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A Scientific Approach to Protecting Biodiversity

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A SCIENTIFIC APPROACH TO PROTECTING BIODIVERSITY

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"Then God said, let us make man in our image, after our likeness and let them have dominion over the fish of the sea, and over the birds of the air, and over the cattle, and over all the earth, and over every creeping thing that creeps upon the earth."[1] Environmental law in the United States today is implicitly based on this idea, viewing humans as apart from and superior to the rest of the world, rather than on a scientific understanding of the world around us. This approach, generally termed "anthropocentrism,"[2] is unsatisfactory, both in theoretical terms and in its practical results.

Alternatives to the anthropocentric approach have been suggested for the last twenty years, since Professor Stone's landmark article suggested that trees should have standing.[3] Most of these articles have been premised on ethical arguments.[4] This Article suggests a different type of non-anthropocentric approach, based on scientific understanding of the environment. Additionally, this Article proposes a method for assessing monetary damages under the non-anthropocentric approach, as an alternative to the current statutory and regulatory provisions for "natural resource damages."

The question of assessing damages is extremely problematic because it involves placing a dollar value on injuries that are incredibly complex and, in a non-anthropocentric approach, impossible to measure

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[1]Genesis 1:26-27.

[2]*See* ROBYN ECKERSLEY, ENVIRONMENTALISM AND POLITICAL THEORY: TOWARD AN ECOCENTRIC APPROACH 51 (1992); Susan Emmenegger & Axel Tschentscher, *Taking Nature's Rights Seriously: The Long Way to Biocentrism in Environmental Law*, 6 GEO. INT'L ENVTL. L. REV. 545, 556 (1994).

[3]Christopher Stone, *Should Trees Have Standing?—Toward Legal Rights for Natural Objects*, 45 S. CAL. L. REV. 450 (1972).

[4]*See, e.g.*, Kenneth A. Manaster, *Law and the Dignity of Nature: Foundations of Environmental Law*, 26 DEPAUL L. REV. 743 (1977); Andrew McLaughlin, *The Heart of Deep Ecology*, *in* DEEP ECOLOGY FOR THE TWENTY-FIRST CENTURY (George Sessions ed. 1995); Mark Sagoff, *On Preserving the Natural Environment*, 84 YALE L.J. 205 (1974); George Sessions, *Ecocentrism and the Anthropocentric Detour*, *in* DEEP ECOLOGY FOR THE TWENTY-FIRST CENTURY (George Sessions ed. 1995); Laurence H. Tribe, *Ways Not to Think About Plastic Trees: New Foundations for Environmental Law*, 83 YALE L.J. 1315 (1974). *But see* Emmenegger & Tschentscher, *supra* note 2, at 556 (arguing that current international environmental law reflects a biocentric approach and avoids moral or ethical arguments).

directly. Moreover, it is the least satisfying aspect of an environmental legal system, since it is retrospective rather than preventative. Assessing damages, however, is necessary. The legal system has to have some method for reacting when injuries do happen, or polluters will act with impunity.

I. BASIC PRINCIPLES

This Article relies on three basic principles: the polluter should pay for any damage he caused, biodiversity is of critical importance to humans, and legal principles should be in harmony with current scientific understanding. The first two principles have been discussed in many other papers, but the third has rarely been explored in this context.

A. The Polluter Pays

The principle that the polluter should pay for the costs of his actions is a well-accepted doctrine. Basic economic theory supports the idea that a decision-maker should be confronted with *all* the costs of his actions, so as to prevent externalization of costs to others. The classic example of externalized costs in environmental law is an industrial plant's pollution of a river (before environmental regulation); the plant receives all of the benefits in the form of lower costs of production, while the costs are spread to all of those who use the river, as well as to the river ecosystem itself. One of the basic functions of environmental law is to force those who accrue the benefits of pollution to internalize the costs of their actions.[5] Only in this way can economic development and environmental protection be balanced.[6]

B. Biodiversity is Crucial to Human Survival

"Biological diversity" can be defined as "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between

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[5]*See* Kenneth F. McCallion, *A Survey of Approaches to Assessing Damages to Contaminated Private Property*, 3 FORDHAM ENVTL. L. REP. 125, 126 (1992).

[6]*See* DAVID W. PEARCE, ECONOMIC VALUES AND THE NATURAL WORLD 3 (1993). The OECD released a formal statement on the polluter pays principle, to which all the member countries subscribe. *See id.* at 41-42.

species and of ecosystems."[7] Biodiversity looks at diversity within species (genetic diversity), among species (species diversity), and among ecosystems (ecosystem diversity). Genetic diversity refers to the diversity within a species' genepool; it allows a species to adapt to changing conditions by providing the raw material upon which natural selection operates.[8] Species diversity refers to the variety of species in an ecosystem. Each species fills a specialized niche within the ecosystem, forming the building blocks of the system.[9] An "ecosystem" can be defined as "the physical environment and all the organisms in a given area, together with the webwork of interactions of those organisms with that physical environment and with each other."[10] Ecosystem diversity forms the basic unit for biodiversity, with all three levels interrelating.[11]

Human survival depends on biodiversity. Most obviously, humans depend on other species for food. The current agricultural monocultures, which are by definition lacking in biodiversity, are extremely susceptible to extinction from either viruses or fungal attacks, potentially leaving people without even the flora and fauna necessary for basic survival.[12] Additionally, large numbers of species provide alternative food sources more suited to varying climates than the twenty species that currently provide ninety percent of the world's food.[13]

Moreover, plants and animals have provided the basis for many of our modern medicines.[14] For example, venom from a South

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[7]CONVENTION ON BIOLOGICAL DIVERSITY, art.2, Dec 29, 1993, 31 I.L.M. 818, 823.

[8]*See* Julie B. Bloch, *Preserving Biological Diversity in the United States: The Case for Moving to an Ecosystems Approach to Protect the Nation's Biological Wealth*, 10 PACE ENVTL. L. REV. 175, 181 (1992).

[9]*See id.* at 182.

[10]PAUL R. EHRLICH, THE MACHINERY OF NATURE: THE LIVING WORLD AROUND US AND HOW IT WORKS 239 (1986).

[11]The different levels are all interrelated: "Regional ecosystem patterns form the basic matrix for, and thus have important influences on, local ecosystems. Local ecosystems, in turn, form the matrix for species and genetic diversity, which can in turn affect effect ecosystem and regional patterns." *Id.* (quoting COUNCIL ON ENVTL. QUALITY, EXECUTIVE OFF. OF THE PRESIDENT, INCORPORATING BIODIVERSITY CONSIDERATIONS IN ENVIRONMENTAL IMPACT ANALYSIS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT 1 (1993)).

[12]Crosses with a wild species of perennial corn allowed domestic corn crops to become perennial as well as having increased drug resistance. *See* Thomas E. Lovejoy, *Biodiversity: What Is It?*, *in* BIODIVERSITY II: UNDERSTANDING AND PROTECTING OUR BIOLOGICAL RESOURCES 7, 8-9 (Marjorie L. Reaka-Kudla et al. eds., 1997). Currently, a species of wild potato from Peru is being crossed with domestic potato species to increase resistance to insect attacks. *See id.*

[13]EDWARD O. WILSON, THE DIVERSITY OF LIFE 287-88 (1992). It should be noted that this idea only refers to plants and not animals, as the author seems to indicate "species."

[14]Approximately 25% of the prescription drugs sold in the United States are derived from plant extracts. *See* Bloch, *supra* note 8, at 185 (citing H.R. REP. NO. 102-259., pt. 1, at 14 (1991)). This figure underestimates the medicinal uses of plants, since it focuses on prescription

American pit viper led to the development of drugs that help regulate blood pressure.[15] The rosy periwinkle provided the cure for Hodgkin's disease and childhood lymphocytic leukemia, while the Pacific yew may help victims of ovarian and breast cancer.[16] Between medicinal and agricultural uses, wild species provide an estimated four and one half percent of the Gross Domestic Product of the United States. Twenty years ago, the approximate value of these wild species was estimated at eighty-seven billion dollars.[17]

In a less obvious manner, ecosystems provide various services that benefit humans along with the rest of the planet. Ecological cycles regulate the levels of oxygen in the air and the levels of nutrients in the soil.[18] On the most basic level, humans depend on plants to provide the oxygen in the air. Plants take in the carbon dioxide produced through animal respiration and use it to produce oxygen for their own use. From this process, excess oxygen is released and is used by animals. Additionally, solar energy is converted to chemical energy by photosynthetic plants, which provide energy for all animals, including humans.[19]

Human survival is also impacted by the complex interactions among different ecosystems. For example, the Amazon River provides food for many people; it in turn relies on the neighboring terrestrial ecosystem for the required nutrient levels.[20] The forests in the Pacific Northwest help control erosion and prevent flooding; the high levels of clearcutting probably helped contribute to bad floods in the early 1990s.[21] These examples focus on direct interactions; however,

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drugs directly derived from plants. Scientists are able to synthetically produce the medicinal chemicals from plants, and thus produce medicines that are not "derived from plant extracts," yet probably would not have been discovered but for the plants. For example, the American Indians used the bark from the willow tree to ease pain; analysis of the willow bark led to the production of salicylic acid, the compound in aspirin. *See* Lovejoy, *supra* note 12, at 9. Additionally, nearly 3000 antibiotics are derived from microorganisms. *See* REED F. NOSS & ALLEN Y. COOPERRIDER, SAVING NATURE'S LEGACY: PROTECTING AND RESTORING BIODIVERSITY 19 (1994).

[15]*See* Lovejoy, *supra* note 12, at 9.

[16]*See* WILSON, *supra* note 13, at 347.

[17]*See* NOSS & COOPERRIDER, *supra* note 14, at 19.

[18]*See* Bloch, *supra* note 8, at 187. For example, the Amazon basin's hydrological cycle is regulated by the forest ecosystem. *See* Lovejoy, *supra* note 12, at 10.

[19]*See* NOSS & COOPERRIDER, *supra* note 14, at 20.

[20]*See* Lovejoy, *supra* note 12, at 9-10.

[21] *"Clear Cutting" Practices in National Timberlands: Hearings before the Subcomm. on Public Lands of the Senate Comm. on Interior and Insular Affairs*, 92nd Cong., 920 (1994). Even if areas of the forest are left undisturbed, the fragmentation of the larger regional forest ecosystem can have serious repercussions. A large forest landscape consists of multiple forest ecosystems that provide services for each other; if the landscape is fragmented, separating the ecosystems, the remaining forest ecosystems may experience a drier microclimate, loss of species,

ecosystems that are spatially very distant interact in often unpredictable ways.[22] Simply put, humans evolved within certain constraints of air and water quality, soil nutrients, and climate. Properly functioning ecosystems are vital to maintaining those levels.

Finally, ecosystems can act as a signal to humans as to the health of our own environment. One author has analogized the ecosystem health to the canaries that miners would take down into the shafts; the canaries would die if the air was bad, giving the miners a warning to get out.[23] Similarly, problems in an ecosystem, such as reduced numbers of lichens or fewer fish, can warn people of a problem with the air or water quality that may affect human health. On a larger scale, widespread disruptions in ecosystems should serve as a warning for potentially large environmental problems, such as climate change, which could threaten people world-wide.

C. Legal Rules About the Environment Should Be Consistent With Science

In determining what legal approach to take, science may not dictate the exact method. Any approach that is inconsistent with current scientific knowledge, however, should be rejected because an approach that is not based on reality is not practical and will not succeed in the long-term. Environmental law has traditionally had several goals, including protection of human health, protection of nature, economic efficiency, national security, preservation for aesthetics and recreation, intergenerational equity, community stability, and pursuit of scientific knowledge and technology.[24] Understanding how ecosystems function and creating rules based on that understanding is crucial to achieving all of these goals. For instance, before human

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reduced genetic diversity within remaining populations, and invasion by non-native species. *See* NOSS & COOPERRIDER, *supra* note 14, at 11.

[22]For example, seemingly disparate ecosystem may share species. Some species of migratory moths require both lowland dry forest and montane cloud forest. *See* T.B. Smith et al., *The Preservation of Process: The Missing Element of Conservation Programs*, *in* ECOSYSTEM MANAGEMENT at 71, 72 (Fred B. Samson & Fritz L. Knopf eds., 1996). Migratory animals, birds, and insects will thus impact multiple ecosystems, and the loss of one ecosystem, possibly resulting in the reduction or loss of the species, will therefore impact the other ecosystem(s). *See also* Robert Costanza et al., *Modeling Complex Ecological Economic System: Toward an Evolutionary Dynamic Understanding of People and Nature*, *in* ECOSYSTEM MANAGEMENT, *supra*, 148-161 (discussing the difficulties in modeling complex interacting systems).

[23]NILES ELDRIDGE, THE MINER'S CANARY 220-229 (1991).

[24]*See* CELIA CAMPBELL-MOHN ET AL., ENVIRONMENTAL LAW: FROM RESOURCES TO RECOVERY 108 (1993).

health can be protected, rulemakers need to understand how pollutants are transferred through the air and hydrological cycles, how toxins may be concentrated through bioaccumulation, and the responses of the human body to different substances. Economic efficiency, national security, and intergenerational equity all require that lawmakers have some sense of the level of use of such toxins that is sustainable over time, as well as any additional resources, such as alternative energy sources. Although different policies and ethical viewpoints may be needed to determine the exact approach to take, the choice of approaches should first be screened through the lens of current scientific knowledge.

The field of oil and gas law illustrates the problems with taking a legal approach that is fundamentally at odds with scientific knowledge. In the late 1800s, when production of oil first became significant, the courts adopted the rule of capture as the basic legal framework. Under this rule, oil and gas beneath the ground were analogized to wild animals and were the property of whomever first "captured" or produced them.[25] This rule had several advantages. It produced clear, predictable results, it encouraged creative technology designed to increase the output of oil from any given well, and it encouraged economic development. However, as with wild animals, the rule of capture encourages waste.[26] Capture encourages every landowner to drill his own well as quickly as possible, regardless of how many wells are needed to drain the reservoir. In the East Texas field, seventeen thousand wells were drilled when fifteen hundred would have been enough to produce all the oil.[27] According to one estimate, the cost of unneeded wells drilled in Texas between 1947 and 1952 was one hundred million dollars.[28]

Additionally, the rule of capture caused more problems with oil and gas than with wild animals because the rule is fundamentally at odds with petroleum engineering. Reserves of oil are found trapped in fractured underground rock formations sealed by an impermeable rock layer.[29] Such reservoirs usually contain water and natural gas in addition to the oil.[30] Since gas and water compress more easily than oil,

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[25]*See* Rance L. Craft, Comment, *Of Reservoir Hogs and Pelt Fiction: Defending the Ferae Naturae Analogy Between Petroleum and Wildlife*, 44 EMORY L.J. 697-98 (1995).

[26]*See id.* at 715-18.

[27]*See* Paula C. Murray & Frank B. Cross, *The Case for a Texas Compulsory Unitization Statute*, 23 ST. MARY'S L.J. 1099, 1110 (1992).

[28]*See id.*

[29]*See id.* at 1102.

[30]*See id.*

they provide the necessary pressure to force the oil out of the ground. When the well is drilled, it creates a low-pressure area, allowing the gas or water to expand, pushing the oil in front of it.[31] This dynamic explains why the adoption of the rule of capture was so significant in oil and gas law. One well can create a low-pressure point that draws oil from beneath a large area of ground that is not necessarily owned by the same person. The same basic dynamic is also what makes the rule of capture so wasteful. As more oil is pushed out of the ground, the pressure below the ground gradually drops, until the gas or water energy has been completely depleted. If wells are drilled into the portion of the reservoir containing gas or water, the very substances needed to produce the pressure to recover the oil escape.[32] Before regulations were passed to modify the rule of capture, the typical wildcat drilling and production left approximately eighty-five percent of a reservoir's oil in the ground, unrecoverable.[33] So, in a period of five years in Texas, one hundred million dollars were spent drilling unneeded wells in a manner that left the majority of the oil unrecoverable beneath the ground.

Now that I have discussed the background principles—polluter pays, the importance of biodiversity, and the need for law to be in harmony with science—this question remains: what is the best way to provide the appropriate amount of protection for biodiversity?

II. CHOOSING A BASIC APPROACH TO PROTECTING BIODIVERSITY

A. Anthropocentrism

As used in the context of environmental protection, anthropocentrism has a very narrow definition. Anthropocentrism is an approach that views humans as separate from the rest of the world.[34] It assumes the superiority of human interests over the interests of all other entities.[35] In this context, merely viewing the situation through human eyes and acting through human institutions does *not* constitute anthropocentrism.[36]

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[31]*See id.* at 1102-03.

[32]*See id.* at 1109.

[33]*See id.* at 1110.

[34]*See* ECKERSLEY, *supra* note 2, at 51.

[35]*See id.*; Emmenegger & Tschentscher, *supra* note 2, at 556.

[36]*See* ECKERSLEY, *supra* note 2, at 55. Eckersley argues that defining anthropocentrism to include merely perceiving the world as humans is similar to saying that "a male cannot be nonsexist or that a white person cannot be nonracist because they can only perceive the world as

An anthropocentric approach is problematic for several reasons. Most fundamentally, the anthropocentric approach is inconsistent with scientific knowledge. Humans are not separate from nature—they are part of nature. Humans are simply one species among the millions on this planet.[37] In science, the terms superior and inferior are meaningless. Evolution is not aimed at creating "superior" beings; rather, evolution allows for a species to adapt to its surroundings in order to maximize its continued survival as a species.[38]

As a consequence of being scientifically unsound, the traditional anthropocentric approach has failed even from a human utilitarian perspective. There is general scientific consensus that environmental degradation threatens human survival. For example, although there is still much debate about the exact effects of the increase of "greenhouse gasses" in the atmosphere, most scientists agree that the increase in carbon dioxide and other gasses will probably have a significant effect on the climate.[39] Those who oppose environmental controls may be correct when they contend that the temperature will not rise much due to negative feedback loops. Under this theory, a slight increase in temperature may cause increased evaporation from the oceans. This increased cloud cover in turn reflects more of the sun's energy and prevents a further increase in the temperature.[40] Although the temperature would not rise drastically, the additional cloud cover would reduce the solar energy available for plants and thus affect the food available for all animals, including humans. Additionally, positive feedback loops could accelerate the rate of temperature increase. For example, ice and snow reflect sunlight, reducing the temperature; as the temperature increases, areas of ice and snow will melt, allowing more sunlight to be absorbed, increasing the temperature more, and melting even more ice and snow.[41] The exact changes in the temperature and weather patterns are unpredictable;

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male or white subjects." *Id.*

[37]Although it may be uncomfortable to realize this, humans are as close to chimpanzees anatomically and genetically as two species of birds. *See* JONATHAN WEINER, THE BEAK OF THE FINCH: A STORY OF EVOLUTION IN OUR TIME 281(1994).

[38]Evolution is not, however, perfect. Random events, such as genetic drift in a small population, can lead a species away from the "optimal" path, possibly to extinction. PAUL EHRLICH & JONATHAN ROUGHGARDEN, THE SCIENCE OF ECOLOGY 112-23, 134-38 (1987). And, of course, some species go extinct, either through catastrophe or because they do not evolve as quickly as necessary.

[39]*See* GILBERT M. MASTERS, INTRODUCTION TO ENVIRONMENTAL ENGINEERING AND SCIENCE 390, 410 (1991).

[40]*See id.* at 410.

[41]*See id.*

however, given that the plants and animals have evolved under the current conditions, rapid drastic changes threaten the food sources necessary for human survival.

Another consequence of the scientific unsoundness of the anthropocentric approach is the depletion of vast sources of potential medicines.[42] Scientists have tested only a small fraction of the species on Earth for chemical activity that may provide new medicines.[43] The millions of unidentified species provide a huge source of potential medicinal breakthroughs. One study estimated that losses from potential medicines in the United States alone is 8.8 billion dollars annually.[44] In addition, the loss of wild species leaves current monoculture food crops vulnerable to disease.[45]

For these reasons, a legal system based on an anthropocentric approach is flawed. Rejecting an anthropocentric approach does not mean attempting to view the world from a non-human viewpoint, nor does rejecting anthropocentrism mean that one has to believe that human survival is unimportant when compared to other individual species. It is simply an acknowledgment of a scientific fact. Humans evolved as part of this planet, along with all of the plants, animals, fungi, and other organisms. Humans are neither above nature nor "unnatural." Humans are part of nature, just as any other species.[46]

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[42]Edward Wilson gives several extremely interesting examples:

"It is fashionable in some quarters to wave aside the small and obscure, the bugs and weeds, forgetting that an obscure moth from Latin America saved Australia's pasture land from overgrowth by cactus, that the rosy periwinkle provided the cure for Hodgkin's disease and childhood lymphocytic leukemia, that the bark of the Pacific yew offers hope for victims of ovarian and breast cancer, that a chemical from the saliva of leeches dissolves blood clots during surgery, and so on . . . ." WILSON, *supra* note 13, at 347.

[43]*See* Bloch, *supra* note 8, at 185 (setting the number at less than five percent).

[44]*See* PEARCE, *supra* note 6, at 87.

[45]*See* Part IB, *supra*, for more discussion. Various modern international agreements reflect the recognition that the anthropocentric approach has failed to protect biodiversity. For example, the 1992 CONVENTION ON BIOLOGICAL DIVERSITY begins with a statement about the intrinsic value of biological diversity. *See supra* note 7, at Preamble. The UN General Assembly Resolution from 1982 reflects the move away from anthropocentrism even more clearly when it states that, "[e]very form of life is unique, warranting respect *regardless* of its worth to man." G.A. Res. 7, WORLD CHARTER FOR NATURE, U.N. GAOR, 37th Sess., Annex (1982)(emphasis added).

[46]In fact, despite the fact that human actions have greatly reduced biodiversity overall, under certain circumstances human intervention may increase variability in a species' genes and thus speciation. *See* WEINER, *supra* note 37, at 241. Shifting from an anthropocentric approach to a nonanthropocentric approach does not require a shift to viewing humans as undesirably interfering with nature. Viewing humans as dominating or contaminating nature stems from the same basic view that humans are separate from nature. *Cf.* Jonathan Baert Wiener, *Law and the New Ecology: Evolution, Categories, and Consequences*, 22 ECOLOGY L.Q. 325, 340-45 (1995) (discussing the two versions of "separatist intuition"). The nonanthropocentric approach

Turning to a non-anthropocentric approach does not mean giving natural objects equal rights with humans; it means seeing humans as part of a system and recognizing that all parts have rights because they are all interconnected.

B. Defining Alternative Approaches

Susan Emmenegger and Axel Tschentscher have set out four basic non-anthropocentric approaches. The first, holism, views the world as a single entity with only one unitary interest.[47] The second approach, biocentrism, views humans as equal to all other living entities of nature; natural competition among these diverse entities is appropriate.[48] The third approach, physiocentrism, also focuses on competition among diverse entities, this time encompassing both living and non-living entities.[49] Both biocentrism and physiocentrism view individual entities as inherently valuable. The fourth approach, ecocentrism, focuses on the interrelationship of entities and their environment. Unlike holism, ecocentrism focuses on multiple entities; unlike biocentrism and physiocentrism, it does not focus on individuals.[50]

It is in defining the fourth approach that I differ from Emmenegger and Tschentscher, who state that "[e]cocentrism assumes harmony of diverse entities, especially harmony between humans and other entities of nature," and competition between entities is seen as destructive.[51] No rationale is given for why harmony is central to an ecocentric approach. In fact, ecosystems are characterized by many different types of interactions: competition, mutualism, commensalism, and parasitism.[52] Emmenegger and Tschentscher's definition is reminiscent of the old understanding of ecology, which saw nature as being static.[53] This view is reflected in many of the environmental

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advocated here is distinct from both strains of thought.

[47]Emmenegger & Tschentscher, *supra* note 2, at 577. Emmenegger and Tschentscher note that Aldo Leopold's work is considered central in holistic ethics. *Id.* at 577 n.182.

[48]*Id.* at 577.

[49]*Id.* Emmenegger and Tschentscher give the example of water shaping a stone as "competition" between non-living entities. *Id.* at 578 n.188.

[50]*Id.* at 578.

[51]*Id.*

[52]*See infra* notes 69-73 and accompanying text.

[53]*See* Wiener, *supra* note 46, at 327 ("For the last several hundred years our expert and lay imaginations have been fixated on a vision of a "balance of nature" in static equilibrium."); David A. Perry & Michael P. Amaranthus, *Disturbance, Recovery and Stability, in* CREATING A FORESTRY FOR THE 21ST CENTURY 31, 41 (Kathryn A. Kohm & Jerry F. Franklin eds., 1997).

statutes, cases, and government policies.[54] For example, until quite recently the government attempted to suppress fires to "protect" forests.[55] Suppressing forest fires did not, however, preserve the "natural order" but merely deprived the forest of nutrients and led to a new mix of forest trees and plants.[56] The assumption that nature does not change has also worked against humans in our attempts to control natural enemies, such as bugs and bacteria. The incorrect assumption of nature as static underlies the increasing uses of pesticides and antibiotics, which merely led to adaptive bugs which are even harder to kill.[57]

Emmenegger and Tschentscher's position seems inappropriate when viewed in light of the modern science of ecology. Ecosystems are not stable entities. They are constantly changing. A basic example in ecology is that of succession, a process where one set of species develops in an area after a disturbance, such as fire, followed by the gradual replacement of the species as time progresses.[58] Another model of an ecosystem is one of oscillation, where the ecosystem may appear the same over a long period of time, but many changes, large and small, are continuously occurring.[59] Both at the level of individual species and ecosystems, nature is not static because evolution is a constant process.[60] An ecocentric approach is better viewed as one that focuses on all of the interrelationships between entities, while understanding that stability and harmony are not "natural."

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[54]*See* Wiener, *supra* note 46, at 338-39 (citing Just v. Marinette County, 201 N.W.2d 761 (Wis. 1972) and examples of fire suppression, preventing hybridization/interbreeding, and attempting to keep the Mississippi River from changing its streambed).

[55]*See id.* at 338.

[56]*See id.* at 338 n.73.

[57]*See id.* at 339.

[58]*See* EHRLICH & ROUGHGARDEN, *supra* note 38, at 48. For example, after agricultural use and fire have destroyed sections of a tropical rain forest, grasses and other herbaceous plants are the first to grow. Then shrubs and saplings begin to grow. As they mature, creating a dense canopy of leaves, the plants that require shade to survive slowly return. *See id.* at 530.

[59]*See* WEINER, *supra* note 37, at 197 (discussing oscillation as the relevant model for the finches on the Galapagos Islands). A well-known example, though usually not referred to in terms of "oscillation," is the moths outside London. Prior to the Industrial Revolution, most of the moths were a light dappled shade, blending with the lichens on the trees; a few moths were black, creating a contrast to the lichens and providing easy prey for the birds. Within a few years of the Industrial Revolution, the pattern had reversed--most moths were black, blending with the soot-covered trees, and the few light-colored moths were at a disadvantage. Once the pollution was curbed, light-colored moths again became more common. *See* M.B.W. Sinclair, *Evolution in Law: Second Thoughts*, 71 U. DET. MERCY L. REV 31, 43 (1993).

[60]*See generally* WEINER, *supra* note 37. Ignoring the dynamics of nature and evolution may prove extremely counterproductive. Despite all of the money spent developing and using pesticides, the fraction of crops lost to pests has actually increased, as insects evolved to deal with the pesticides. *See* WEINER, *supra* note 37, at 265.

C. Ecocentrism as the Best Approach for Protecting Biodiversity

Now that the basic approaches have been defined, the issue becomes which non-anthropocentric approach best protects biodiversity. The main criterion for judging which approach best protects biodiversity is consistency with scientific knowledge because only an approach based in reality can succeed in protecting the environment in the long term. In addition, the approach should be reconcilable with the basic legal system and likely to achieve the goal of protecting biodiversity.

The holistic approach seems impossible to reconcile with science or the American legal framework. The assumption that all of nature is one entity existing in harmony seems absurd in light of the complex interactions in ecology. In addition, since there is only one entity, holism assumes that conflicting interests are impossible.[61] Given that assumption, how can the legal system, which is based on conflicting interests, function? That leaves the other three approaches, all of which recognize conflicting interests.

Of the remaining three approaches, ecocentrism best reflects current scientific understanding. Nature does not protect individuals. The whole process of evolution is predicated on the fact that some individuals will survive and others will not. As Darwin wrote, "extinction and natural selection go hand in hand."[62] Even individual species are not "respected" in nature. Some species become extinct as others prosper. Adaptive radiation allows new species to form to fill empty niches in the local environment.[63] Despite the legal focus on individual species embodied in the Endangered Species Act,[64] the underlying battles have been over preservation of the ecosystems as a whole.[65] Individual species are important as they relate to each other,

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[61]*See* Emmenegger & Tschentscher, *supra* note 2, at 577.

[62]*See* WEINER, *supra* note 37, at 40 (quoting DARWIN, ORIGIN OF SPECIES).

[63]Conversely, when similar species occupy overlapping territories, they will diverge to reduce the overlap in their niches. *Id.* at 55.

[64]16 U.S.C. §§ 1531-1544 (1994).

[65]One example is the continuing battle over the spotted owl in the Pacific Northwest. The real debate is the cost of protecting the old-growth forest ecosystem, with the Endangered Species Act and the owls merely providing the legal ammunition. *See* Alyson C. Flournoy, *Beyond the "Spotted Owl Problem": Learning from the Old-Growth Controversy*, 17 HARV. ENVTL. L. REV. 261, 269-71 (1993); Vincent J. Schodolski, *Most Unhappy with Clinton Forest Plan: Loggers, Environmentalists Both Sue*, CHI. TRIB., July 10, 1994, at A15 ("At the heart of the suit brought by more than a dozen environmental groups is the charge that the existing forest management plan won't effectively protect the deteriorating Pacific Northwest environment.").

to keep the ecosystem functioning properly.[66] Moreover, the relationship between different species is not clear-cut. The traditional model of a branching tree is probably inaccurate. Species are much more interrelated than this model suggests, and their relationships to each other more closely resemble a complex net.[67] Attempting to base environmental law on individuals seems "unnatural."

Therefore, the exclusive focus on the individual in biocentrism and physiocentrism seems irreconcilable with ecology. Even at the ecosystem level, nature does not divide into discrete units. Ecosystems interact with each other. For example, the productivity of the Amazon River basin rests on floods resulting when the rivers spill into the flood plain forest. This flooding allows fish to feed on fruits, nuts, and seeds. Because of this chain reaction, nutrients are transferred from the terrestrial ecosystem to the aquatic ecosystem.[68]

Additionally, the focus in biocentrism and physiocentrism on competition is simplistic in view of how organisms actually interact. Competition is only one facet of the interactions involved in an ecosystem. Many organisms also form mutualistic relationships, in which both species benefit. In symbiotic relationships, the species are intimately associated. An extremely important example of this sort of

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[66]Local ecosystem diversity is "the critical biological operating unit[] in nature." *See* J.B. Ruhl, *Biodiversity Conservation and the Ever-Expanding Web of Federal Laws Regulating Nonfederal Lands: Time for Something Completely Different?*, 66 U. COLO. L. REV. 555, 570 (1995). The different levels are all interrelated: "regional ecosystem patterns form the basic matrix for, and thus have important influences on, local ecosystems. Local ecosystems, in turn, form the matrix for species and genetic diversity, which can in turn affect ecosystem and regional patterns." *Id.* (quoting COUNCIL ON ENVTL. QUALITY, EXECUTIVE OFF. OF THE PRESIDENT, INCORPORATING BIODIVERSITY CONSIDERATIONS IN ENVIRONMENTAL IMPACT ANALYSIS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT 1 (1993).

As a general rule, ecosystem function depends on maintaining a certain level of intermediate diversity. *See* Perry & Amaranthus, *supra* note 53, at 41. In the case of a "keystone species," however, the individual species is crucial to the entire ecosystem. The best-known example is the sea otter in the northeastern Pacific Ocean. Sea otters feed on sea urchin, which in turn feed on kelp. A large sea otter population keeps the sea urchin numbers low, allowing the kelp to flourish; the resulting large kelp beds form the basic support for a complex community of plants and animals. When sea otters were overexploited, the sea urchin population exploded, causing the loss of many of the associated organisms. The effects can be seen at every level of the ecosystem, from small kelp beds to fewer harbor seals and bald eagles. *See* Holly Doremus, Comment, *Patching the Ark: Improving Legal Protection of Biological Diversity*, 18 ECOLOGY L.Q. 265, 306 (1991). However, as a general rule, the importance of a single species is relatively small because other species will often evolve to fill any empty niches. For example, on the Galapagos Islands, it is likely that only one species of finch originally colonized the islands; that species evolved into the thirteen current species because of the different opportunities available. *See* WEINER, *supra* note 37, at 206.

[67]*See* WEINER, *supra* note 37, at 201.

[68]*See* Lovejoy, *supra* note 12, at 10.

relationship is the association between mycorrhizal fungi and plants. The fungi form an association with the plants' roots, aiding the plants in the uptake of key nutrients in return for energy in the form of sugars.[69] A more colorful example are the small tropical fish which will clean parasites off larger fish; the small fish get food in return for aiding the larger fish.[70] Organisms also form other sorts of mutualistic relationships, which are less closely associated than symbiosis. The most common example is pollination, where the animals obtain food from the plants while aiding in the plants' reproduction.[71] Additionally, organisms may have commensalistic interactions, where one species benefits and the other does not appear to be harmed. Mimicry is the best example of this sort of interaction: one species evolves to resemble another. For example, certain orchids present young male bees with structures that visually, tactilely and olfactorily mimic those of the female bee. The male bees are then attracted to the orchids. The males attempt to mate with the flower, thus pollinating them. When the females emerge (normally, after the males), the males shift from the flowers to their own species.[72] The orchids have been successfully pollinated, and the male insects have not been appreciably harmed. Lastly, species may be parasitic, attacking another species but not killing it outright. For example, leaches and mosquitos attach to the outside of an animal, suck its blood, and then detach.[73] This harms the species that is used, but it is not the equivalent of two species in competition for the same food sources or nesting areas. Mutualism, commensalism, and parasitism are all important ways that species interact, but none of these forms of interaction can be explained or appropriately accounted for in a system that focuses solely on competition between individuals.

One argument against the ecocentric approach is that our legal system traditionally focuses on individuals. However, focusing on a composite entity is not a novel idea. Corporations are considered to have interests, rights, and duties, quite separate from the individual shareholders, bondholders, officers and directors that form the corporation. Similarly, the ecosystem as a whole has interests that are not adequately protected by looking at the individuals composing it. Additionally, an ecocentric approach need not *preclude* concern for

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[69] *See* EHRLICH & ROUGHGARDEN, *supra* note 38, at 25.
[70] *See id.* at 307.
[71] *See id.* at 299.
[72] *See id.* at 311.
[73] *See id.* at 277-78.

individual beings. At the heart, each ecosystem is made up of individuals. Each part is relevant to the system, and the system cannot function properly without all of its parts.[74] The best analogy is a system that focuses on the welfare of the general society, rather than being concerned with specific individuals' rights. At some level, individuals will be protected as part of society. In a similar manner, international law has traditionally focused on the rights and duties of countries. More modern treaties have also recognized that certain groups of peoples have rights, such as self-determination, while other treaties have looked at the individuals within the countries.[75]

Moreover, focusing on the ecosystem as a composite unit is important because focusing on individual species can lead to conflicting goals. For example, protection of an endangered bird, the snail kite, is blocking plans to increase the flow of water through the Florida Everglades National Park, a step endorsed to preserve the entire Everglades.[76] In another example, game managers have historically advocated forest harvest patterns that increase fragmentation of the landscape because game species, such as deer, thrive in such conditions; however, fragmentation harms the overall biodiversity of the forest area.[77] At the same time, the ecocentric approach allows for more flexibility than an approach focused on individuals. Because ecosystems can withstand some degree of disturbance while

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[74]When I speak of protecting "individuals," this refers to individual species. Given the normal functioning of nature, I do not think it is realistic to consider protection of individual organisms outside of the species framework. However, focusing on individual species may be appropriate in certain circumstances. Although extinction is a natural process, individual species may sometimes be crucial to an ecosystem. Such "keystone" species are crucial to the functioning of the entire ecosystem. The best-known example is the sea otter in the northeastern Pacific Ocean. *See supra* note 66. Additionally, some species serve as "indicators" of the overall health of the ecosystem. The best-known indicator species is the spotted owl in the Northwestern old-growth forests. Many different species, including birds, mammals, reptiles, invertebrates, and plants thrive in the old-growth forests. The owl requires larger undisturbed areas than any of these other species, and thus protecting the owl's habitat protects all the species. *See* Doremus, *supra* note 66, at 306-07. However, although individual species may serve an important function in the ecosystem, or serve as an indicator of the ecosystem's overall health, the main focus should remain on the ecosystem as a whole.

[75]*See, e.g.*, *United Nations Documents*, <http://heiwww.unige.ch/humanrts/un-orgs.htm>.

[76]*See* James Drozdowski, Note, *Saving an Endangered Act: The Case for a Biodiversity Approach to ESA Conservation Efforts*, 45 CASE W. RES. L. REV. 553, 584-85 (1995); Doremus, *supra* note 66, at 309.

[77]*See* NOSS & COOPERRIDER, *supra* note 14, at 26.

maintaining their integrity, human use of natural resources need not be halted.[78]

Along with being the most scientifically sound approach to protecting biodiversity, ecocentrism is the most practical. The lack of knowledge about different species that exist makes focusing on individuals, as in the biocentric and physiocentric approaches, difficult. Scientists have identified only a small fraction of the number of species that exist.[79] How can we protect individual species of which we have no knowledge? Lack of scientific certainty weighs in favor of a cautious approach.[80] It is much more feasible to protect a given ecosystem and all of the species within it, both identified and unidentified. Additionally, it is more cost-effective to protect at the ecosystem level. For example, the Sacramento National Wildlife Refuge protects 257 vertebrate species, along with an uncounted number of plants and invertebrates, at a total annual cost of one million dollars. The program to preserve the California condor costs about the same amount.[81]

Additionally, the ecocentric approach will probably be more successful in the long-term than the biocentric or physiocentric approaches. Many of the crucial elements of the global ecosystem are small and, to humans, not very attractive—fungi, bacteria, and insects.[82] Given the public outcry over saving spotted owls at the possible cost of jobs in the Northwest,[83] public support for protecting fungi species

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[78]*See* Scott W. Hardt, *Federal Land Management in the Twenty-First Century: From Wise Use to Wise Stewardship*, 18 HARV. ENVTL. L. REV. 345, 392 (1994).

[79]Scientists have identified only 1.8 million of the estimated 10 to 100 million species on earth. *See* NOSS & COOPERRIDER, *supra* note 14, at 6.

[80]This precautionary principle is rapidly becoming customary international law. *See Rio Declaration on Environment and Development, U.N. Conference on Environment and Development*, U.N.Doc. A/Conf.151/5/Rev.1, Principle 15 (adopted June 13, 1992); *See* CONVENTION ON BIOLOGICAL DIVERSITY, *supra* note 7, at Preamble; James E. Hickey, Jr. & Vern R. Walker, *Refining the Precautionary Principle in International Environmental Law*, 14 VA. ENVTL. L.J. 423 (1995); Bernard A. Weintraub, *Science, International Environmental Regulation, and the Precautionary Principle: Setting Standards and Defining Terms*, 1 N.Y.U. ENVTL. L.J. 173, 210-11 (1992); Gregory D. Fuller, Comment, *The Precautionary Principle: Environmental Protection in the Face of Scientific Uncertainty*, 31 WILLIAMETTE L. REV. 495 (1995).

[81]*See* Drozdowski, *supra* note 76, at 588 n.189.

[82]*See* Ruth Patrick, *Biodiveristy: Why Is It Important?*, *in* BIODIVERSITY II: UNDERSTANDING AND PROTECTING OUR BIOLOGICAL RESOURCES 15, 15-18 (Marjorie L. Reaka-Kudla et al. eds., 1997).

[83]Phrasing the issue as one of "owls versus people" is incorrect. The real debate is the cost of protecting the old-growth forest ecosystem, with the Endangered Species Act and the owls merely providing the legal ammunition. *See* Flournoy, *supra* note 65, at 269; Schodolski, *supra* note 65, at A15 ("At the heart of the suit brought by more than a dozen environmental groups is the charge that the existing forest management plan won't effectively protect the deteriorating Pacific Northwest environment.").

seems unlikely. In contrast, a call to protect the beautiful old-growth forests, as an entire ecosystem, is more likely to garner public support.

The ecocentric approach, in addition to being more "natural" and scientifically sound, corresponds more closely to human interests than do other approaches. Aside from simple pollution prevention, biological diversity is one of the central instrumental interests of environmental law. Diverse species provide a huge potential resource for mankind in the form of foods and medicines. Since we have not identified the majority of species on this planet, the easiest way to protect the most species is to protect their ecosystems. Additionally, the values that are not related to direct use of the natural object ("passive use values") spring more from the ecosystem, rather than from individual entities or even individual species.[84]

The advantages of focusing on ecosystems rather than individuals or discrete aspects of an ecosystem are gradually being realized even within the anthropocentric model. The environmental laws in the 1970s and 1980s focused on "discrete" parts of the environment—clean air, clean water, hazardous wastes, and endangered species. In the last few years, there has been an increasing move toward approaching environmental problems on an ecosystem-wide basis.[85]

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[84]As discussed below, passive use values encompass such things as the worth of knowing that a given natural area exists and will exist in the future. *See infra* note 108 and accompanying text. One study of the contingent valuation method showed that for species conservation, passive use values were in the range of $1-18 per person (if one excludes humpback whales), while the range for prized habitat was $9-107 per person per year. *See* PEARCE, *supra* note 6, at 75.

[85]For example, in the area of biodiversity, the Fish and Wildlife Service issued a policy statement in March 1994 proposing an ecosystem approach. *See* Ruhl, *supra* note 66, at 590. The EPA, which does not have authority over any of the statutes that directly protect biodiversity, has also recently turned its attention toward protecting ecosystems rather than individual parts, such as the air or water. *See id.* at 647-48. Current Forest Service regulations require that regional and forest plans be based upon the "[r]ecognition that the National Forests are ecosystems and their management for goods and services requires an awareness and consideration of the interrelationships among plants, animals, soil, water, air, and other environmental factors within such ecosystems." Hardt, *supra* note 78, at 393 (quoting 36 C.F.R. § 219.1(b)(3)(1992)). In 1991, the National Biodiversity Conservation and Environmental Research Act was proposed in Congress to shift the focus from endangered species to "endangered ecosystems." *See* Bloch, *supra* note 8, at 204 (quoting United States Congressman James Scheuer (D-NY) as to the purpose of the bill). Several other bills have been proposed to provide protection to specific ecosystems. *See, e.g.*, H.R. 1590, 102d Cong. (1991); Ancient Forest Protection Act, H.R. 842, 102d Cong., (1991); Forest Community Survival Act, H.R. 2807, 102d Cong., (1991); Forest Biodiversity and Clearcutting Prohibition Act, H.R. 1969, 102d Cong., (1991) & S. 3228, 102d Cong., (1992). Many commentators, both scientists and legal scholars, have endorsed the move towards an ecosystem approach. *See, e.g.*, Hal Salwasser, *In Search of an Ecosystem Approach to Endangered Species Conservation*, *in* BALANCING ON THE BRINK OF EXTINCTION: THE ENDANGERED SPECIES ACT AND LESSONS FOR THE FUTURE 247 (Kathryn A. Kohm ed., 1991); Virginia S. Albrecht & Thomas C. Jackson, *Battle Heats Up as Congress Begins Review of*

Having come so far, it would be unfortunate to move backwards in the transition to a non-anthropocentric approach.

I have not discussed one factor that several academics have focused upon in recent years—the intrinsic value of non-humans.[86] The main reason for such a focus is that the ecocentric approach can be adopted without believing that non-humans and the world have intrinsic value. Given that, I prefer to leave the ethics debates to those more experienced in the area, while focusing on the scientific and policy reasons to adopt the ecocentric approach.[87] Obviously, the statement that humans are not separate from the rest of nature has ethical implications, but it need not be based on ethics.

In practice, an ecocentric approach would require revisions in several aspects of the law. First, the ecosystem should be made a rights-holder, legally entitled to bring suit. A trustee could be appointed to represent its interests, as is done for humans who are not competent to appear in court.[88] In addition, new ways to measure damages will have to be formulated. The damages issue is the focus of the second half of this Article.

III. APPLICATION TO CIVIL LIABILITY

A. Current Anthropocentric Approach: Natural Resource Damages

Three federal environmental statutes provide a remedy for injury to public lands: the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA),[89] the Clean Water Act (CWA),[90] and the Oil Pollution Act of 1990 (OPA).[91] These laws

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Endangered Species Act, NAT'L L.J., May 18, 1992 §1; William M. Flevares, Note, *Ecosystems, Economics, and Ethics: Protecting Biological Diversity at Home and Abroad*, 65 S. CAL. L. REV. 2039 (1992); L. Scott Mills, *The Keystone-Species Concept in Ecology and Coservation*, 43 BIOSCIENCE 219 (1993); Michael E. Soule, *Conservation: Tactics for a Constant Crisis*, 253 SCIENCE 744 (1991).

[86]*See, e.g., supra* note 4.

[87]In other words, it is not necessary to know whether we are assigning rights because we want a certain outcome for humans or assigning rights because we actually think the natural ecosystems have rights.

[88]This is basically the same suggestion as made by Professor Stone almost 20 years ago, substituting the ecosystem in place of individual natural objects. *See* Stone, *supra* note 3.

[89]CERCLA § 107, 42 U.S.C. § 9607 (1999).

[90]Clean Water Act § 311(f)(5), 33 U.S.C. § 1321(f)(4) (1999).

[91]Oil Pollution Act of 1990 § 1006, 33 U.S.C. § 2706 (Supp. 1999). OPA's provisions largely replace the liability created in the CWA regarding oil spills. *See* Terry Fox, Comment, *Natural Resource Damages: The New Frontier of Environmental Litigation*, 34 S. TEX. L. REV. 521, 561-62 & n.273 (1993). The CWA is still important, however, in the overall field of natural

allow public trustees (generally government officials) to sue the responsible parties to collect for natural resource damages on behalf of the public.[92] "Natural resources" are defined as: "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources."[93] Damages to any of these resources, or to their "services,"[94] constitutes injury for which compensable damages are recoverable. All three statutes indicate that the measure of damages is meant to be the cost of restoration.[95] The major case interpreting the meaning of "natural resource damages" under these statutes, *Ohio v. United States Department of Interior*,[96] held that restoration was the presumptive measure of damages.[97] The court used the term

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resource damages. *Cf.* Kennecott Utah Copper Corp. v. United States Dep't of Interior, 88 F.3d 1191, 1228 (D.C. Cir. 1996) (finding CERCLA and the CWA are coextensive remedial schemes that allow recovery of interim services).

[92]The CWA recognizes the authority of federal and state officials to serve as natural resource trustees. Clean Water Act § 311(f)(5), 33 U.S.C. § 1321(f)(5) (1999). CERCLA additionally recognizes Indian tribal trustees. CERCLA § 107(f), 42 U.S.C. § 9607(f) (1999). OPA adds heads of foreign governments to the list. Oil Pollution Act of 1990 § 1006(b), 33 U.S.C. § 2706(b) (1999).

[93]42 U.S.C. § 9601(16) (1995); 33 U.S.C. § 2701(20) (1999).

[94]*See* 43 C.F.R. § 11.14(nn) (1999) (defining natural resource services as "the physical and biological functions performed by the resource, including the human uses of those functions"). This conception of "services" incorporates some level of ecosystemic approach.

[95]The CWA specifically states that the measure of damages is the cost of "restoration or replacement of natural resources damaged or destroyed." Clean Water Act § 311(f)(4), 33 U.S.C. § 1321(f)(4) (1994). CERCLA's statutory language and legislative history indicate that the proper measure of damages is restoration. *See* Ohio v. United States Dep't of Interior, 880 F.2d 432, 441-53 (D.C. Cir. 1989). *See also* CERCLA § 107(f)(1), 42 U.S.C. § 9607(f)(1) (1999) (providing that the funds recovered by trustees "shall be retained . . . for use only to restore, replace, or acquire the equivalent of such natural resources"); CERCLA § 301(c)(2), 42 U.S.C. § 9651(c)(2) (1999) (listing factors to be considered in assessing natural resource damages); CERCLA § 122(j)(2), 42 U.S.C. § 9622(j)(2) (1999) (allowing settlement only "if the potentially responsible party agrees to undertake appropriate actions necessary to protect and restore the natural resources"); 126 CONG. RECS. 30,970 (1980) (remarks of Sen. Williams) ("The legislation will provide for the restoration of natural resources which have been damaged . . . ."); *id.* at S30,942 (remarks of Sen. Mitchell) ("[W]e want prompt, full compensation in such cases so we can replant the trees in the park . . . ."); *id.* at S21,377 (remarks of Sen. Gravell) ("The most important aspect to this bill from a national viewpoint is the provision of funds for the restoration, rehabilitation and replacement of natural resources . . . ."); Superfund Amendments and Reauthorization Act of 1986, Pub. L. No. 99-499, 100 Stat. 1613 (1986) (codified as amended in scattered sections of 42 U.S.C.) (indicating that the language in CERCLA § 107(f)(1) was meant to further the "primary purpose of . . . restoration or replacement of natural resources"). Like the CWA, OPA clearly states that the measure of damages should include the cost of restoration. OPA § 1006(d); 33 U.S.C. § 2706(d).

[96]Ohio v United States Dept. of Interior, 880 F.2d 432 (D.C. Cir. 1989). A companion case, *Colorado v. United States Department of Interior*, 880 F.2d 481 (D.C. Cir. 1989), dealt with regulations governing "minor" spills. Since the issues relevant to this paper were identical, I will not discuss any of the distinctions.

[97]Ohio v. United States Dept. of Interior, 880 F.2d at 459.

"restoration" as shorthand for "restoring, rehabilitating, replacing, or acquiring the equivalent of" the natural resource.[98]

Regulations have been promulgated to implement these statutes. The regulations provide that some form of restoration costs be used in every situation, with the trustees considering a range of possible alternative actions that would accomplish the "restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources."[99] The regulations "allow [] trustee officials to rely upon natural recovery when appropriate."[100] In fact, the regulations *require* that trustees consider "No Action-Natural Recovery" as an alternative.[101] The regulations also require trustees to "consider both cost effectiveness and the relationship between costs and benefits."[102] Looking at the factors listed to guide the trustees,[103] the decision regarding which method of restoration to use depends on the cost and benefits of each method when combined with the value of the services lost to the public during the restoration period.[104]

The definition of "services" under these regulations is debatable. The *Ohio* decision required the agency to take passive use

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[98]*Id.* at 441.

[99]43 C.F.R. 11.82(a) (setting out the Department of Interior's regulations for assessing natural resource damages under CERCLA). The regulations provide that some form of restoration costs be used in every situation, with the trustees developing a "reasonable number of possible alternatives for the restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services those resources provide." *Id. See* Natural Resource Damage Assessments, 61 Fed. Reg. 440, 441 (1999).

[100]Natural Resource Damage Assessments, 59 Fed. Reg. 14,262, 14,271 (1994).

[101]*See* 43 C.F.R. § 11.82(c)(2) (1999).

[102]Natural Resource Damage Assessments, 59 Fed. Reg. at 14,274.

[103]*See* 43 C.F.R. § 11.82(d). The first factor is technical feasibility, which encompasses both existence of the technology and the ability to obtain the necessary equipment, supplies, etc. The second factor, the relationship between expected costs and benefits, and the third factor, cost-effectiveness, both focus on cost-benefit analyses. The fourth factor, the results of any planned response actions, simply establishes what the status of the natural resources will be once the first phase of CERCLA is completed. The fifth factor, the potential for additional injury resulting from proposed actions, and the eighth factor, the potential effects on human health and safety, basically look at the results of the different alternatives, on the environment and on people. The sixth factor, the natural recovery period, is closely linked to cost, in the form of the amount of compensable values lost. The seventh factor, the ability of the resources to recover with or without alternative actions, is again closely related to the costs and benefits of each alternative. The ninth factor, consistency with relevant Federal, State and tribal policies, can be seen as a specific type of benefit. The tenth factor, compliance with the applicable Federal, State and tribal laws, is basically a legal feasibility requirement.

Overall, these factors require the trustee to weigh the costs and benefits of each alternative, with certain costs and benefits specified for special attention, along with ensuring technical and legal feasibility.

[104]*See* 43 C.F.R. § 11.81(a)(2).

values into account.[105] Passive use values include the value to people: of retaining the option of future use (option value), of knowing that a given natural environment is protected (existence value), of knowing that the resource is preserved for future generations (bequest value), and of having the option to use the resource in yet-unknown ways (quasi-option value).[106] Passive use values can only be measured effectively by the use of contingent valuation, which uses direct questioning of individuals through surveys to estimate a dollar figure for these damages.[107] The current regulations restrict the use of contingent valuation to circumstances where "the authorized official determines that no use values can be determined."[108] Thus, in many circumstances, the interim losses that will be measured will only be use values such as hunting and fishing licenses and entrance fees to parks.[109]

The natural resource damages provisions in all the statutes apply only to public lands. For damage to ecosystems on private lands, the landowners can sue for cleanup costs.[110] For additional damages landowners must rely on the common law. Traditionally, the measure of damages has been the lesser of the cost of restoration or the

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[105]*See* Ohio v. United States Dep't of Interior, 880 F.2d 432, 464 (D.C. Cir. 1989) (stating that limiting the role of passive use values to the bottom of the hierarchy was not a permissible reading of the statute).

[106]*See* Frank B. Cross, *Natural Resource Damage Valuation*, 42 VAND. L. REV. 269, 285-88 (1989) (discussing these values).

[107]*See* Jeffrey C. Dobbins, *The Pain and Suffering of Environmental Loss: Using Contingent Valuation to Estimate Nonuse Damages*, 43 DUKE L.J. 879, 917 (1994). Many papers have been written on the use of contingent valuation to measure nonuse values. *See, e.g.*, Brian R. Binger et al., *The Use of Contingent Valuation Methodology in Natural Resource Damage Assessments: Legal Fact and Economic Fiction*, 89 NW. U. L. REV. 1029 (1995); Peter Bohm, *CVM Spells Responses to Hypothetical Questions*, 34 NAT. RESOURCES J. 37 (1994); Faith Halter & Joel T. Thomas, *Recovery of Damages by States for Fish and Wildlife Losses Caused by Pollution*, 10 ECOLOGY L.Q. 5, 24-28(1982).

[108]43 C.F.R. § 11.83(c)(1)(iii); *see also id.* § 11.83(c)(2)(vii)(B) (restating this restriction as applied specifically to the contingent valuation methodology). The NOAA regulations under OPA take different approach to restricting the inclusion of nonuse values. Contingent valuation is restricted to situations where the trustee decides to take a valuation approach to the interim losses, as opposed to a resource-to-resource or service-to-service approach. *See* Natural Resource Damage Assessments, 61 Fed. Reg. 440, 453 (1996).

[109]*Cf.* Dobbins, *supra* note 107, at 917 (arguing that the only methodology available to a trustee for measuring nonuse values is contingent valuation). Given the current regulations' limitation on the use of contingent valuation for estimating nonuse values, any measure of nonuse values is effectively limited to circumstances where use values cannot be assessed. *See* 43 C.F.R. § 11.83(c)(2)(vii)(B) (1995).

[110]*See* CERCLA § 107, 42 U.S.C. § 9607; OPA § 1002(b), 33 U.S.C. § 2701(b).

diminution in value of the property.[111] The trend has been towards allowing restoration, but that remedy is still not a presumption.[112]

B. Critique of the Current Approach

The current laws and regulations reflect an anthropocentric approach—they focus on the value of nature as a resource to humans.[113] The general problems relating to an anthropocentric approach apply here: it is inconsistent with the science of ecology, and it appears to be insufficient to protect the environment.[114] There are additional objections to the anthropocentric approach in this specific context. First, the statutes specifically protect public lands, leaving liability for damage to private lands in the discretion of the courts. This distinction between public and private lands is based upon the idea that the laws protect public lands for the value as resources to the general public. The underlying assumption is that private landowners have sufficient protection for the use of their own lands. This assumption ignores the fact that a biologically diverse ecosystem on private land is just as valuable, in terms of ecology, as is the same ecosystem on public land. Additionally, this distinction allows a public trustee to acquire "equivalent" natural resources in place of restoring the damaged ecosystem. In terms of public lands, this remedy repairs the damage done by the polluter. In terms of overall biodiversity and the global ecology, however, such acquisition is a net loss. Public and private ecosystems should be treated as one unit in considering how best to assess damages to either. As far as nature is concerned, the distinction between public and private lands is completely artificial and illogical.[115]

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[111] *See* RESTATEMENT (SECOND) OF TORTS § 929(1)(a) (1977).

[112] *See* Thomas Scott Stewart, *Utah v. Kennecott Corporation: Seeking Ultimate Values with the "Grossly Disproportionate" Test for Natural Resource Damage Assessments*, 13 St. Louis U. Pub. L. Rev. 887, 900-01 (1994).

[113] CERCLA defines natural resources to include "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources." CERCLA § 101(16), 42 U.S.C. § 9601(16) (1999).

[114] The rate of destruction of biodiversity is still quite high. Judging by how few cases have actually involved natural resource damages, it may be fairly inferred that the current laws are insufficient deterrent.

[115] I am not trying to argue for a complete abolishment of the distinctions between public and private property. Taken to the extreme, a pure ecocentric approach could be used to argue that a private landowner could not cut down a tree on his own property if the benefits did not outweigh the costs to the ecosystem. My argument falls far short of that extreme, because I feel that an ecocentric approach, although the best paradigm for environmental law, does not somehow replace all the competing values in our legal system.

Second, taking the anthropocentric approach leads to undervaluation of the damaged ecosystems. Although the presumptive measure of damages is "restoration," the trustee may often resort to natural recovery (simply letting time heal the damage) because of the way "restoration" is defined in the current regulations. Although natural recovery may, under certain circumstances, be the best or only way to restore the environment,[116] it is entirely unsatisfactory in terms of making the polluter pay and in deterring pollution. The damages in situations where the trustee chooses the option of natural recovery will be composed mainly of the interim losses.[117] The likelihood of under valuation in these cases is severe. Since the use of contingent valuation, and hence the inclusion of passive use values, is severely restricted, the interim losses will often be composed solely of the lost use values. Even where passive use values are included, the loss is still likely to be undervalued because of the agencies' guidelines on the use of contingent valuation.[118] Even if the contingent valuation fully accounted for passive use losses, the damages still would not reflect the losses to the ecosystem and the surrounding ecosystems it affects.

Overall, the current regulations reflect a very limited view of damages even within an anthropocentric approach. Even a more liberal approach to natural resource damages would still be limited by the focus on ecosystems as resources directly utilized by humans, rather than an understanding of their full importance.

C. Proposal: Ecosystem Damages

I suggest a new approach for assessing civil liability for damages to natural objects—ecosystem damages. First, this approach

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[116]Some of the efforts to clean up the *Exxon Valdez* oil spill, such as the use of high-pressure sprays, may have actually caused additional harm. *See* Meredith Goad, *Marsh's Recovery Largely Up to Nature*, PORTLAND PRESS HERALD Oct. 6, 1996, at 1A; Merv Fingas, *Oil Spills and Their Cleanup*, CHEMISTRY & INDUSTRY 1005 (Dec. 18, 1995).

[117]The damages will be based on the cost of natural recovery (such as fencing off the area) and the "compensable value" component. *See* 43 C.F.R. § 11.81(a)(2).

[118]For example, both the NOAA and the DOI regulations state that the survey should ask respondents their "willingness-to-pay" for the lost resources, as opposed to their "willingness-to-accept." *See* 43 C.F.R. § 11.83(c)(2)-(3) (1999). Since the resources were publicly owned, and were taken from the public, the theoretically correct measure of damages is their willingness to accept money in exchange for the losses. *See* Daniel S. Levy & David Friedman, *The Revenge of the Redwoods? Reconsidering Property Rights and the Economic Allocation of Natural Resources*, 61 U. CHI. L. REV 493 (1994); Natural Resource Damage Assessments, 59 Fed. Reg. 52,749, 52,755(1994); Natural Resource Damage Assessments, 59 Fed. Reg. 1062, 1146 (1994). Using the willingness-to-pay format consistently results in substantially lower figures. *See* Levy & Friedman, *supra*, at 496.

would involve reevaluating the trustee's role. The beneficiary would be the ecosystem rather than the American public. As such, the trustee's duty of care would run to the natural objects themselves. The trustee could either be a public official, as under the current laws, or a court-appointed environmental group. Allowing environmental groups special standing to protect the environment is already occurring in Switzerland.[119] This suggestion is very similar to Professor Stone's in *Should Trees Have Standing?*[120] However, Professor Stone took more of a physiocentric approach, focusing on individual natural objects, such as trees and rivers. As discussed in Part II, this approach does not seem to correspond with the current scientific understanding of the environment. Under an ecocentric approach, as opposed to Stone's physiocentric approach, any monetary damages collected that could not be applied toward restoration of the damaged ecosystem could be used for other ecocentric purposes, rather than being held in "trust" for the specific natural object damaged.[121]

The structure for assessing civil liability under an ecocentric approach should be consistent both with the legal aspects of granting ecosystems rights and with the underlying scientific rationale. The remedy should focus on the ecosystem whenever possible. Therefore, the default rule should be restoration. By restoration, I mean activities designed to help the composite organisms of an ecosystem (plants, animals, fungi, bacteria) create a functioning entity again.[122] Such actions could include transplanting organisms from other areas, increasing nutrient levels, increasing water levels, and so forth. Restoration makes the ecosystem "whole," a general goal of much of tort and contract law. Restoring the ecosystem also minimizes the ecological consequences of the damage. The ecocentric approach would require an even stronger presumption in favor of restoration than is required under the current statutes and the *Ohio* decision. The *Ohio* court interpreted the statutes to require restoration unless it was not

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[119]There was originally a proposal to amend the Swiss Constitution to grant standing to environmental groups. Ernst Brandl & Hartwin Bungert, *Constitutional Entrenchment of Environmental Protection: A Comparative Analysis of Experiences Abroad*, 16 HARV. ENVTL. L. REV. 1, 56 (1992). The proposal failed. *Id.*

[120]Stone, *supra* note 3.

[121]*See id.* at 480-81.

[122]*See* Stanley V. Gregory, *Riparian Management in the 21st Century*, *in* CREATING A FORESTRY FOR THE 21ST CENTURY 69, 79 (Kathryn A. Kohm & Jerry F. Franklin eds., 1997) ("The goal of ecological restoration is to reestablish the ability of the system to maintain its function and organization without continued human intervention.").

feasible or it was grossly disproportionate to use values;[123] the current regulations, although superficially always requiring restoration, have undermined this aspiration by defining restoration to include natural recovery.[124] In an ecocentric approach, where the ecosystem itself is the center of the suit, the presumption in favor of restoration should be overwhelming. Restoration would not be the appropriate measure of damages only where it is technologically infeasible,[125] or where it is grossly disproportionate to the total losses to the ecosystem, not just the lost use by humans.[126]

In setting this default, the laws, however, will have to recognize that restoration attempts can only approximate the status quo ante. As discussed in the first part of this paper, ecosystems are not static; there is constant change and movement. Species themselves are constantly changing,[127] and small differences that are difficult for humans to measure may be significant.[128] A new field, restoration ecology, addresses many of the problems in this area.[129] One problem is that ecosystems develop over a long period of time. Human efforts to accelerate the process can only do so much.[130] Second, restoration efforts beyond a certain point may actually harm the ecosystem more than they help.[131] Overall, the goal may be more to return the area to a fully functioning ecosystem that approximates the services provided by

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[123]*See* Ohio v. United States Dep't of Interior, 880 F.2d 432 (D.C. Cir. 1989).

[124]*See* 43 C.F.R. § 11.82(c) (1999).

[125]*See, e.g.*, Perry & Amaranthus, *supra* note 53, at 46-48 (discussing circumstances in which an ecosystem cannot be restored because of permanent changes in the soil).

[126]One example of where it may be grossly disproportionate is where the area was already polluted, so that restoring the ecosystem to a functioning level again would require the polluter to pay for damages he did not cause. *See* Stewart, *supra* note 112, at 913.

[127]For example, the patterns of dots on guppies in a river can have serious implications for their ability to survive and reproduce. *See* WEINER, *supra* note 37, at 93.

[128]For example, the patterns of dots on guppies in a river can have serious implications for their ability to survive and reproduce. *See id.* at 93.

[129]*See, e.g.*, CREATING A FORESTRY FOR THE 21ST CENTURY, (Kathryn A. Kohm & Jerry F. Franklin eds., 1997). This field is far too complex to be addressed in this Article.

[130]For example, one study of restored coastal mashes near San Diego reported that, 5 years after restoration began, the restored wetland resembled the reference wetland by only about 57%, based on indicators such as biomass, plant height, soil organic-matter content, etc. *See* William R. Jordan, III, *Ecological Restoration and the Conservation of Biodiversity*, *in* BIODIVERSITY II: UNDERSTANDING AND PROTECTING OUR BIOLOGICAL RESOURCES 371, 377 (Marjorie L. Reaka-Kudla et al. eds., 1997). The restoration of the Henry Greene Prairie, done in the 1940s, attempted to restore the historic prairie that had been virtually eliminated through intensive farming. Parts of Greene Prairie now closely resemble natural prairies in the area with respect to the species, abundance, and distribution of vascular plants. *See id.* at 378.

[131]*See* Cross, *supra* note 106, at 299-300 n.154.

the old one, both to humans and to other ecosystems, rather than a vain attempt to recreate the old ecosystem.[132]

If restoration is not practical, then the best alternative measure of damages would be replacement of the ecosystem. In this context, "replacement" means something very different from what it means when used in the current regulations. In the regulations, replacement covers the situation where fifty acres of a public forest is damaged, and the trustee takes funds and buys fifty acres of the neighboring forest land from a private owner. This "replaces" the "resources" that the public lost through environmental damage. In terms of global biodiversity and ecosystem-diversity, it is, however, still a net loss; instead of 100 acres of forest land, there is now fifty acres of forest land and fifty acres of contaminated land with little or no biodiversity. Since the major concern under the ecocentric approach is to preserve overall biodiversity, this sort of replacement is inadequate. Instead, replacement in the ecocentric approach would involve purchasing land that was either (1) contaminated but restorable, or (2) ecologically-barren (such as farmland with monoculture crops), and establishing an ecosystem similar to the unrestorable ecosystem. As with restoration of the damaged ecosystem, the replacement ecosystem will not be an exact substitute; ecosystems are simply too complex and dynamic to achieve an exact substitute.

The major problem with using restoration or replacement is that it may often take a long time or even be impossible. In those circumstances, what damages should be assessed during restoration or as an alternative? A determination that the cost of restoration is grossly disproportionate requires that the losses be quantified. This requires assessing damages and using a method such as the one outlined below.

One possibility would be to view interim losses as unnecessary: if the ecosystem is restored, then it does not matter that there was a brief time when the ecosystem was damaged. This argument, although plausible on the surface, overlooks the deterrent aspect of damages. Even though the period during which an ecosystem was damaged may

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[132] *Cf.* NOSS & COOPERRIDER, *supra* note 14, at 9 ("In terrestrial communities some of the most important processes are fire and other natural disturbances, hydrological cycles, nutrient cycling, plant-herbivore interactions, predation, mycorrhizal interactions between tree and shrub roots and fungi, and soil building processes."). Restoration ecology is a rapidly growing field, too complex to be adequately addressed in this paper. *See* CREATING A FORESTRY FOR THE 21ST CENTURY, *supra* note 129; STEVEN L. YAFFEE ET. AL, ECOSYSTEM MANAGEMENT IN THE UNITED STATES (1996).

have been brief in relation to long-term evolution,[133] it is still a loss, both to people (as recognized under the current laws) and to nature. Such losses include damage to the services provided by an ecosystem: habitat for migratory animals, contributions to the surrounding air and water, and so forth. If the polluter is not forced to pay for all the costs of his actions, then there is insufficient incentive to prevent future pollution.[134] Also, in scientific terms, even a brief loss is significant. As discussed earlier, one major reason for focusing on ecosystems is the services that ecosystems provide, to humans and to other ecosystems. Although the loss of direct human services, such as recreation, may be simple and relatively insignificant, the loss of services such as regulating the hydrological cycle or providing habitat for migratory animals is important.

My proposal for determining monetary damages, either interim losses or damages assessed when restoration and replacement are impractical, is to set up a panel to establish damages for different ecosystems and portions of ecosystems based on a set of factors discussed below. These guidelines would then become the presumptive measure of damages for a judge in setting damages. In some ways, this system is analogous to Workers' Compensation, in which values have been set for various injuries, such as the loss of an eye or a leg—a level of individualized determination has been traded for greater certainty. Unlike Workers' Compensation, this proposal does not involve an insurance-type pool; the polluter should pay for the damage he specifically caused.

The selection of the members of the panel should reflect the duties of the panel. The ultimate goal is to determine as accurately as possible the monetary equivalents for damaged ecosystems. What elements should be considered? First, one needs to recognize that an ecocentric approach does not ignore humans. Humans are part of the ecosystem, and their interests are relevant. Therefore, the measures of

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[133] *But see* WEINER, *supra* note 37 (discussing the rapid evolution of finches on the Galapagos Islands).

[134] Valuation of ecosystems is important to prevent economic development when the benefits from that development would not outweigh the benefits gained through protecting the ecosystem, rather than assuming that natural systems have negligible economic value. For example, when deciding whether to divert water from wetlands for agricultural purposes, the benefits of the agriculture should be weighed against such benefits as commercial fishing, recreation, fuelwood, and water cleansing. In a study of wetlands in Nigeria, it was determined that the net benefits of preserving the wetlands were $45 per 1000 m^3, while the benefits from diverting the water through a dam were only 4 cents per 1000 m^3. *See* PEARCE, *supra* note 6, at 69-71.

damages under the current anthropocentric approach should be included. Under an ecocentric approach, however, humans are just one species among many. Thus, the major element of damages will consist of the value of the ecosystem to other species and the global ecosystem. Many factors will go into this element of the damages: biodiversity richness; ecological functions such erosion protection, flood prevention, and water cleansing; importance to neighboring ecosystems, such as effects on the hydrological cycle[135] and habitat for migratory animals, and so forth. Since ecological issues dominate the ecocentric approach, they should be weighted more heavily than human use of the ecosystem. One possible division would be to assign seventy percent of the damages to the ecological damages and thirty percent to human use. The exact division can be debated, but the total emphasis should remain on the ecosystem itself.

Now that the elements of the damages are known, the composition of the panel can be determined. It should be heavily dominated by scientists such as zoologists, botanists, chemists, and environmental engineers. Scientists have the most expertise in understanding how extensive the damages are and to what extent such damages have affected other ecosystems. They will be able to make the best predictions as to what the future effects of the damages will be, although admittedly that is an extremely complex issue. Along with scientists, the panel should also include economists to create tools to measure the losses to humans by whatever methodology is determined to be appropriate.[136]

The panel should invite outside comment to help it in its deliberations. Important sources of information for the panel would include indigenous peoples, environmental groups, and industry groups. Local indigenous peoples may be able to give the scientists and economists a better sense of the possible human uses of an area.[137] Environmental groups, such as the Nature Conservancy, have an existing level of expertise in placing a monetary value on different ecosystems based on various factors. Industry groups can provide information on the current levels of technology, helping to ensure that

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[135]For example, the Amazon River ecosystem has a strong influence on the entire hydrological cycle for the area. *See* Lovejoy, *supra* note 12, at 10.

[136]Thus, the economists could be left to decide if and how to include passive use values.

[137]In inviting local indigenous populations to aid the panel, the panel must be careful not to place a greater importance on areas that are inhabited as opposed to those that are uninhabited, beyond even the simple inclusion of human use values. Given that the main concern in this paper is to protect ecosystems for their global importance to humankind, skewing the panel in favor of inhabited areas would be inappropriate.

the panel's determination of the cost restoration is well-grounded in practical realities. Certainly, other sources of information may also be appropriate in individual circumstances.

One issue that will be problematic is defining what constitutes an ecosystem. An "ecosystem" can be defined as "the physical environment and all the organisms in a given area, together with the webwork of interactions of those organisms with that physical environment and with each other."[138] Within a forest, there are micro-ecosystems, such as trees, in which some organisms live their entire existence. How large must the ecosystem be before damages are assessed? What is considered a *de minimis* injury? The answer may differ depending on the location and type of the area at issue. Additionally, the fact that a change in one ecosystem will have unpredictable, and possibly long-term, effects on other ecosystems will have to be taken into account. This sort of fact-specific problem is best left to the members of the panel.

The panel's determinations will serve as a guideline for judges in civil suits. Once the jury has found that the polluter is liable for the damage to the ecosystem, the judge will set the damages.[139] He will be able to deviate from the guidelines only if there is clear and convincing evidence to support such a deviation.

Since damages set by the panel's guidelines will be assessed as either interim losses or as alternatives to restoration or replacement, by definition such damages cannot be used for restoration or replacement. Even so, it is important to award damages simply as a deterrent measure and punishment for the polluter. These damages should go into a special fund. They can be used to buy pristine natural lands to protect from future damage (the view of "replacement" under the current regulations). They can also be used to fund scientific research to study ecosystems. Another valid use would be for technological research on ways to prevent such damage (such as alternative energy sources) or better means to restore damaged ecosystems (such as bio-remediation).

Finally, provisions should be made to allow for similar recovery for damages to private lands. Protection of ecosystems on private land should not be left to the common law. Landowners could be deemed as

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[138]EHRLICH, *supra* note 10, at 239 (1988).

[139]An alternative would be to establish the panel as part of an administrative agency, such as the Department of the Interior, and have the case tried before an Administrative Law Judge. Another option would be to leave the determination of damages to the jury, with the panel's guidelines before them, with the judge having the power to reform the judgment if any deviation is not supported by clear and convincing evidence.

trustees for their land. Just as with public lands, these laws should focus on protecting ecosystems, not individual natural objects. Only those landowners who preserve natural ecosystems rather than destroying them would be eligible to sue for ecosystem damages; as a result, most of the private land protected in this manner would probably belong to groups like the Nature Conservancy.

CONCLUSION

The current legal system lags far behind the scientific understanding of our environment. Such a lag is unsurprising—our legal system is often reactive, rather than pro-active. However, the legal system must begin to adapt. The failure to protect the environment adequately has already cost humanity in many ways, ranging from potential medicines that have been lost to unpredictable changes in the climate. Restructuring environmental law in a manner consistent with science would provide an appropriate framework within which ethical and social issues could be weighed. Science cannot provide a single answer. It can, and must, provide the basis for a long-term solution to the questions of what to protect and at what cost.