and solutions for biodiversity conservation and management.

III.5 Parks and Reserves

Neotropical dry forests in Costa Rica are threatened by unintentional forest fires and excessive logging by the cattle industry. According to one study, before 1980, the cattle industry in particular was responsible for more deforestation than all other economic activities combined, including commercial logging (Lehmann, 1992). As mentioned earlier, fire is often used to clear roads, pastures, and properties of unwanted vegetation; such fires are often allowed to burn uncontrolled and can easily become very ecologically destructive. Though the establishment of ecological preserves served to protect a good deal of Costa Rica’s dry forests, forests outside of protected areas were still heavily exploited. In 1988, the government made an attempt to encourage more responsible use of unprotected land by launching a number of economic incentive programs to encourage reforestation, though due to insufficient enforcement and rapid turnover in government administrations these had little effect (Quesada & Stoner, 2004). The issue of enforcement and monitoring, as mentioned before, is a severe one, and illegal logging and extraction, even from national parks, continues largely unchecked, especially when conservation officers are off duty, particularly late at night or on weekends (Kishor and Constantino 1993). Heavy logging of unprotected areas like agricultural zones or remnant forests causes greater problems still, as some studies have indicated that isolated trees act as “stepping stones” or biological corridors for gene flow of animal and plant life between protected areas (Aldrich and Hamrick, 1998).

Quesada and Stoner review the conservation methods employed at two parks containing tropical dry forest; Parque Nacional Palo Verde and Reserva Biológica Lomas Barbudal, both located in the Guanacaste province of Costa Rica. Though cattle grazing was permitted before the declaration of these parks as preserves, it was forbidden upon their establishment and only reinstated in part during the late 1980’s to early 90’s. During this period, cattle-grazing was used as a management practice to control fires (by reducing invasive plants and other fuels for wildfires) and prevent invasion of wetlands (Mozo 1995, Quesada and Stoner, 2004). Cattle grazing was also used at the Palo Verde reserve’s wetlands to maintain open waterbird habitat (Vaughan et al. 1995).

Numerous studies on these reserves have shown that the cattle grazing management plan, though it did provide some income and incentive for local support of the preserved areas, failed to preserve diversity or control invasive organisms within the reserves. According to the authors of the study, the wildlife management plans for both the Palo Verde and Lomas Barbudal preserves initiated these management plans with little to no systematic research of published information regarding the effectiveness of cattle grazing for ecosystem management (Quesada & Stoner, 2004).

Reviewing the difficulties of this policy, Quesada and Stoner present a number of recommendations for the management of parks and preserves which will serve as a convenient segue into a broader review of issues and solutions in conservation management. The authors are quick to assert that protection of intact ecosystems (in this case neotropical dry forests) is essential, and that the practice of establishing and protecting preserves and natural parks is an irreplaceable method of biodiversity conservation. Quesada and Stoner (2004) also suggest a variety of methods for the protection of dry forest ecosystems from fire and invasives. The general advice to be taken from their more specific suggestions is that funds and personnel are the most important tool for a preserve, and are necessary for the type of integrated management systems necessary to protect biological phenomena from a variety of often unique and situational threats. In regard to the difficulties encountered by the Palo Verde and Lomas Barbudal preserves, Quesada and Stoner suggest that management practices should be established on a firm foundation of systematic research and published scientific literature (Quesada and Stoner, 2004).

The authors next stress the importance of restoration ecology, explaining that if particularly threatened ecosystems are to be conserved, not only must those still existing be protected, but "restoration and natural regeneration programs…need to be implemented immediately, within both protected areas and privately owned land" (Quesada and Stoner, 2004, pp. 277). They add that economic incentives given to private landowners should be greater for total protection of ecosystems than simply for restoration to encourage preservation over exploitation. To help create more scientifically sound and effective management plans, they recommend the formation of a scientific panel for each large reserve area that is familiar with its particular conservation issues and how to address them (Quesada and Stoner, 2004).

In regard to ecotourism, Quesada and Stoner admit its viability as a source of economic revenue from conservation, but emphasize that it should be regulated heavily by the government. Recalling the gruesome "dark side" of ecotourism discussed at the beginning of this section, it is clear that such regulation would be necessary. The authors add that a "hotel tax" or other tax on ecotourist activities might be another powerful tool, directing profits the maintenance and management activities of natural parks and preserves while discouraging environmentally detrimental business practices (Quesada and Stoner, 2004).

The suggestions of Quesada and Stoner represent some of the most basic and readily apparent solutions to conservation and management; notably that greater funds, personnel, and training than is currently allotted to biodiversity conservation are necessary. In addition, greater organization of these assets is required. At the same time, related efforts like restoration and ecotourism must be both encouraged and carefully monitored for environmental impacts. These necessities for improving conservation and management of biodiversity are repeated throughout the literature of conservation biology like some sort of management mantra: money, people, information, enforcement, legislation.

III.6 Adaptive Management

Beyond the sort of archetypal suggestions to improve today's conservation measures are a number of more specific and salient issues in conservation which--though they warrant much more thorough attention--will be examined here only in passing as part of a larger survey of conservation issues and solutions. The first of these concerns the very nature of conservation management as a practice; if biodiversity conservation is largely a science of necessity and is thus justified even in some level of uncertainty, how can management be conducted effectively with uncertainty?

Among other like-minded thinkers, Bryan Norton (2003) makes a case for what is often called "adaptive management", the concept of employing a management strategy characterized by constant change (or adaptation) according to certain changing conditions. In the case of biodiversity conservation, the success of biodiversity conservation "will depend more on a willingness and ability to react to new information than on a single forever-binding choice" (Norton, 2003, pp. 112). Because conservation biology must rely on only the most recent information provided, it must be allowed to change with the growing and changing knowledge-base to which it is bound. As Norton explains, "chosen policies should, given the best available science at the time of their implementation, protect both species and the ecological processes associated with them" (Norton, 2003, pp. 111). Though the definition of biodiversity conceived in this work is considerably broader than what Norton mentions here, his point is met with agreement: if the conservation and management of biodiversity is to make good of its reliance on current information, it must be flexible enough to change with shifts in understanding.

An additional component of adaptive management is the role of research. Norton explains a multifaceted role for conservation management, claiming that practices must "protect species [and other components of biodiversity] while continuing to explore ways to be more sensitive to… ecosystem-level processes and characteristics" (Norton, 2003, pp. 122). Though again Norton's ecosystem-level definition of biodiversity is considered narrow in comparison to the definition created in part I of this work, the clear lesson in his statement rings true. Management must not only consist of protection and constantly changing methods of protection, but also must strongly emphasize research, particularly in certain areas that are suspected to be particularly important for conservation biology as a science and the management of individual phenomena (a list of possibly important research subjects will be summarized later in this section). Thus, adaptive management must function as a self-fueling process, constantly evolving based on the best information available, but also seeking out new information on germane and important subjects.

Beyond the structure of conservation biology as a global effort and discipline lie myriad problems for the protection of biodiversity, one of which will be covered in depth for the remainder of the section.

III.7 The Prioritization Problem

Perhaps the most marked problem for biodiversity conservation, especially in light of management practices, is the issue of prioritization. Naturally, sufficient resources will never be available to preserve and protect all conceivably valuable phenomena in nature, even by the standards of a very restricted definition and shrunken biodiversity ethic. Thus, some method of prioritizing phenomena so that greater effort may be put toward those of greater value becomes necessity, for fear that a unique behavior in botfly larva might be conserved at the expense of the last patch of rainforest. As evident in the prioritization adequacy condition mentioned in section II, this prioritization is immensely important in conservation biology and an essential "bridge" between the theoretical and the practical. This issue is closely tied to the ethic adopted by the conservationist, and thus is largely dependent on ethical perspective.

According to Sahotra Sarkar, the issue in biodiversity conservation is in choosing which areas or spaces to be preserved over others. This "place prioritization problem" is "critical to biodiversity conservation because not all places that are of some biological interest can be conserved in practice" (Sarkar, 2005, pp. 160). Sarkar presents a number of criteria by which areas may be ranked for conservation; all of these depend in one way or another on the property of one or more biodiversity "surrogates", or phenomena representative of the overall biodiversity present in a system.

As mentioned previously, there is a great deal of debate over the existence of biodiversity surrogates; is it reasonable to expect that a single (or small group of) phenomena be a "litmus test" for the biological diversity of a single system? This quandary, like the existence of a diversity-stability connection, is a vastly important research topic for conservation biology, and one which should be thoroughly investigated in the future.

Asserting that reasonable surrogates for biodiversity can be found, Sarkar suggests that, aside from the abundance (or richness) of surrogates, their rarity and complementarity should be considered. The rarity of a surrogate is the rather intuitive idea of its overall inverse abundance, while complementarity is defined by the number of surrogates unique to that particular system (Sarkar, 2005). Thus, areas may be prioritized by any combination of these properties, with "ties" in properties for one particular surrogate being broken by the next rarest or most unique surrogate, and so on. Bryan Norton takes a similar approach to prioritization, stating that ecosystems themselves are the target of conservation, and that prioritization should also be between physical areas, though perhaps by means of economic value for practicality (Norton, 2003).

When considering the inclusive and pluralist definition of biodiversity formed in the first section of this text, the prioritization problem becomes all the more difficult and complex. Are places really all that should be prioritized? Do certain areas have the ability to include most of the biological phenomena to which value is attributed? My response is that this is not necessarily the case. Though place prioritization is clearly the most practical solution—human beings have been mapping out the world and drawing lines across it for millennia—it may not protect all phenomena outlined earlier in this work. To illustrate this point, one need look no further than most migratory seabirds, for example, the arctic tern (*Sterna paradisaea*), a seabird which—though not at all endangered—travels more than 24,000 miles annually in its migration from nesting grounds in the arctic to feeding grounds in the southern hemisphere, a journey undertaken largely over the ocean (Cramp, 1985). If by some unfortunate turn of events the arctic tern were declared critically endangered, how would place prioritization measures protect it? Would separate marine reserves at both ends of its migration be protected, or would its entire range of migration routes (spanning nearly all of the Pacific and Atlantic oceans) be preserved? The point is that a prescribed area on its own does not necessarily encompass all phenomena—be they species, behaviors, or morphological forms—that it may contain at one point in time. While territorial species or species with traditional mating and courting grounds may be restricted to prescribed areas, it must be understood that—especially given the apparently accelerating rate of global climate change—biological systems are dynamic and often quite mobile. The drawing of lines for reserves alone might not preserve all that humans wish to save.

While Norton's stand on the issue implies that ecosystems are the only "currency" of the myriad components of biodiversity for prioritization, I am less convinced. While ecosystems are certainly important and often do encompass much of the biodiversity of a particular region, as the discussion of communities in section I implies, this is not always the case. Thus, while value *can* and often *should* be attributed to ecosystems and specific areas, they are not the only phenomena which deserve inclusion in prioritization. Sarkar's use of surrogates for place-prioritization is a logical and efficient approach to this problem, but I would add a slight adjustment. Not only should places be valued for their surrogates, but these surrogates *themselves*, if they are recognized to exist and represent other phenomena, must be given priority for conservation. The difference in management which might result would be between creating a reserve in which, for example, all of Yellowstone National Park's wolves were protected, and protecting also the wolves themselves. If wolves left a protected area under normal place-prioritization, they would be subject to culling. If the wolves, too, were given priority and protected simply as they are, their protection would not depend on their location.

Though I propose here that various phenomena (as surrogates or individually) should be given value during management and prioritization, I have not addressed the great question created by my assertion: how are these phenomena to be prioritized *with respect* to one another? This question necessitates a great philosophical and scientific inquiry which I could not hope to address in this work. However, I would like to make it clear that this is another important question for conservation biology which, if answered, would have immense benefits for the discipline. A major focus of future research should be in seeking an effective framework for organizing the myriad phenomena which constitute biological diversity.

In order to avoid completely shirking responsibility for my earlier assertions and abandoning any investigation of possible prioritization methods for the various components of biodiversity, I will propose a theoretical method of prioritization by which different phenomena might be compared. The system is based on that used in my investigation of valuable natural phenomena in section I, what I call the "evolutionary" approach. The idea behind this approach is to evaluate natural phenomena with respect to the dynamic process of which they are a part, that is, evolution. Different sources of biological variation are thus viewed as different distinct "units" of evolution. While conventionally species have been the objective "unit" of evolution, it is undeniable that less prominent sources of variation—such as behavior or developmental differences—could eventually lead to divergence and evolution under the correct environmental circumstances. Thus, components of biological diversity are ranked in importance by their potential role in the evolutionary process.

From this perspective, it makes sense that great value is placed on species and ecosystem diversity in existing accounts for biodiversity conservation. All existing species are doubly valued as both the discernable products of the evolutionary process *and* as the predecessors of future species. Phenomenological species provide a simple way to identify and define species, but greater "resolution" for prioritization is needed for prioritization *between* species. Both of the methods used today—based on rarity and distinctness—are more than suitable for this purpose. While the rarity of a species—usually determined by its total numbers or range—is fairly intuitive, the concept of distinctness requires a closer look. Phylogeny is the primary tool for determining the uniqueness of a given species. It is the goal in prioritization to give greater priority to species which represent a more independent evolutionary history; one that might not easily be repeated or replaced by another, similar species, if that species or lineage were to go extinct. Thus, an organized account of speciation events and the relation of species to one another is necessary to allow the prioritization of more unique lineages which are unlikely to arise again; this sort of understanding, though difficult, is currently studied with great success using a mixture of molecular and morphological traits (Williams et al, 1991).

Ecosystems, as established in part I, lie on a spectrum in the degree to which they carry their own unique properties and "exist" as objective units. It follows that ecosystems which have more emergent properties and form more coherent "wholes" deserve unique conservation in their own right, while those which lean more in the direction of a "community of indifference" would be better managed by the preservation of the individual species and populations from which they are formed. Thus, prioritization with respect to ecosystems should follow from their position on this "scale of coherence", where more strongly apparent ecosystems with greater organism interdependence are given higher priority for conservation than those which would be covered simply by species conservation.

Ecosystems are considered the most valuable component of biodiversity according to the "evolutionary" approach to prioritization for many of the same reasons that Bryan Norton gave in his case for ecosystem conservation. Ecosystems—particularly those with strong webs of interaction and clear emergent properties—represent perhaps the largest readily-conservable unit of the evolutionary process. An intact ecosystem features a great number of lineages evolving simultaneously. Characteristics like emergent properties and ecosystem services add greater priority to such larger phenomena, but are not necessary to provide adequate priority for conservation. Because ecosystems reflect a broad range of biodiversity components and, as targets for conservation, protect many phenomena *in-situ*, they are given the highest priority in the "evolutionary" approach to prioritization. It must be noted, however, that this priority varies according to the interactions within the system and the benefits and emergent properties it carries. An ecosystem far to the "coherence" side of the spectrum would have conservation priority far above that of just the species within it, while a "community of indifference" would have total priority equal to that of the conservation of its parts.

Morphological disparity, particularly in "subspecies" and other types of distinct populations not considered separate species, constitute a logical "next step" in the prioritization of biodiversity components by an evolutionary approach. While subspecies, color-forms, and other morphologically-distinct populations are for one reason or another not considered separate species, they represent some genetic diversity and a strong "potential" for the formation of a separate species. As discussed in part I, the divergence of distinct subpopulations due to changes in selective pressures or reproductive isolation are common circumstances for the formation of species. Thus, though by most definitions (genetic, biological, or phenomenological) morphological differences between organisms do not carry the same priority for conservation as separate species, the variety they represent has the *potential* to create new species and may thus necessitate some lesser—though still important—priority.

Continuing down the same logical chain presented in part I, the link between other components of biodiversity—particularly developmental and behavioral differences—and those that are customarily given value is clear. Differences in the development of an organism due to environmental conditions can lead to morphological differences which in turn can eventually result in speciation. Behavioral differences may alter both environmental conditions and selective pressures on an organism, resulting in different developmental forms. Returning to the calculus analogy made in part I, each rectangle outlined beneath the immeasurable curve of "biodiversity" is given smaller and smaller priority as a theoretically complete definition of biodiversity is approached. In this way, the prioritization of components of biodiversity can be centered upon the conceptual framework of modern biology, the evolutionary process. By attributing value and priority according to this progression, conservation effort can be exerted in a manner proportional to the evolutionary importance of a given phenomenon.

III.8 Suggestions for Conservation

Over the course of this section, a great many suggestions and improvements have been reviewed for their utility in biodiversity conservation. To conclude, I would like to summarize these suggestions, both those which emerged from my own research and those put forth by other authors.

Perhaps the least surprising and widespread suggestions for future conservation were reiterated throughout the section and mentioned repeatedly by authors representing disparate beliefs and disciplines. These ubiquitous suggestions advise the allocation of increased funds toward conservation measures, as well as an increase in the availability of personnel and training for management and research. Public education on a variety of conservation issues is widely held as an effort of great importance to the conservation movement. An educated and responsible public provides great support for conservation initiatives and would not create the sort of problems an ignorant populace would. Where problems still occur (and may be inevitable) enforcement is cited as a necessary measure that is often lacking. While legislation may often be functional, if it is not properly enforced it cannot be put into practice and will not effectively "deliver". Lastly, it is almost unanimously accepted among conservationists that scientific knowledge regarding these issues is incomplete. Thus, a system of adaptive management is necessary to ensure that management always proceeds despite uncertainty, but that in the process it is consistently founded upon the best available research at the time of application.

Moving on to more specific suggestions, I'd like to address a few of the "lessons" that can be taken from Costa Rica's experience in law and policy. In regard to the overly complex laws adopted by the country, it is evident that passing *too much* legislation in favor of conservation can be just as harmful as too little, confounding management until it loses functionality. Conservation legislation should thus be strong, simple, and clear so that it can be correctly implemented and enforced. Costa Rica has also clearly demonstrated the potency of environmental laws which provide economic incentives for "ecosystem services" and other environmentally conscious decisions while discouraging ecologically harmful activities through taxation. Such economic influence is a powerful motivator and should certainly be implemented elsewhere.

Hanson's discussion of biodiversity inventories presents a number of relevant suggestions to the practice of gathering information on biodiversity, notably that developed countries should understand that taxonomy is certainly not a dead science and that the classification and organization of information on natural systems continues to be an important practice today. The exchange of information between institutions in developed nations with good resources and educated professionals and developing nations with huge stores of undocumented biodiversity should certainly be increased, encouraging a flow of both monetary and human resources to bolster the struggling efforts at documenting the massive amounts of biodiversity put at risk by development. Given the additional amendments to the customary definition of biodiversity made in this text, it follows that future inventories should include several components of biodiversity in addition to species diversity, including behavioral, ecological, morphological, and developmental diversity.

Information gathered from inventorying and research should, as Aburto, Frankie, and Vinson explain, be disseminated to the public as quickly and efficiently as possible. Scientists working in conservation should not be “shy” and report only data through academic channels, but should either freely communicate with journalists about their work to spread awareness or align themselves with a political figure to garner advocacy for their efforts. Furthermore, environmental education efforts must be integrated with local culture and social practices to enable free exchange of information between conservationists and the local population, avoid an attitude of indoctrination or forced education, and promote interaction characterized by mutual respect and understanding. With regard to the pluralist ethic established in the second section of this work, it is evident that ethical education is also a substantial part of environmental education, and that intrinsic and demand-value ethics are the most effective for use in a non-academic setting. Thus, both information and ethical perspective should be more freely communicated with the public to promote a healthier attitude towards and relationship with the environment on the part of people who will have frequent and unmonitored interactions with vulnerable natural phenomena.

Through the work of Quesada and Stoner (not to mention many other authors), it is clear that the protection of natural areas remains one of the most effective methods of preserving biological variety employed today. They advise, however, that emphasis should be placed on preserving natural systems which are still *intact*, rather than waiting before they are threatened to protect them, when valuable phenomena can be harmed or lost entirely. Quesada and Stoner also emphasize the importance of contiguity between protected and non-protected areas and the necessity for wildlife “corridors” to enable free exchange of genetic and material resources between the biota of protected regions. Furthermore, the authors advise that greater attention should be paid to restoration practices in order to regain lost “ground” in global conservation efforts and relieve the strain on protected regions which may be unique or threatened.

The protection of biological phenomena should focus not only on specific areas, but on the phenomena themselves (species, populations, or otherwise) which may move outside these management areas and still deserve protection. In addition, prioritization of these myriad phenomena is necessary to direct conservation effort and resources to appropriate targets given the circumstances. The evolutionary prioritization model provides one possible way of organizing phenomena, thus ranking their importance according to their role as “units” in the continued process of evolution, with ecosystems and species at the forefront, though still attributing value to phenomena like unique, non-genetic behaviors and morphological disparity.

Finally, a number of salient questions remain which have been targeted in this work as ones which warrant special attention in the near future. For the establishment of a potential, universally binding demand ethic for conservation, further research into the nature of the diversity-stability hypothesis is essential. Furthermore, more systematic methods of conservation prioritization (like the evolutionary model suggested here) are necessary to give greater structure to conservation efforts. Lastly, in an effort to simplify the complex nature of conservation by these new suggestions, it is important to investigate the possible existence of biodiversity “surrogates”, or phenomena which can give a simple and effective reading of the biodiversity of an area without great effort and inventorying or data collection.

Thus, in the course of this work, a great many prescriptive suggestions and “take-home lessons” emerge that are worth consideration for the further improvement of conservation. It is my sincere hope that these improvements and ideas (the majority of which are certainly not novel or original to this work) are implemented in the future and can benefit the conservation of biological variety in coming years.

Conclusion

In the short span of this work, I have presented what I believe to be a set of practical responses to three of the broadest and most challenging questions confronting the field of conservation biology: specifically, the “what”, “why”, and “how” of biodiversity conservation. Addressing each in logical order, I reviewed the thoughts of contemporary thinkers on each of these subjects and gleaned what I viewed as the most valuable points to derive functional answers to these difficult problems. In the concluding paragraphs I would like to both review these responses and remind the reader of their intended purpose.

In section I, I expanded upon the traditional definitions of biodiversity (species and ecosystems) with the addition of other sources of biological variety, notably those suggested by MacLaurin and Sterelny (morphological and developmental) and presented my case for the addition of unique, non-genetic behavior. I also made the assertion that ecosystems were a valuable and unique source of biological diversity, but that their value and distinctness was heavily dependent on the strengths of interactions of the communities within them. Drawing an analogy from Riemann sums in calculus, I treated the definition of biodiversity as a subjective term largely impossible to formally define, but instead presented a “closest approximation” by means of the summation of several smaller components. In this way, I hope to present an inclusive biodiversity definition which allows the attribution of value and the direction of conservation effort to all sources of biological diversity. Using this inclusive definition, policymakers will not only have a consistent and somewhat formalized account of what is meant by the term “biodiversity,” but will also be able to provide protection for the myriad phenomena previously excluded by policies of species protection.

The second section of this work confronted the widespread uncertainty with regard to the value of biodiversity. Acknowledging the overwhelming consensus that indeed the many components of biodiversity do have value and warrant conservation, I set out to create a practically applicable ethic which could promote the effective conservation of biological variety in both a political and social setting. Borrowing from Sahotra Sarkar's "Adequacy Conditions for a Conservation Ethic", I presented an additional adequacy condition of my own—the comprehensibility condition—and organized these conditions into the core, practical, and secondary categories. I then reviewed a sampling of conservation ethics presented by contemporary thinkers and assessed their respective strengths and weaknesses in application. Concluding that no "master conservation ethic" yet exists, I adopted a pragmatic approach and created a practical-pluralist conservation ethic which encourages the use of a variety of ethics to reflect the various relationships human beings have with the environment. In the presentation of this ethic I hope to give conservationists the freedom to adopt a wider ethical perspective of biodiversity issues and to utilize ethical systems where their strengths best apply.

Section III began with an investigation of Costa Rica's action and legislation in favor of biodiversity conservation, reviewing both the successes and failures of its strong commitment to environmental sustainability. I next summarized the experiences and suggestions of several authors on the process of biodiversity conservation, also explaining the implications of an inclusive biodiversity definition and pluralist ethic on these practices. Lastly, I proposed the "evolutionary prioritization method" by which the myriad components of biodiversity presented in part I might be prioritized for conservation and management. By the end of the section, I presented a simplified list of suggestions from both myself and other writers on ways to improve today's conservation methods and better protect earth's biological diversity.

Though I am confident that the philosophical solutions proposed in this work are an effective contribution to the theoretical and practical problems facing modern conservation efforts, I wish to make it clear that the ideas reviewed in the preceding three sections are but a step in the right direction. It is my hope that other conservationists can improve and build upon my thinking or find more suitable alternatives for the same questions. Despite my assertion of their functionality, it is clear that these practical conclusions are far from ideal. Thus, it is my hope that future research in addressing these difficult conservation questions focus on the pursuit of more objective solutions, such as a clearer or more principled biodiversity concept or a universally applicable “master ethic” for the evaluation of biological phenomena. Thus, while management practices must adapt continually to the best available science, the principles behind conservation, too, must continue to improve with the advances in philosophical research.

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