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# What Are Slugs Good For?: Ecosystem Services and the Conservation of Biodiversity

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# WHAT ARE SLUGS GOOD FOR? ECOSYSTEM SERVICES AND THE CONSERVATION OF BIODIVERSITY

DALE D. GOBLE\*

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## I. INTRODUCTION

*The concept of “ecosystem services” was conceived as a tool for conserving biodiversity. Ecosystems, the argument goes, provide services that would be far more costly if we sought to provide them through engineered approaches; valuing the benefits that nature confers will help society more consciously evaluate the environmental tradeoffs between alternative actions. Given this objective, ecosystem services can be characterized as a “surrogate” for biodiversity—a step that makes explicit the assumption that, if we conserve ecosystem services, we will conserve biodiversity. It is this assumption that is the focus of this article. Surrogates are employed when it is difficult, expensive, or impossible to measure something. An examination of the concept of biodiversity demonstrates that it is such a something. Are ecosystem ser-*

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\* Margaret Wilson Schimke Distinguished Professor of Law, University of Idaho. My thanks to Gretchen Daily, Holly Doremus, Bryan Norton, J.B. Ruhl, J. Michael Scott for their helpful comments, and the participants at the Symposium on The Law and Policy of Ecosystem Services organized by J.B and Jim Salzman at Florida State University College of Law -- it was a model of what such events should be. They all are, of course, absolved of any responsibility.

*vices a suitable surrogate for biodiversity? A preliminary review suggests two problems. First, the spatial and temporal scales of biodiversity and ecosystem services differ substantially. Second, the utilitarian valuation that is implicit in the term "services" and explicit in the attempt to monetize that value also undercuts the usefulness of ecosystem services as a surrogate because it appears likely that there will always be a more "efficient" way to provide any specific service. Ultimately, whether ecosystem services are a suitable surrogate for biodiversity depends upon whether biodiversity has value beyond utility.*

What are slugs good for? They aren't tasty like cows or corn. They can't be bottled in garlic oil and sold as faux escargot. Slugs are neither charismatic<sup>1</sup> nor megafauna. Slugs are just icky.

Slugs do, however, serve a role in the ecosystems they inhabit. They are decomposers, chewing up leaves, feces, and other detritus and helping to recycle the nutrients back into the soil.<sup>2</sup> Slugs thus contribute to what has become known as "ecosystem services." In Gretchen Daily's frequently cited definition, ecosystem services are "the conditions and processes through which natural ecosystems . . . sustain and fulfill human life."<sup>3</sup> The service to which slugs contribute is replenishing soil fertility.

In defining ecosystem services, Daily noted that the concept had been born from the conclusion "that society is poorly equipped to evaluate environmental tradeoffs, and that the . . . continued resolution [of these tradeoffs] on the sole basis of the social, economic, and political forces prevailing today threatens environmental, economic, and political security."<sup>4</sup> The goal was to foster

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1. In the reverse psychology of such matters, the native slug of the Pacific Northwest, the banana slug, is the school mascot of the University of California, Santa Cruz. The species was not, however, chosen to grace the "tails" side of the new Washington state design for the quarter; the salmon was chosen instead. Richard Roessler, *In Search for Identity, Toss Goes to Fish*, THE SPOKESMAN-REVIEW, May 5, 2006, at 1A.

2. See generally ROBERT E. RICKLEFS, *ECOLOGY* 239-40 (3d ed. 1990).

3. Gretchen C. Daily, *Introduction: What are Ecosystem Services?*, in NATURE'S SERVICES 1, 3 (Gretchen C. Daily ed., 1997) [hereinafter NATURE'S SERVICES]. The same definition with a more expansive discussion can be found in Gretchen C. Daily et al., *Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems*, 2 ISSUES IN ECOLOGY 2 (1997), available at [http://www.esa.org/science\\_resources/issues/FileEnglish/issue2.pdf](http://www.esa.org/science_resources/issues/FileEnglish/issue2.pdf); see also GEOFFREY HEAL, *NATURE AND THE MARKETPLACE* 1-3 (2000); Shahid Naeem, *Ecosystem Consequences of Biodiversity Loss: The Evolution of a Paradigm*, 83 *ECOLOGY* 1537, 1540 (2002); NATIONAL RESEARCH COUNCIL COMMITTEE ON ASSESSING AND VALUING THE SERVICES OF AQUATIC AND RELATED TERRESTRIAL ECOSYSTEMS, *VALUING ECOSYSTEM SERVICES* 1 (2005) [hereinafter cited as NRC AQUATIC COMMITTEE].

4. NATURE'S SERVICES, *supra* note 3, at 2. For an earlier statement of the problem, see Gretchen C. Daily et al., *Managing the Earth's Life Support Systems: The Game, the*

better understanding of the value of biodiversity by “characteriz[ing] the ways in which the earth’s natural ecosystems confer benefits on humanity.”<sup>5</sup> Ecosystem services are thus offered as a tool for conserving biodiversity. Specifically, valuing the benefits that nature confers will increase awareness and encourage conserving “natural ecosystems.” As Geoff Heal noted, “Most of the services provided by natural ecosystems are dependent on adequate and appropriate biodiversity. So in selling any of these services we are obtaining an economic return on biodiversity.”<sup>6</sup>

Since advocates of ecosystem services argue (at least in part) that the concept of ecosystem services will lead to the conservation of biodiversity, the concept can be characterized as a surrogate for biodiversity. Characterizing the relationship between ecosystem services and biodiversity as a surrogacy makes the conservation objective explicit, and it is the connection between ecosystem services and biodiversity that is the focus of this article. It is sufficient to note that, if the conservation of ecosystem services (the “surrogate”) is to conserve biodiversity (the “target”), the services must be correlated to biodiversity so that changes in the services mirror changes in biodiversity. That is, if markets for ecosystem services are to conserve biodiversity then the service must be dependent upon biodiversity so that a reduction in biodiversity reduces the value of the service and thus provides a direct and immediate incentive to the decisionmaker to cease the destructive actions. Stated from the opposite perspective, if there is no necessary correlation between ecosystem services and biodiversity then there is no reason to assume that conserving ecosystem services will conserve biodiversity.

Examining the relationship between ecosystem services and biodiversity as a formal surrogacy relationship facilitates a more analytical examination and brings the issues into sharper relief. Does the concept of ecosystem services work as a surrogate for biodiversity? Can the concept be used to distinguish between good and bad policy choices? Will markets for these services provide incentives that foster choices that conserve biodiversity? Untangling these questions requires not only an examination of the concepts of biodiversity and ecosystem services, but also the idea of

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*Players, and Getting Everyone to Play*, 6 *ECOLOGICAL APPLICATIONS* 19 (1996). For amplification on the themes, see Gretchen C. Daily, *Countryside Biogeography and the Provisions of Ecosystem Services*, in *NATURE AND HUMAN SOCIETY* 104 (Peter H. Raven & Tania Williams eds., 1997).

5. *NATURE’S SERVICES*, *supra* note 3, at 2.

6. HEAL, *supra* note 3, at 106. Daily also makes the point implicitly. See Gretchen C. Daily, *Introduction: What are Ecosystem Services?*, in *NATURE’S SERVICES* 1, *supra* note 3, at 1-4.

surrogacy that ties them together.

## II. THE CONCEPT OF BIODIVERSITY

Biodiversity has proven notoriously difficult to define or measure.<sup>7</sup> The National Research Council's Committee on the Noneconomic and Economic Value of Biodiversity began a chapter titled "What Is Biodiversity?" by noting that:

The word *biodiversity* is used in many ways. Economists and ecologists, ranchers and gardeners, mayors and miners all view biodiversity from different perspectives. When people discuss biodiversity, they often use it as a surrogate for "wild places" or "abundance of species" or even "large, furry mammals." Yet from the viewpoint of those engaged in biodiversity-related sciences—such as population biology, ecology, systematics, evolution, and genetics—biodiversity has a specific meaning: "the variety and variability of biological organisms."<sup>8</sup>

Although the variety-and-variability definition is more specific than "wild places," it is only slightly so—the Committee itself spent twenty-three more pages amplifying the definition.<sup>9</sup> A con-

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7. This term was coined in the run-up to the National Forum on BioDiversity that was held in Washington, D.C. at the end of September 1986. Walter G. Rosen created the neologism by compressing the term "biological diversity." See DAVID TAKACS, *THE IDEA OF BIODIVERSITY* 34-40 (1996). The term quickly assumed an independent identity: "In 1988, *biodiversity* did not appear as a keyword in *Biological Abstracts*, and *biological diversity* appeared once. In 1993, *biodiversity* appeared seventy-two times, and *biological diversity* nineteen times." *Id.* at 39 (citation omitted) (emphasis in original). See generally Bryan Norton, *Toward a Policy-Relevant Definition of Biodiversity*, in 2 *THE ENDANGERED SPECIES ACT AT THIRTY: CONSERVING BIODIVERSITY IN HUMAN-DOMINATED LANDSCAPES* 49 (J. Michael Scott, et al. eds., 2006).

8. NATIONAL RESEARCH COUNCIL COMMITTEE ON NONECONOMIC AND ECONOMIC VALUE OF BIODIVERSITY, *PERSPECTIVES ON BIODIVERSITY* 20 (1999) [hereinafter cited as NRC BIODIVERSITY COMMITTEE]. The Committee's definition tracks the definition given by the congressional Office of Technology Assessment:

Biological diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequency. For biological diversity, these items are organized at many levels, ranging from complete ecosystems to the chemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, genes, and their relative abundance.

U.S. CONGRESS, OFF. OF TECH. ASSESSMENT, *TECHNOLOGIES TO MAINTAIN BIOLOGICAL DIVERSITY* box I-A, at 3 (1987) [hereinafter OTA].

9. NRC BIODIVERSITY COMMITTEE, *supra* note 8, at 20-42.

temporaneous discussion compiled nine additional variations on the variety-and-variability definition<sup>10</sup> and more continue to be drafted:

Biodiversity is the variety of life. The concept of biodiversity includes the entire biological hierarchy from molecules to ecosystems, or the entire taxonomic hierarchy from alleles to kingdoms, all the logical classes in between (individuals, genotypes, populations, species, etc.), and all of the different members of all those classes. It also includes the diversity of living interactions and processes at all these levels of organization.<sup>11</sup>

E.O. Wilson captured the difficulty when he commented "it is, in one sense, everything."<sup>12</sup>

These variations on the theme of variety are descriptively powerful because they share a pervasive, intuitive understanding that nature is diverse. But this intuitive understanding masks complex questions concerning what variety and variability is crucial. Is it the uniqueness of each specimen or the variety and variability of a population, a subspecies, or a species? Should the focus instead be on assemblages of species such as communities, ecosystems, and landscapes? If answers to these questions are forthcoming they only produce more questions. For example, how is the variety and variability to be measured? Is it even measurable? As one mathematical ecologist has noted, "diversity is rather like an optical illusion. The more it is looked at, the less clearly defined it appears to be and viewing it from different angles can lead to different perceptions of what is involved."<sup>13</sup>

The lack of clarity substantiates Bryan Norton's conclusion that there can be no single "objective scientific definition" of biodiversity in the sense that there is a standard for measuring it.<sup>14</sup>

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10. Kevin J. Gaston, *What Is Biodiversity?*, in BIODIVERSITY 1, 1-2 & table 1.1 (1996).

11. Sahotra Sarkar & Chris Margules, *Operationalizing Biodiversity for Conservation Planning*, 27 J. BIOSCIENCE 299, 299 (2002). See also, e.g., Kent H. Redford & Brian D. Richter, *Conservation of Biodiversity in a World of Use*, 13 CONSERVATION BIOLOGY 1246, 1247 (1999) ("the natural variety and variability among living organisms, the ecological complexes in which they naturally occur, and the ways in which they interact with each other and with the physical environment.").

12. E.O. Wilson, *Introduction*, in BIODIVERSITY II at 1, 1 (Marjorie L. Reaka-Kudla et al. eds. 1988).

13. ANNE E. MAGURRAN, ECOLOGICAL DIVERSITY AND ITS MEASUREMENT 1 (1988).

14. Bryan G. Norton, *On What We Should Save: The Role of Culture in Determining Conservation Targets*, in SYSTEMATICS AND CONSERVATION EVALUATION 23, 25-29 (P. Forey et al. eds. 1994).

Definitions and measures are tools that have utility to the extent that they help us navigate the world and not because they result from any "correspondence to prior realities."<sup>15</sup> The difficulty with the consensus, variety-and-variability definition is that it cannot be applied in the day-to-day universe where choices are constrained by limited resources. Since we can't protect every specimen—or even every place of biological interest—how can we decide what should be conserved?<sup>16</sup> There have been several suggestions for clarifying the concept of biodiversity so that it can be used as a guide for conservation decisions by focusing on either three hierarchical levels (genes, species, and ecosystems),<sup>17</sup> five biospatial levels (genes, populations, species, assemblages such as communities, and landscapes or ecosystems),<sup>18</sup> three nested scales (alpha, beta, and gamma diversity),<sup>19</sup> or three ecosystem attributes (composition, structure, and functions).<sup>20</sup> These approaches not only raise their own concerns,<sup>21</sup> but also demonstrate the importance of context. Michael Soule, for example, offered the five biospatial levels to call attention to "the biological and social contexts of conservation actions, particularly how both biogeography and political geography dictate different conservation tactics."<sup>22</sup> Reed Noss, on the other hand, focused on the three ecosystem attributes because he was seeking a method for selecting "indicators of biodiversity

15. Norton, *supra* note 7.

16. See, e.g., Justin Garson et al., *Birds as Surrogates for Biodiversity: An Analysis of a Data Set from Southern Quebec*, 27 J. BIOSCIENCE 347 (2002). This issue is often discussed as a question of reserve planning. See, e.g., Craig R. Groves et al., *Planning for Biodiversity Conservation: Putting Conservation Science into Practice*, 52 BIOSCI. 499 (2002); C.R. Margules & R.L. Pressey, *Systematic Conservation Planning*, 405 NATURE 243 (2000); Mark W. Schwartz, *Choosing the Appropriate Scale of Reserves for Conservation*, 30 ANNUAL REV. ECOLOGY & SYSTEMATICS 83 (1999).

17. ELLIOTT A. NORSE ET AL., CONSERVING BIOLOGICAL DIVERSITY IN OUR NATIONAL FORESTS 2-3 (1986); OTA, *supra* note 8, box I-A, at 3; NRC BIODIVERSITY COMMITTEE, *supra* note 8, at 2-3; ORGANISATION FOR ECONOMIC CO-OPERATION & DEVELOPMENT, SAVING BIOLOGICAL DIVERSITY 19-23 (1996) [hereinafter OECD].

18. Michael E. Soule, *Conservation: Tactics for a Constant Crisis*, 253 SCI. 744 (1991).

19. See NRC BIODIVERSITY COMMITTEE, *supra* note 8, at 23-24, 26-30; BRYAN G. NORTON, WHY PRESERVE NATURAL VARIETY? 31-34 (1987); R.H. MacArthur, *Patterns of Species Diversity*, 40 BIOLOGICAL REV. 510 (1965); ROBERT H. WHITTAKER, COMMUNITIES AND ECOSYSTEMS (1970); R.H. Whittaker, *Evolution and Measurement of Species Diversity*, 21 TAXON 213 (1972).

20. Reed F. Noss, *Indicators for Monitoring Biodiversity: A Hierarchical Approach*, 4 CONSERVATION BIOLOGY 355 (1990).

21. One difficulty that these approaches share is that many of the categories they employ are characterized by very blurry edges. Even the concept of "species"—the fundamental taxonomic unit of all biological classification—has proved remarkably resistant to clarity and unanimity. As the twentieth century's leading taxonomist and historian of biology noted, "There is probably no other concept in biology that has remained so consistently controversial as the species concept." ERNST MAYER, THE GROWTH OF BIOLOGICAL THOUGHT 251 (1982). This is perhaps less surprising when it is recalled that evolution is, after all, about continuums.

22. Soule, *supra* note 18, at 744.



for use in environmental inventory, monitoring, and assessment programs.”<sup>23</sup> The difference between Soule’s and Noss’s approach reflects not only their differing objectives but also the impossibility of using a single metric to measure something that is “everything”—we can at best measure only parts of the irreducibly complex whole that we call biodiversity.<sup>24</sup>

The lack of clarity on what we mean by biodiversity is important not because there is some true definition waiting to be discovered, but because it reveals substantial uncertainties in our understanding of an important conservation objective. Our inability to define biodiversity means we cannot be sure that our conservation management is effective at conserving what we need to conserve to conserve biodiversity. In a political universe of constrained choices and the competing interest of the moment, such concerns quickly become political liabilities.<sup>25</sup> This difficulty reflects recurrent problems associated with attempting to measure and describe complex systems—a difficulty that has elsewhere led to the use of surrogates that can be measured.

### III. ECOSYSTEMS, THEIR COMPOSITION, STRUCTURE, AND FUNCTION

Ecosystem services is neither a scientific concept nor something that is (at least in theory) measurable, like the number of species in an ecosystem or the pathways that carbon moves through that ecosystem, because the term “services” brings values into the question. Therefore, before examining the concept of ecosystem services, it is useful to examine the science behind the concept.

Ecosystems are generally described as an assemblage of organisms and the abiotic environment with which and within which the organisms interact:

[a] community has a close-linked, interacting relation to environment, as climate and soil affect the

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23. Noss, *supra* note 20, at 356.

24. For example, Landres and his colleagues note in their discussion of indicator species that ecological criteria for selecting indicators may be either species-based or community-based depending upon whether a particular species or the quality of the community is of concern. The “types of data needed under each approach are different and, generally, cannot be substituted for one another.” Peter B. Landres et al., *Ecological Uses of Vertebrate Indicator Species: A Critique*, 2 CONSERVATION BIOLOGY 316, 320 (1988).

25. For a description of how real-world complexity can be translated into ideological warfare see Joel Achenbach, *The Tempest*, WASH. POST, May 28, 2006, at W8, available at [http://www.washingtonpost.com/wp-dyn/content/article/2006/05/23/AR2006052301305\\_5.html](http://www.washingtonpost.com/wp-dyn/content/article/2006/05/23/AR2006052301305_5.html) (describing how the ambiguities of global climate change are manipulated by skeptics to undermine science).

community and the community affects the soil and its own internal climate or microclimate, as energy and matter are taken from [the] environment to run the community's living function and form its substance, transferred from one organism to another in the community, and released back to [the] environment. A community and its environment treated together as a functional system of complementary relationships, and transfer and circulation of energy and matter, is an *ecosystem*.<sup>26</sup>

Ecologists who study ecosystems generally focus on the contributions of the interdependent parts of the system to its overall function by examining interactions such as the transformation of energy and the cycling of elements within an ecosystem.<sup>27</sup>

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26. WHITTAKER, *supra* note 19, at 1. See also NATURE'S SERVICES, *supra* note 3, at 2 ("An ecosystem is the set of organisms living in an area, their physical environment, and the interactions between them."); GENE E. LIKENS, THE ECOSYSTEM APPROACH: ITS USE AND ABUSE 9 (1992) ("a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries"); NRC AQUATIC COMMITTEE, *supra* note 3, at 7; OECD, *supra* note 17, box 2, at 23 ("the plants, animals, microorganisms and physical environment of any given place, and the complex relationships linking them into a functional system"); ROBERT E. RICKLEFS, THE ECONOMY OF NATURE 3 (4th ed. 1997) ("Assemblages of organisms together with their physical and chemical environments"). From its inception, the concept has been focused on the interaction between the living and nonliving components of the biosphere. See A.G. Tansley, *The Use and Abuse of Vegetational Concepts and Terms*, 16 *ECOLOGY* 284, 299 (1935) ("Though the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them from their special environment, with which they form one physical system.").

Our understanding of these interactions has changed as it has become increasingly apparent that ecosystems are not equilibrium systems - there is no "balance of nature." That is, ecosystems are not "static entities in equilibrium," but rather "complex systems that are dynamic and unpredictable across time and space." Tabatha J. Wallington et al., *Implications of Current Ecological Thinking for Biodiversity Conservation: A Review of the Salient Issues*, 10 *ECOLOGY & SOC'Y* (2005), available at <http://www.ecologyandsociety.org/vol10/iss1/art15>. Ecosystems, in other words, are historically contingent: they evolve over time as the biotic alters the abiotic and is in turn altered by the new environment. LIKENS, *supra*, at 10. At a global scale, for example, life has transformed this planet into a place that is hospitable to the life that has co-evolved with the changing abiotic environment that life itself has modified. One example is oxygen. Although early life was anaerobic, it produced oxygen as a waste product which (as the amount of oxygen in the atmosphere increased) provided a competitive advantage for organisms that could tolerate oxygen. *E.g.*, VLADIMIR N. BASHKIN, *MODERN BIOGEOCHEMISTRY* 24-27 (2002); RICKLEFS, *ECOLOGY*, *supra* note 2, at 33; see generally PETER WESTBROEK, *LIFE AS A GEOLOGICAL FORCE* (1991); Naem, *supra* note 3, at 1540. Human impacts have come to play an increasingly dominant role. See, *e.g.*, Peter M. Vitousek et al., *Human Domination of Earth's Ecosystems*, 277 *SCI.* 494 (1997). Ecologists have come to recognize that current "natural" ecosystems are at least human-influenced. See, *e.g.*, Jesse Bellemare et al., *Legacies of the Agricultural Past in the Forested Present: An Assessment of Historical Land-Use Effects on Rich Mesic Forests*, 29 *J. BIOGEOGRAPHY* 1401 (2002); David Foster et al., *The Importance of Land-Use Legacies to Ecology and Conservation*, 53 *BIOSCI.* 77 (2003); Tansley, *supra* note 26, at 303-04. Simply removing the disturbance is thus no guarantee that the system will return to its previous status.

27. *E.g.*, RICKLEFS, *ECONOMY OF NATURE*, *supra* note 26, at 190-94.