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VALUES, POLICY, AND ECOSYSTEM HEALTH

OPTIONS FOR RESOLVING THE MANY ECOLOGICAL POLICY ISSUES WE FACE DEPEND ON THE CONCEPT OF ECOSYSTEM HEALTH, BUT ECOSYSTEM HEALTH IS BASED ON CONTROVERSIAL, VALUE-BASED ASSUMPTIONS THAT MASQUERADE AS SCIENCE

Who hasn't heard of ecosystem health? It is considered by many to be a useful, perhaps essential, concept in formulating ecological policies. It has an extensive following, especially in the popular media and with advocacy groups (Scrimgeour and Wicklum 1996, Gaudet et al. 1997, Lancaster 2000).

Part of its appeal is that it appears to be a simple, straightforward, intuitive metaphor (Ryder 1990, De Leo and Levin 1997). Applying the notion of human health to ecosystems provides a paradigm for viewing ecological policy questions. By implication, adopting the metaphor also defines what types of scientific information are necessary to help decisionmakers (Norton 1995, Meyer 1997, Shrader-Frechette 1997, Lackey 1998). Adopting ecosystem health as a public policy goal, however, could have major, although usually unclear, ramifications. And if Rapport (1995, 1998a, 1998b) and many others are correct, the implications to individuals and society of implementing ecosystem health as a cornerstone of public policy would be considerable, perhaps even revolutionary.

[Defining ecosystem health](#)

The purposes of this article are to evaluate the notion of ecosystem health and to describe the implications of adopting ecosystem health as a goal in ecological policy. Throughout the article, I have attempted to be policy relevant without being a policy advocate.

To most proponents of ecosystem health, the alluring feature of the human health metaphor is that people have an inherent understanding of personal health (Ryder 1990).

Similarly, and by extension, most people envision a healthy ecosystem (e.g., a forest, lake, or pastoral landscape) as being pristine or at least appearing to be minimally altered by human action. Thus, it is argued, ecosystem health is intuitively grasped by the general public, policy officials, and scientists (Meyer 1997).

Most concepts of human health focus on the individual human, whereas ecosystem health treats the entire ecosystem as the unit of policy concern, not the individual animal or plant (Figure 1; Schaeffer et al. 1988). The individual animal or plant—the typical focus of animal rights and animal welfare policy—is not usually the level at which ecological policy is debated.

There is no universal conception of ecosystem health; thus, there is considerable variation in the concept's definition (Calow 1992, De Leo and Levin 1997). Karr and Chu (1999), for example, reflect a common but not universal position that concepts of ecosystem health and integrity, although related, are fundamentally different. They define ecosystem health as the preferred state of ecosystems modified by human activity (e.g., farmland, urban environments, airports, managed forests). In contrast, ecosystem integrity is defined as an unimpaired condition in which ecosystems show little or no influence from human actions. Ecosystems with a high degree of integrity are natural, pristine, and often labeled as the baseline or benchmark condition. Natural ecosystems, by definition, would continue to function in essentially the same way if humans were removed (Anderson 1991).



Figure 1. Whose health? Notions of human health typically focus on the condition of the individual. Ecosystem health, in contrast, treats the ecosystem, not the individual animal or plant, as the unit of policy concern. Photo: US Environmental Protection Agency.

Others make no such distinction between the two and may even describe ecosystem health and integrity as different words for the same general concept. Regier (1993), for example, concludes that "the notion of ecosystem integrity is rooted in certain ecological

concepts combined with certain sets of human values" and, thus, a desired ecosystem condition "other than the pristine or naturally whole may be taken to be 'good and normal.' " Hence, according to Regier and many others, if one accepts that there are multiple (and equally acceptable) benchmarks for ecosystems with integrity, then the terms ecosystem health and ecosystem integrity would be conceptually the same. For the remainder of this article, I will use the increasingly popular definitions of ecosystem health and ecosystem integrity advanced by Karr and Chu (1999; described above), whereby the two notions represent different, but related, intellectual constructs.

Most ecological policy debates concern ecosystem health rather than ecosystem integrity (Westra 1998). Such an emphasis on health (ecosystems altered by humans) is understandable because the vast majority of ecosystems are not pristine or even close to pristine; hence, according to the definitions used here, altered ecosystems lack at least some integrity (Figure 2). Westra (1998) clearly describes the relationship between the two concepts:

An ecosystem can be said to possess integrity when it is wild—that is, free as much as possible from human intervention today, and "unmanaged," although not necessarily pristine. This aspect of integrity is the most significant one; it is the aspect that differentiates the wild from ecosystem health, which allows support and manipulation. (p. 32)

Points of controversy

Ecosystem health, especially in the 1970s and 1980s, was defined in nebulous terms—definitely not as a clearly articulated policymaking construct (Steedman 1994, Lancaster 2000). It was typically depicted as a broad societal aspiration rather than a precise policy goal or management target (Rapport 1995). Lacking precise definition, the concept was impractical as a public policy objective. As ecosystem health emerged from semantic ambiguity with more precise definition and description, it became a serious topic for discussion and, predictably, a lightning rod for conflict (Wicklum and Davies 1995, Meyer 1997, Lancaster 2000).

Defining and implementing policies on ecosystem health continue to be controversial (Callicott 1995, Jamieson 1995, Wicklum and Davies 1995, Belaoussoff and Kevan 1998). Addressing questions of ecosystem health might appear to be a fairly scholarly, perhaps even arcane, activity, free from the intrigue that dominates much of the science and policy underlying natural resource management, but such is not the case. Ecosystem health is seldom discussed dispassionately because, as Wicklum and Davies (1995) observe: "The phrases ecosystem health and ecosystem integrity are not simply subtle semantic variations on the accepted connotations of the words health and integrity. Health and integrity are not inherent properties of ecosystems" (p. 999).

Wicklum and Davies realize that the word health elicits powerful, positive images even if its meaning is variable and ambiguous. Therefore, they argue, a precise understanding of ecosystem health is essential because it is likely to be used and given a variety of meanings by scientists, policy advocates, politicians, bureaucrats, and the general public. In practice, it may fall to scientists and other technocrats to provide operational clarity to the perplexing, value-laden notions of ecosystem health that appeal on an intuitive level to nearly everyone (Meyer 1997). In reality, when value-based ecological concepts such as ecosystem health are generally accepted, they may be useful in general conversation but they are impossible to quantify (Ryder 1990, Lancaster 2000).

Ecosystem health and related concepts have become highly charged political terms (Jamieson 1995), often to the extent that they become shorthand for factions in political debates. Even in the relatively isolated venues of academic and government laboratories, an assertion that ecosystem health is not a scientifically sound concept may be sufficient cause for being branded a political reactionary. Conversely, scientists embracing the notion of ecosystem health may be dismissed by fellow scientists as political zealots who use their scientific credentials to champion personal policy preferences. Callicott et al. (1999) characterize debates over the merits of ecosystem health and similar concepts as those in which "partisans of a single normative concept try to make it cannibalize or vanquish all the rest."



Figure 2. Defining ecosystem health. Most notions of ecosystem health concern all types of landscape-level ecosystems, not merely those unaltered or minimally altered by human actions. Photo: Robert T. Lackey.

Thoughtful discussions about ecosystem health and similar concepts are usually abstract, often contentious, and rarely lead to consensus. But is the use of the health metaphor, even as a heuristic tool, ill-advised? Shrader-Frechette (1997) counseled against using the concept of ecosystem health to communicate with the public about environmental issues because it does not add new information to policy debates, nor does it explain policy tradeoffs. Kapustka and Landis (1998) exhort against using the metaphor because it is misleading and based on values and judgments, not on verifiable scientific reality, whereas Callicott et al. (1999) classify the concept as an "ill-defined normative concept" that reflects the "occurrence of normal ecosystem processes and functions." Conversely, Callicott (1995) concludes that ecosystem health is intellectually defensible and heuristically valuable, but he concedes that the value, thus the calibration, of ecosystem health is subjective. Few proponents explain in specific terms the implications for individuals and society of basing policies on the concept.

Regardless of the merit and direction of the scholarly debate, notions of ecosystem health frame important public policy issues, such as sustainability of agriculture, overuse of marine resources, scarcity of water for domestic and agricultural use, and ecological consequences of introduced species. Ecological policy issues are not mere abstract intellectual concerns, but matters that affect people's daily lives (Shrader-Frechette 1997).

Normative science's assumptions

A number of implicit, but highly contested, value-based assumptions masquerade as science (Lancaster 2000) in the ecosystem health debate. Such "science" is often dubbed normative science, whereby facts are interpreted through the filter of an assumption that implies an inherent policy preference (Lackey 1999). Many examples of normative science are obvious; others are subtle.

An example of the use of normative science in ecosystem health is the long-debated assumption that ecosystems are "real" (Calow 1992, Callicott 1995). Kapustka and Landis (1998) assert that "no human has ever seen an ecosystem" because it is not a discrete unit like individual birds, trees, or worms, or even a population of organisms. However, when a science or policy problem is specified (e.g., a "salmon" issue), then the ecological boundaries (i.e., the ecosystem) follow intuitively. Thus, ecosystems are context-specific entities because they cannot be delimited without a science or policy concern, and therefore they may have heuristic problemsolving value but they are not analogous to the patient in medicine (Suter 1993).

Although rarely stated clearly, in most formulations of ecosystem health, there is a premise that natural systems are healthier than human-altered systems (Figure 3; Wicklum and Davies 1995). For example, consider a defined geographic location. Given the alternatives of a pristine woodland, a housing subdivision, or an industrial complex, which is the healthiest? The subdivision may be necessary, even somewhat aesthetically pleasing, and the industrial complex may serve a worthy purpose, but almost everyone considers the unaltered woodland to be the healthiest. Tacitly, the assumption is that pristine, or less altered, is good and preferred, whereas highly altered ecosystems, by contrast, are less desirable, if not degraded. Thus, recognizing the normative basis for ecosystem health, Fairbrother (1998) concludes that "use of the term 'ecosystem health' as a definition of an idealized state is not an appropriate paradigm."

Another common assumption involves the importance of biological diversity to society. Biological diversity is certainly an important element in understanding the structure and function of ecosystems, but the key policy assumption revolves around the level of importance society places on biological diversity or its constituent elements. For example, some argue that biological diversity is such a core (i.e., societal) policy value that scientists should actively lobby for it. As Meffe and Viederman (1995) bluntly recommend,

Scientists can take a clear stand that biodiversity is good, that functioning and intact ecosystems are good, that continued evolutionary change and adaptation are good, and that diversity and variation in general is good. Scientists cannot and should not remove themselves from these usually unstated value judgments. (p. 328)

They encourage scientists to drop the facade of political neutrality and lobby for those policy choices that they (scientists) deem to be in the best interests of society (Meffe and Viederman 1995).

Invariably, concepts of ecosystem health implicitly assume that certain ecosystem features such as biological diversity have an inherent policy importance (Schaeffer et al. 1988).

Ecosystems are complex, typically in both structure and function, and the diversity of species within an ecosystem may be important in determining how that particular ecosystem functions, but biological diversity is inherently no more important to ecosystems than nutrient cycling, carbon storage, or the rate of photosynthesis. As a public policy priority, society collectively may ascribe high (or low) value to preservation of certain, perhaps all, species, based on human values and preferences, without considering biodiversity's ecological function (Lackey 1998).

Although not universally agreed upon, a common tacit assumption is that there is a natural ecosystem state (i.e., balance of nature) akin to the simple homeostatic dynamics of physiological systems (Anderson 1991, Belovsky n.d.). The existence of such a natural state is appealing because disruption of an ecosystem's balance-deviation from its natural state-can be used to define and measure its health. Unfortunately, ecosystems do not adhere to this idealized view. Instead of predictably approaching single-point equilibrium, they may oscillate over time in a fairly indeterminate manner (Belovsky n.d.).

Societal values

Few challenge the assertion that societal preferences should drive the environmental management goals inherent in implementing ecosystem health, but how will societal aspirations be selected (Gaudet et al. 1997, Meyer 1997)? Society is not a monolith; there are many competing opinions on what should be preeminent societal aspirations or preferences. The marketplace, the most common adjudicator of societal preferences, is never totally unconstrained, nor do most participants have much understanding of the long-term ecological consequences of their individual market decisions. Thus, economics has an important role in resolving competing societal preferences, but it is insufficient in itself.

Although the language framing ecosystem health is value laden (Jamieson 1995), the values are not easily translated into public policy. The crux of the policy challenge is deciding which of the diverse societal preferences are to be adopted. Resolving policy issues always consists of making tradeoffs, winnowing partially or entirely exclusive alternatives, picking winners and losers, and settling for plenty of compromises. How will this be done for ecosystem health?

Consider any specific ecological policy issue: Who are the stakeholders and how should their conflicting input be used to define ecosystem health? The task is relatively easy when policy problems are defined narrowly, such as licensing a particular chemical or authorizing a timber harvest rate for an individual forest. The task is more difficult for achieving broad societal aspirations such as ecosystem health. For example, who are the stakeholders for deciding policy on national forests? Are they local, regional, or national citizens; some weighted combination; or all citizens equally? Obviously, local residents are most directly affected by policy decisions about national forests in their area, but the forest belongs to everyone; thus, urban voters several time zones away may have the controlling political power. For example, defining stakeholders as those most directly affected would result in national forests being managed primarily for the benefit of adjacent residents. Conversely, defining stakeholders as all members of society would most likely result in different policy priorities.

What role should science and scientists play in defining ecosystem health? Scientific information is important, even essential, but it is only part of what is needed (Gaudet et al. 1997). Most important ecological policy issues involve coarse scales. Unfortunately, most scientific information is of a fine scale and narrowly focused and thus only indirectly

relevant to many ecological policy questions. Furthermore, political institutions (legislative and regulatory agencies) must balance competing values and preferences, a process in which the role of scientific information is limited. For the political process of adjudicating conflicts over value and preferences, science offers no moral or ethical guidance (Kapustka and Landis 1998, Lancaster 2000).

An argument is sometimes advanced that, because the inexactness of ecosystem health shrouds difficult and painful tradeoffs, use of the term actually obscures societal values and preferences by not forcing an explicit selection from competing policy options. In evaluating various attempts to implement ecosystem health, Suter (1993) observes the following:

Use of unreal properties (particularly unreal properties with imposing names) in environmental regulation obscures the bases for decision making; increases the opportunity for arbitrariness; and decreases the opportunity for informed input by the public, regulated parties, or advocacy groups. (p. 1536)

Shrader-Frechette (1997) asserts that the phraseology does little, in spite of grand rhetoric, to improve decisionmaking because proponents of ecosystem health have failed to "clarify the precise respects in which the term yields additional scientific explanation beyond those provided by assessments of production, biodiversity, and so on." Conversely, Meyer (1997) concludes that the value of ecosystem health is that it "offers a view of nature that is useful for an audience of managers, policy makers, and taxpayers."

Misuse of ecosystem health

The most pervasive misuse of ecosystem health is insertion of personal values under the guise of scientific impartiality. Most concepts of ecosystem health require a benchmark (i.e., a preferred condition) of an ecosystem. Often, the implicit assumption, or benchmark, is that an undisturbed or natural ecosystem is superior, thus preferred, to an altered one (Anderson 1991). An ecosystem altered by human influences is obviously different from the previous state, but there is no scientific basis for a specific ecological state to be considered better (more healthy) and thus the benchmark. Lele and Norgaard (1996) caution those searching for scientifically derived benchmarks for ecosystems: "Naturalness as the benchmark is neither value free nor logically or practically useable."

Practical expressions of ecosystem health reflect values and preferences (Gaudet et al. 1997). However, the concept is misused when professionals, usually operating from bureaucratic positions, effectively determine, based on their preferences, what healthy (i.e., preferred) ecosystem conditions to target (Lancaster 2000). Ecosystem health is normative because someone must decide what ecosystem condition or function is good (Sagoff 1995). Ecosystems display no preferences about their states; thus benchmarks must come from the individuals doing the evaluation (Jamieson 1995). One common approach is to arbitrarily select reference sites to serve as the benchmarks (e.g., the best attainable or healthiest condition) for the ecosystems in question. However, Kapustka and Landis (1998) argue that the principal mistake scientists make in attempting to define healthy ecosystems is incorporating beliefs, morals, values, and ethics as properties of ecological systems. Assuming that higher biological diversity is inherently superior to lower biological diversity is an example.

Another, less obvious misuse is defining a public policy goal in vague terms, labeling it ecosystem health to engender broad political support but camouflaging the ramifications of its adoption. Indeed, there is general public support for the idea of maintaining

ecosystem health, but few grasp the consequences of such a policy approach, including the possible implications for democratic processes or the autonomy of nation-states. Westra (1996), for example, candidly stated some far-reaching political consequences: "No country's unilateral decision, no matter how representative it might be of its citizens' values, should be permitted to prevail, unless it does not conflict with the global requirements of the ethics of integrity, thus with true sustainability" (p. 281).

A deceptive, but often effective, use of the concept of ecosystem health is pejoratively categorizing opposing policy choices. Because health conveys a positive connotation, the common practice in policy debates is to capture the high ground by claiming your policy choices are necessary for health and those of your opponents lead to sickness or ecosystem degradation. After all, the competing policy choices, by definition, must not be appropriate for achieving ecosystem health. Policy choices are rarely so clear-cut, however. For example, a policy decision to drain a wetland to create a corn field might legitimately be categorized as appropriate to maintain ecosystem health. Either the wetland or corn field could be healthy, depending on the societal preferences embraced.

Environmental managers are culpable, often unintentionally, of misusing the concept of ecosystem health. Understandably, those responsible for making difficult, controversial policy decisions may be reluctant to define their goals clearly, so they sometimes embrace ecosystem health in the mistaken belief that it is a scientifically operational term. After evaluating the potential uses of the health metaphor in environmental management, Suter (1993) draws this conclusion:

Environmental managers are active agents, translating the inchoate norms of the current generation and the poorly predicted needs of future generations into specific actions to protect or restore real, valued properties of actual ecosystems.... Hence, the decision to abandon ecosystem health as a goal is not just a matter of semantics. (p. 1538)

Kapustka and Landis (1998) admonish against using normative concepts such as ecosystem health: "If we are to manage the environment, it should be done with the clear knowledge that choices will have to be made, not fueled by misplaced desires or myths."

Alternatives

Ecological policy issues, such as managing human land use, biological diversity reductions, or the cumulative effects of chemical use, are real and demand serious attention by society (Science Advisory Board 2000). Value-based concepts stemming from normative science can be compelling, but even many proponents concede that there are serious conceptual or operational difficulties with such concepts. Whether the intuitive heuristic value of the phrase ecosystem health "outweighs its clearly invalid theoretical implications remains to be seen" (Scrimgeour and Wicklum 1996). But what, if any, are the alternatives?

The most direct alternative to using normative science is to cease using words such as ecosystem health and simply and clearly describe what is proposed. More specifically, rather than proposing an objective of, say, managing a forest for health, policy proponents should express exactly and clearly the public policy and management objective.

A second alternative to using ecosystem health is to treat ecological policy issues as yet another complex public policy question and not rely on any metaphor. Other policy issues, such as welfare, education, energy, and transportation, are also complex and challenging, but overarching, heuristic models or metaphors are not typically used except in political discourse.



Figure 3. A natural misunderstanding. Although rarely stated explicitly, there is often an underlying premise that natural systems are inherently healthier than human-altered systems and are, therefore, preferable as a policy choice. Photo: Robert T. Lackey.

If a notion of ecosystem health is to be used in implementing ecological policy, then coherent, clear, quantifiable definitions should be used (Ulanowicz 1997). Currently there are many, often contradictory, definitions of ecosystem health, so consensus on the exact meaning is essential to focusing policy debate on societal tradeoffs, not semantic niceties.

Public involvement should be the essence of using normative concepts because those concepts require inherent value judgments. Rykiel (1998) explains: "In a simplistic sense, science deals with true and false, whereas society deals with good and bad. Science can delineate the possibilities and describe the system that is likely to result from a policy, but it cannot decide if the resulting system is good or bad" (p. 486).

Thus, policy decisions are normative by definition, because values and preferences are used by decisionmakers to select a particular option.

Future direction

Ecology has become much more than a scholarly discipline; it has impacts far beyond simply enhancing our understanding of ecosystems. Many uses of ecology (including ecosystem health) typically have a strong normative and politically green flavor. As Worster (1990) observes,

The science of ecology has had a popular impact unlike that of any other academic field of research. Consider the extraordinary ubiquity of the word itself: it has appeared in the most everyday places and the most astonishing, on day-glo T-shirts, in corporate advertising, and on bridge abutments. It has changed the language of politics and philosophy—springing up in a number of countries are political groups that are self-identified as "Ecology Parties." (p. 1)

The future role of normative science, generally, and ecosystem health, particularly, is uncertain. At the ideological extreme, there are stark opinions. Some argue that using normative science in constructs such as ecosystem health is desirable, even essential, for implementing ecological policy. Scientists, they assert, have an obligation to incorporate policy value judgments into ecology, even to the point that such "scientific" concepts as ecosystem health should be adopted as the cornerstone of ecological policy (Callicott 1995). Some scientific disciplines and professions (e.g., conservation biology, restoration ecology) unapologetically embrace normative science postulates as the core of their trade, maintaining that biological diversity is inherently good, extinction of populations and species is inherently bad, ecological complexity is inherently good, evolution is good, and biological diversity has intrinsic value (Soule 1985).

Others, however, assert that normative science-based concepts, such as ecosystem health, hide behind a veneer of science and disguise the necessary and difficult policy choices involving competing, often divisive, societal values (Kapustka and Landis 1998, Lancaster 2000). In short, it is not the role of science to hide fractious choices that society should appropriately decide, but to help lay out options and assess the consequences of various choices (Meyer 1997).

Scientists and scientific information continue to play an important role in resolving ecological policy, but the role, in my opinion, should be carefully circumscribed (Lackey 1998, 1999). Often, even within the community of scientists, ecology has been treated more as a belief system than a science. It is easy, perhaps even encouraged, for scientists to abuse privileged roles in ecological policy debates by surreptitiously labeling personal values and policy preferences as "science" (Salzman 1995).

Understanding the values and preferences of society is crucial to appropriately implementing concepts of ecosystem health, but obtaining such understanding credibly is difficult. To assert, however, that concepts of ecosystem health are merely scientific constructs is incorrect. As Russow (1995) concludes, "The claim that scientific descriptions in general or measures of ecosystem health in particular are value neutral is simply false." The likely alternative to public involvement is that the values of scientists and other technocrats will be used as surrogates for societal values and preferences.

The ecological policy concerns that engender widespread debate over ecosystem health and other normative constructs will not disappear. These concerns need to be addressed because of the increasing demand on limited ecological resources (Salwasser et al. 1997). The resolution of ecological policy is likely to become increasingly challenging because interactions among the planet, the nonhuman occupants, and the large, yet expanding, human population constitute a dynamic system of rapidly increasing complexity (National Research Council 1997). Whether or not one finds intellectual sustenance in the notion of ecosystem health, the policy concerns its proponents attempt to confront are genuine.

Rapport on ecosystem health

"An ecosystem health focus sets the stage for a new environmental ethic—one in which actions may be judged by their contribution to maintaining or enhancing the health of the regional ecosystem" (Rapport 1995).

"Enhancing ecosystem health represents a goal with critical importance to our future. Without ecosystem health, the very foundations of our social and economic systems are undermined" (Rapport 1998a).

"The articulation of ecosystem health goals and indicators of performance to achieve these goals is a necessity if the future for humankind is to be viable" (Rapport 1998b).

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References cited

Anderson JE. 1991. A conceptual framework for evaluating and quantifying naturalness. *Conservation Biology* 5: 347-352.

Belaoussoff S, Kevan PG. 1998. Toward an ecological approach for the assessment of ecosystem health. *Ecosystem Health* 4: 4-8.

Belovsky GE. n.d. Ecological stability: Reality, misconceptions, and implications for risk assessment. *Human and Ecological Risk Assessment*. Forthcoming.

Callicott JB. 1995. A review of some problems with the concept of ecosystem health. *Ecosystem Health* 1: 101-112.

Callicott JB, Crowder LB, Mumford K. 1999. Current normative concepts in conservation. *Conservation Biology* 13: 22-35.

Calow P. 1992. Can ecosystems be healthy? Critical consideration of concepts. *Journal of Aquatic Ecosystem Health* 1: 1-5.

De Leo GA, Levin S. 1997. The multifaceted aspects of ecosystem integrity. *Conservation Ecology* 1: 3. (13 June; www.consecol.org/vol1/iss1/art3)

Fairbrother A. 1998. Establishing the health of ecosystems. Pages 101-107 in Cech JJ, Wilson BW, Crosby DG, eds. *Multiple Stresses in Ecosystems*. Boca Raton (FL): Lewis Publishers.

Gaudet CL, Wong MP, Brady A, Kent R. 1997. How are we managing? The transition from environmental quality to ecosystem health. *Ecosystem Health* 3: 3-10.

Jamieson D. 1995. Ecosystem health: Some preventative medicine. *Environmental Values* 4: 333-344.

Kapustka LA, Landis WG. 1998. Ecology: The science versus the myth. *Human and Ecological Risk Assessment* 4: 829-838.

- Karr JR, Chu EW. 1999. Restoring life in running waters: Better biological monitoring. Washington (DC): Island Press.
- Lackey RT. 1998. Seven pillars of ecosystem management. *Landscape and Urban Planning* 40: 21-30.
- . 1999. The savvy salmon technocrat: Life's little rules. *Environmental Practice* 1: 156-161.
- Lancaster J. 2000. The ridiculous notion of assessing ecological health and identifying the useful concepts underneath. *Human and Ecological Risk Assessment* 6: 213-222.
- Lele S, Norgaard RB. 1996. Sustainability and the scientist's burden. *Conservation Biology* 10: 354-365.
- Meffe GK, Viederman S. 1995. Combining science and policy in conservation biology. *Wildlife Society Bulletin* 23: 327-332.
- Meyer JL. 1997. Stream health: Incorporating the human dimension to advance stream ecology. *Journal of the North American Benthological Society* 16: 439-447.
- National Research Council. 1997. Building a Foundation for Sound Environmental Decisions. Washington (DC): National Academy Press.
- Norton B. 1995. Ecological integrity and social values: At what scale? *Ecosystem Health* 1: 228-241.
- Rapport DJ. 1995. Ecosystem health: Exploring the territory. *Ecosystem Health* 1: 5-13.
- . 1998a. Defining ecosystem health. Pages 18-33 in Rapport DJ, Costanza R, Epstein PR, Gaudet CL, Levins R, eds. *Ecosystem Health*. Malden (MA): Blackwell Science.
- . 1998b. Answering the critics. Pages 41-50 in Rapport DJ, Costanza R, Epstein PR, Gaudet CL, Levins R, eds. *Ecosystem Health*. Malden (MA): Blackwell Science.
- Regier HA. 1993. The notion of natural and cultural integrity. Pages 3-18 in Woodley SJ, Kay JJ, Francis G, eds. *Ecological Integrity and the Management of Ecosystems*. Delray Beach (FL): St. Lucie Press.
- Russow L. 1995. Ecosystem health: An objective evaluation? *Environmental Values* 4: 363-369.
- Ryder RA. 1990. Ecosystem health, a human perception: Definition, detection, and the dichotomous key. *Journal of Great Lakes Research* 16: 619-624.
- Rykiel EJ. 1998. Relationships of scale to policy and decision making. Pages 485-497 in Peterson DL, Parker VT, eds. *Ecological Scale: Theory and Applications*. New York: Columbia University Press.
- Sagoff M. 1995. The value of integrity. Pages 162-176 in Westra L, Lemons J, eds. *Perspectives on Ecological Integrity*. Dordrecht (Netherlands): Kluwer Academic Publishers.

Salwasser H, MacCleery DW, Snellgrove TA. 1997. The Pollyannas vs. the Chicken Littles- Enough already! *Conservation Biology* 11: 283-286.

Salzman L. 1995. Scientists and advocacy. *Conservation Biology* 9: 709-710.

Schaeffer DJ, Herricks EE, Kerster HW. 1988. Ecosystem health: I. Measuring ecosystem health. *Environmental Management* 12: 445-455.

Science Advisory Board. 2000. *Toward Integrated Environmental Decision-making*. Washington (DC): US Environmental Protection Agency. Publication EPA-SAB-EC-00-011.

Scrimgeour GJ, Wicklum D. 1996. Aquatic ecosystem health and integrity: Problems and potential solutions. *Journal of the North American Benthological Society* 15: 254-261.

Shrader-Frechette K. 1997. Ecological risk assessment and ecosystem health: Fallacies and solutions. *Ecosystem Health* 3: 73-81.

Soule ME. 1985. What is conservation biology? *BioScience* 35: 727-734.

Steedman RJ. 1994. Ecosystem health as a management goal. *Journal of the North American Benthological Society* 13: 605-610.

Suter GW. 1993. A critique of ecosystem health concepts and indexes. *Environmental Toxicology and Chemistry* 12: 1533-1539.

Ulanowicz RE. 1997. *Ecology, the Ascendant Perspective*. New York: Columbia University Press.

Westra L. 1996. Ecosystem integrity and the "fish wars." *Journal of Aquatic Ecosystem Health* 5: 275-282.

----- . 1998. The ethics of integrity. Pages 31-44 in *The Land Ethic: Meeting Human Needs for the Land and Its Resources*. Bethesda (MD): Society of American Foresters.

Wicklum D, Davies RW. 1995. Ecosystem health and integrity? *Canadian Journal of Botany* 73: 997-1000.

Worster D. 1990. The ecology of order and chaos. *Environmental History Review* 14: 1-18.

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