HUGH LEHMAN

ECOSYSTEM HEALTH AS A MORAL REQUIREMENT

ABSTRACT. Some writers have suggested that it would be desirable to assess the state of the Earth's environments by making use of a concept of ecosystem health. We subject this suggestion to scrutiny first by calling attention to obscurities in the notion of an ecosystem and then by calling attention to obscurities in and objections to some views about ecosystem health. Finally, we note, that even if *ecosystem health* can be adequately clarified, there are reasons for saying that whether we are morally obligated to protect the health of some ecosystem depends on other circumstances. In many possible circumstances we would not be obligated to protect the health of a particular ecosystem.

There has been much useful discussion of the importance of protecting human environments.[1] Such discussion has been prompted by many human activities that are perceived as damaging our environments. Such activities, even while producing some undeniable benefits, have lead to the death, illness, or impoverishment[2] of other human beings. Chemicals improperly stored is one such activity. Improper farming methods causing water pollution is another. Contamination of our atmosphere through burning of fossil fuels is another. Human actions that contribute to the impoverishment, illness, or death of other human beings undermine the environment of those other human beings.

Since the environment of any human being may be said to consist of ecosystems, we may say that human actions that contribute to the impoverishment, illness, or death of other human beings degrade the ecosystems on which the health, wealth, or life of those other human beings depends. Some people choose to express this thought through use of the concept of *ecosystem health.*[3] Ecosystems that are degraded are said to be less healthy. In light of moral concerns arising out of some effects of human activities on our environment, we may ask whether we are morally obligated to conserve ecosystem health.

[1] The literature on this subject is huge. Here are a few examples: Eckholm (1976), Myers (1984), Wilson, ch. 15 (1992).

[2] I intend that the term *impoverishment* be understood broadly. Impoverishment, so understood, refers to loss of anything that enhances the value of life. Loss of wealth, natural beauty, biodiversity, etc. are kinds of impoverishment.

[3] See Rapport (1997), Rapport et al. (1998), Waltner-Toews and Nielson (1995).

Journal of Agricultural and Environmental Ethics **12:** 305–317, 2000.

In this paper, we argue first that in order to answer this question some attention needs to be addressed to clarify the concept of ecosystem health. Clarification of the concept of ecosystem health in turn depends on clarification of the concept of an ecosystem. In the absence of such clarification, the reference of such terms as *an ecosystem* or *the ecosystem* are indeterminate. In light of such indeterminacy, it is difficult or even impossible to ascertain whether scientific or ethical claims about ecosystems are correct. While some writers have called attention to some of the obscurities, there is more to be said in this regard.[4] Second, assuming that the concept of ecosystem health can be sufficiently clarified, we raise questions concerning the validity of some alleged criteria of ecosystem health. Finally, we argue that even if we can achieve common understanding of criteria for ecosystem health, questions need to be addressed concerning the limits of our moral obligations to achieve and conserve ecosystem health.

WHAT IS AN ECOSYSTEM?

While ecosystems are complex collections of interacting entities, reference to an ecosystem persisting over a period of time, resisting stress, reorganizing itself, etc. presupposes that we know which entities and which interactions constitute one particular ecosystem. Perhaps the clearest way to call attention to the obscurity of the notion of an ecosystem is to contrast that notion with an idea of something else that might be said to be in good or ill health. For this purpose, let us consider a chicken. While the concept of a chicken is not perfectly clear and precise it is far clearer and more precise than the concept of an ecosystem.

Normally, we know, with a sufficient degree of precision, the spatial and temporal limits of particular chickens, in other words we know the spatial and temporal boundaries between any particular chicken and the rest of the world. Generally, if asked, we could count the number of chickens in any specified region during a particular interval of time. We know what the elements of chickens are and how they are related to form a chicken. We can enumerate the states that are properly parts of a chicken that is functioning well. For example, we know, at least in general, what sorts of processes are parts of the chicken physiology and which processes are extraneous to the chicken. What we are talking about may be called a metaphysical problem. It is the problem of individuation of chickens. A portion of what we take to be our universe is singled out as one enduring

[4] See especially: Gallopin (1995); Shrader-Frechette (1997).

object. Because of its characteristics, the object in question is classified as a chicken. Our human disposition to pick out parts of the universe as individual chickens appears to rest both on innate patterns of thought and perception as well as on social conventions.

A clear concept of an ecosystem would be analogous to our clear concept of chicken. The collection of entities and processes and the physical and biological processes that constitute a healthy ecosystem would be understood by reference to shared linguistic conventions. The spatial and temporal limits of the ecosystem would also be determined by reference to such common understandings. Such understanding could facilitate descriptions of those processes or states that constitute a normally functioning ecosystem. Such a system would be described by reference to its elements or parts and by reference to system-states; the functioning of the system would be described in terms of sequences of system-states. Such descriptions can be produced for functioning chickens. Lack of integrity of an ecosystem (or of health of a chicken) could be represented as some failure of the proper reiteration of some sequence. There is some literature concerning the nature of ecosystems. However, it appears that the problems of individuating ecosystems have barely been addressed much less resolved. So far as I can determine, there is no consensus about this issue.[5]

In the absence of such common understandings, judgements about the health or integrity of ecosystems reflect only the individual perspectives and preferences of particular scientists or other individuals. Suppose, for example, that someone is discussing the environment of a particular farm and says something about the ecosystem containing that farm, for example, that the ecosystem containing that farm is unhealthy. For such a statement to be meaningful and correct, the statement should be understood to refer to one and only one ecosystem that allegedly contains the farm and that ecosystem should be unhealthy. The spatial and temporal limits of that ecosystem should be understood by the speaker (or writer) and listeners (or readers) as should the elements of that ecosystem and the structures and dynamic processes that obtain among those elements. Elements or phases that are parts of the ecosystem should be understood as such. Similarly, objects or processes that are not part of the ecosystem should be recognized as extrinsic to it. The claim that the ecosystem is unhealthy should

[5] For references on this matter see Rolston (1988) p. 364, note 6. Problems arising from vagueness of boundaries of ecosystems are noted in Callicott (1995) Some further criticisms of the of ecosystem are presented in Suter (1992). Various definitions of ecosystems are presented in Wall et al. (1995) These do not help to clearly determine the identity of ecosystems. For problems in regard to the notiion of ecosystem health see Haworth et al. (1998).

represent a failure of some required phases of a healthy ecosystem to occur. However, often these conditions are not satisfied. Unless the speaker has taken the trouble to specify the spatial and temporal limits of the ecosystem that he or she has in mind, to enumerate the elements of the ecosystem and to specify what structures or dynamic processes unite those elements into a system, the listeners will not know what they are. Nor will anyone (speaker or listeners) be able to tell whether there is just one ecosystem containing the farm or whether changes in or on the farm or in its environment are changes within an ecosystem or replacement of one ecosystem by another. Given such obscurities, scientific research cannot answer questions about whether an alleged ecosystem has integrity, or is capable of resisting stress or of reorganizing itself.

In support of the above claims, let us look at one attempt to define *agroecosystem*.[6] According to these writers, "An agroecosystem is a . . . geographically and functionally coherent domain of agricultural activity. It includes all living and physical components and the interactions among them." In order to define *ecosystem* rather than *agroecosystem*, we might consider modifying this definition by substituting the terms "biological activity" for "agricultural activity." However, this definition does not solve the problem of individuating ecosystems. It contains the unclear terms, *geographically coherent* and *functionally coherent*. Because of this lack of clarity it would not be possible, by reference to this definition, to determine the limits or dynamic interacting parts of ecosystems. The modified version would help neither to determine the spatial or temporal boundaries of ecosystems, nor to provide a sufficient basis for counting ecosystems, nor to distinguish the parts of those ecosystems from exterior processes, nor to specify the sequence of stages of a functioning ecosystem. These authors also suggest that agroecosystems should be considered with respect to nested hierarchies of ecosystems that they term *holarchies*. Whatever value this suggestion has in calling attention to the dependence of local units of production on surrounding regions, it does not resolve the problems of individuation to which we have been referring. Any geographical region may be viewed as nested in any of a potentially infinite number of distinct holarchies.

Of course, scientists or others wishing to refer to relations among objects and processes in our environments can, in any particular context, make clear the limits of the ecosystems to which they wish to refer. Precision can be obtained by way of stipulations regarding elements and limits of ecosystems, etc. Indeed, in any discussions in which it was essential to be clear and precise as to which systems were under consideration, such

[6] Waltner-Toews and N.O. Nielsen (1995). See also Kay (1994).

stipulations would be required. Authors wishing to discuss the health of particular ecosystems could make such stipulations. However, the application of the concept of "health" to ecosystems is problematic for other reasons. Let us turn next to considering some problems that arise.

WHAT IS ECOSYSTEM HEALTH

In order to determine whether we have moral obligations to preserve ecosystem health, we must be clear as to the ecosystems to which we are referring. Further, we need to be clear concerning the nature of ecosystem health and of its relationship to fundamental moral obligations. First, let us consider some problems with the concept of ecosystem health.

In general, health of a human being is a physiological and mental condition that, barring accidents, will enable the human being to live long, reproduce (with a suitable other person), and live well in a range of the ways that are open to human beings to live. For example, humans can perform a range of actions such as running for some distance, throwing, playing musical instruments, batting, painting, making things out of clay, etc. Further, healthy humans can live largely free of pain. A healthy person will be able to do a wide range of these activities without pain, or with pain that is moderate and of short duration. Barring accident, the person will retain these capacities for extended periods of time falling within a normal range. While these remarks about a healthy human being may well require some further qualifications, they give an overall idea concerning the idea of human health. Human health may be defined as those physiological conditions that enable a person to engage in many such acts or processes. An unhealthy person will not be able to do most of such things, or will not be able to do them as well or as long.

If we are to speak of the health of an ecosystem, it is reasonable to ask for a general idea of ecosystem health that could be compared with the general idea of human health. We would be willing to say that an ecosystem is healthy if certain biological processes, barring accidents, will enable the ecosystem to function long and well in a range of the ways that are typical of ecosystems, and be able to do most of the kind of things that ecosystems do. However, it does not appear that there is a consensus that there are characteristic ways in which all ecosystems tend to function for typical life-expectancies. Perhaps if a taxonomy of species of ecosystems were developed, then we could determine that certain species of ecosystems were capable of performing certain functions and would have characteristic life-expectancies. However, we don't yet seem to have a taxonomy of ecosystems or a description of what processes must occur

for the ecosystems to perform well and long in characteristic ways. In the absence of such a taxonomy and descriptions of ecosystems, it is not easy to make sense of claims that certain ecosystems are more healthy while others are less.

In the absence of such an overall concept of ecosystem health, it is difficult to assess claims that are often made concerning alleged criteria of ecosystem health. If someone says that criteria A, B, C, etc. are criteria of human health, we understand that if a person is healthy then most or even all of criteria A, B, C, etc. are satisfied. For example, if a person is healthy then her blood pressure falls within a certain range, her pulse falls within a certain range, her body temperature falls within a certain range, etc. When, for some person, these criteria are not satisfied, then in general we may expect that that person will not feel well or will not live as long or as well. She may, for example, suffer more pain. Given that we lack a general notion of ecosystem health, it is not clear how to understand claims to the effect that certain conditions are criteria of ecosystem health. Conceivably, can we say that if an ecosystem is healthy then certain conditions A, B, C, etc. are satisfied? However, what reason could we have for saying that these criteria are criteria of ecosystem health rather than criteria of something else? In the absence of an overall concept, there is no reason for saying that these criteria are criteria of ecosystem health.

To see what such an overall picture of ecosystem health would amount to, let us suppose that we had a generally accepted taxonomy of ecosystems and that there was general agreement that ecosystems manifesting certain features were healthy ones. (The features would be analogous to features of healthy humans such as a long life, relatively free of pain, combined with capacities to perform some of the range of typically human activities reasonably well.) Given such a general idea of ecosystem health, we would expect that claims that certain designated ecosystems were healthy would be generally accepted. We could investigate those ecosystems that were generally agreed to be healthy and discover biological conditions that could serve as indicators of ecosystem health, just as pulse, blood pressure, etc. can serve as indicators of human health.

Even though a general idea of ecosystem health has not been developed, some writers have suggested that certain sets of features are criteria of ecosystem health.[7] For example, the following features have been suggested.

[7] See Rapport (1997). Several other criteria are mentioned here. However, the additional criteria do not apply to all ecosystems but only to managed systems. The distinction between managed and non-managed systems raises questions that we shall not pursue directly. Some vague notions of agroecosystem health, e.g., integrity and efficiency, are discussed in Wall et al. (1995).

An ecosystem may be said to have changed from better to worse health when the following happen: reduced energy throughput, reduced nutrient cycling, reduced capacity to cope with stress, reduced level of organization or complexity.

If the analogy with human health is to be developed then conditions such as the above could be formulated as follows: In a healthy ecosystem energy throughput will be within such and such range, nutrient cycling will be within so and so range, etc. If stresses of designated types occur within designated limits the ecosystem will respond in ways that preserve energy throughput, nutrient cycling, etc. Perhaps scientists devoted to development of a theory of ecosystem health will develop a theory of ecosystems that permits formulation of an idea of ecosystem health along the above indicated lines.

However, many questions might be raised concerning the criteria of ecosystem health that were mentioned above. Let us consider some of these. One of the criteria was reduced energy throughput. Suppose we understand this in the following way: To say that a decrease in energy throughput of an ecosystem is a decrease in the health of that ecosystem is to say that, other things being equal, if an ecosystem moves from a state of higher energy throughput, to a state of lower energy throughput that system has thereby become less healthy. But why should we agree that this is a criterion of health? Are human beings with high metabolism healthier? Consider a human society that changes from a state in which practically all transportation of human beings is in private automobiles to a state in which much transportation of human beings involves public transport, bicycles, and walking. In certain ecosystems containing such a society, there may well be a decrease in energy throughput. Perhaps, however, those ecosystems containing that society will be healthier after the changes in question.

Another suggested criterion of ecosystem health was reduced nutrient recycling. A question similar to the above can be made with respect to nutrient recycling. Just imagine a human society of gluttons being transformed into a society in which most people don't overeat. Could not certain ecosystems containing that society be healthier even though, on the whole, nutrient recycling through those ecosystems was reduced?

What has the amount of nutrient recycling got to do with health anyway? Consider two possible stages of a hypothetical ecosystem. Suppose that over time, one of the stages has evolved into the other. The two stages differ in respect of proportions of populations. We can imagine these two stages as a forest that has transformed over time. Now, suppose that in respect to all but one of the criteria mentioned above the two stages are

equal but that in one stage the level of nutrient recycling is twenty percent higher than in the other stage. This may be a result of the change in proportion of some parts of the ecosystem over time. Do we have any reason to say that the stage with the higher level of nutrient recycling is healthier? I do not believe so. The ecosystem may be equally healthy in both stages. Indeed the change from one stage to another may be part of a larger cycle in which proportions of certain populations fluctuate inversely with respect to each other within certain limits.

Questions might also be raised about complexity. First of all, we shall want to know how complexity is determined. Answering this question will not be easy. Next, we may ask why an decrease in complexity is an indicator of less health. With respect to human society, some people would suggest that a simpler society is healthier.

The one remaining criterion is capacity to cope with stress. We are inclined to agree that a healthier system (whether the system is a human being, an animal or an ecosystem) is better able to cope with stress, that is better able to return parameters of health to levels within the healthful range, than is a less healthy system. However, this capacity is not in itself a recognizable or observable feature of a system analogous to a person's pulse or body temperature. This capacity may be called a higher level capacity. What it amounts to is the claim that in a healthy system the recognizable criteria of health stay within (or return to) healthful levels in spite of inputs that tend to force them beyond the healthful limits. However, the notion of stress is logically tied to the idea of health. Something is stressful if it tends to degrade health. Thus, since the idea of what a healthy ecosystem can do is undetermined, the application of the concept of stress to ecosystems must also be problematic.

In a recent paper, "Assessing Ecosystem Health", three "indicators of ecosystem health" are mentioned.[8] These are "vigor," "organization," and "resilience." These criteria are obscure in themselves. Further, greater obscurity arises out of failure to characterize the sets of entities or processes and interactions that characterize the specific ecosystems to which these indicators are to be applied. For example, the Great Lakes Basin is referred to as an ecosystem that has suffered a decline in health. But, we may ask, what are the types of entities and processes and interactions that characterize this ecosystem? If certain entities and processes are stipulated then the system will be seen to increase in complexity, vigor, or resilience. Other choices concerning entities and processes yield other conclusions given these indicators.

[8] Rapport et al. (1998).

Even if the systems in question were clearly specified, application of the criteria to those systems does not yield unique conclusions due to the obscurity of the indicators. It is suggested in the above paper that vigor varies directly with "activity, metabolism or primary productivity." Should we agree that an ecosystem that has greater activity, metabolism, or primary productivity is a healthier ecosystem? This question is unclear. For one thing, the terms "activity," "metabolism," and "primary productivity" appear to signify more than one type of process. Is it possible for metabolism to increase while primary productivity remains stable or even decrease? Surely, for a farm this appears to be possible. Changing a farm field from a field of grain to a field of weeds could yield both increases in metabolism and decreases in, what the farmer would count as, the primary productivity of the farm. Should we say that the weed field is healthier? Have farm systems declined in resilience? Again no clear answer is implied by these criteria. A farm system which includes inputs of fertilizers, herbicides, irrigation, etc. may preserve its structure and function in the face of droughts, infestations of pests, etc. that would have undermined productivity of farms lacking these inputs.

According to "Assessing Ecosystem Health," organization varies directly with the diversity and number of interactions between system components. Thus, this indicator implies that some farm fields would have a very low level of organization since, presumably, the system has relatively few components (once weeds, fungi, or other pests have been eliminated or reduced in numbers) and therefore few interactions among the components. Finally, according to this paper, a system is highly resilient if it has a strong tendency to preserve its structure and function in the presence of stress. The authors of this paper claim that there was a decline in ecosystem health in the Great Lakes Basin ecosystem due to reductions in fish abundance and infertility of agricultural soils.[9] However, we might wonder whether these indicators agree with each other. Is there a lower level of metabolism in the Great Lakes Basin compared with the early nineteenth century? The primary products of this region may well have changed during the last two centuries. Are we entitled to say that the primary productivity of the region has declined overall in this period? These questions do not have clear answers. Should we say that this system's resiliency has declined or simply that the ecosystems of interest to people in this region early in the nineteenth century are not the same ecosystems as those of interest to people concerned with this region at the present time?

[9] Such a claim appears among the conclusions of Rapport (1997), pp. 397–402.

MUST WE ACHIEVE ECOSYSTEM HEALTH?

To pursue the final question of this paper, let us assume that the problems we have been discussing concerning the concepts of "ecosystem" and "ecosystem health" have been overcome and that the concepts have been developed and clarified satisfactorily. Now, let us consider whether we have a moral obligation to conserve or achieve ecosystem health.

Of course, if someone says "such and such ecosystem must be protected" we would not agree until some specific ecosystem is clearly specified. We do not agree that there is an obligation to sustain the health (whatever health is) of every existing ecosystem. Very likely, it is permissible for some existing ecosystems to be eradicated and replaced. Indeed, replacing some ecosystems with others may well be a moral obligation. In support of such claims, we may consider various hypothetical cases. Consider, for example, an ecosystem that has emerged in a river estuary as a consequence of excessive run-off of fertilizer and agricultural chemicals. In the estuary there may be a severe paucity of living organisms. Suppose in such a case that we have clearly identified an ecosystem that we may call the estuary ecosystem. It is very likely that there is no obligation to preserve that ecosystem or to make it as healthy as it could be. Rather, there may be an obligation to recreate another ecosystem, one that more closely approximated the ecosystems existing in the estuary prior to the formation of the estuary ecosystem. Further, while the hypothetical example considered here involved an ecosystem that resulted from human agricultural activity, that is really a nonessential feature. Conceivably, the estuary could have developed an unhealthy ecosystem as a result of factors other than those that attend human social activities. If that were the case there could well be no moral obligation to leave it as is.

Given that it is not a moral obligation to preserve or achieve the health of all ecosystems, the answer to the question whether we have a moral obligation to preserve the health of some ecosystem will depend on the nature and circumstances of the ecosystem in question. For example, suppose the ecosystem is found in the soil of a highly productive agricultural region and that it is essential for such an ecosystem to be in a healthy state to maintain continued agricultural productivity in that region. Suppose further that a considerable segment of the existing human population derives a significant proportion of its nourishment from the crops produced in that region. Then, given virtually any plausible ethical assumptions it will be almost certain that those ecosystems should be preserved in a healthy state. Unless alternative sources of nourishment were provided for the people in question, failure to preserve the health of those ecosystems would jeopardize the well-being of those people. However, as the estuary example shows,

in other circumstances, there would be no obligation to preserve the health of the identified ecosystems.

OBJECTIONS

We have taken the position that in some circumstances we do not have a moral obligation to preserve the health of some existing ecosystem. It might be argued against this that failure to preserve the health of any existing ecosystem will have morally unacceptable consequences. Allowing some ecosystem to become unhealthy, or even to disappear altogether, will invariably have unacceptable moral implications because of the interdependence among the Earth's ecosystems. When one ecosystem becomes unhealthy, the infection will spread to other ecosystems and ultimately will cause ill-health, death or impoverishment of human beings.

Before replying to this objection, let us first note that the argument presented here has some validity. The Earth's environmental systems have some interconnectedness. Degradation or destruction of one system could effect other systems and thereby bring about morally unacceptable results. However, contrary to the view expressed in this objection, it is not inevitable that destruction of any system will have such destructive consequences for other systems that human welfare would be undermined. On the contrary, the consequences of degradation of a system can be, on the whole, beneficial. Elimination of habitat for the mosquitoes that spread malaria in North America in past centuries almost certainly involved degradation of some existing systems or ecosystems. There may well have had some undesirable consequences that resulted therefrom. However, the claim that the consequences of those changes to North American environments were morally unacceptable is almost certainly false. To establish the contrary of this one would have to show, at the very least, that controlling malaria at that time could have been achieved in ways other than eliminating the habitat of the mosquitoes and that these other ways of controlling malaria would have produced greater benefits or lesser harms. The claim that eliminating those mosquito-including ecosystems had any morally unacceptable consequences is not obviously correct. There is no reason, of which I am aware, to accept this claim.

One final remark is necessary. The argument given here that we are not necessarily obligated to protect the health of every ecosystem has clearly appealed to anthropocentric ethical assumptions. However, the same conclusion would follow if these were replaced with ethical assumptions that implied that we had fundamental moral obligations to sentient animals, or

to living creatures, or to preserve certain features, for example biodiversity, of the Earth's environment.

CONCLUDING SUMMARY

In this paper, we have raised questions about appeal to the notion of "ecosystem health" as a way of assessing environmental degradation. We have argued that there are significant conceptual problems concerning these notions and that in light of these appeal to these ideas in evaluating environmental change is highly problematic. Of course, future scientific and philosophical thought might yield an improved notion of "ecosystem health," a notion that could be of value in considering environmental practices and policies.

Clearly finding a way to assess changes in our environments is of the greatest importance. The number of writings in which scientists call attention to environmental changes that are very harmful is vast. The works of Myers and Eckholm cited in this paper are only two of a vast number of works that document such harms and probable harms. Loss of farmland, loss of fisheries, flooding, landslides, and loss of healthful air and water are only a few of the harms that have resulted from environmental changes. However, environmental changes often result from human activities that yield human benefits. Finding a consensus or near-consensus, on ways to assess harms and benefits so that coherent environmental practices and policies could be developed to protect our environment, is of the greatest importance. Without such a consensus individuals or governments will often be unable to take steps to prevent further environmental damage and the attendant harm to human welfare.

REFERENCES

Callicott, J. Baird, "A Review of Some Problems with the Concept of Ecosystem Health," *Ecosystem Health* 1(2) (June 1995).

Eckholm, Erik P., *Losing Ground: Environmental Stress and World Food Prospects* (New York: W. W. Norton & Co., 1976).

Gallopin, Gilberto C., "The Potential of Agroecosystem Health as a Guiding Concept for Agricultural Research," *Ecosystem Health* 1(3) (September 1995).

Haworth, Larry, Conrad Brunk, Dave Jennex, and Sue Arai, "A Dual-Perspective Model of Agroecosystem Health: System Functions and System Goals," *Journal of Agricultural & Environmental Ethics* 10(2) (1997/1998).

Kay, James, J., "Some notes on: The Ecosystem Approach, Ecosystems as Complex Systems and State of the Environment Reporting," unpublished (1994).

Myers, Norman, *The Primary Source: Tropical Forests and Our Future* (New York: W. W. Norton & Company, 1984).
Rapport, D. J., "Is Economic Development compatible with Ecosystem Health?" *Ecosystem Health* 3(2) (June 1997).
Rapport, D. J., R. Constanza, and A.J. McMichael, "Assessing Ecosystem Health," *Tree* 13(10) (October 1998).
Rolston, Holmes, III, *Environmental Ethics: Duties to and Values in The Natural World* (Philadelphia: Temple University Press, 1988).
Shrader, Frechette K., "Ecological Risk Assessment and Ecosystem Health: Fallacies and Solutions," *Ecosystem Health* 3(2) (June 1997).
Suter, Glenn W., "A Critique of Ecosystem Health Concepts and Indexes," Publication 3951, Environmental Sciences Division, Oak Ridge National Laboratory (1992).
Wall, Ellen, John Smithers, and Gord Wichert, "A Framework for the Integration of Concepts and Research in Agroecosystem Health," Discussion Paper #18, Agroecosystem Health Project, Faculty of Environmental Sciences, University of Guelph (1995).
Waltner-Toews, D. and N. O. Nielsen, "Assessing Agroecosystem Health." Discussion Paper #23, Agroecosystem Health Project, Faculty of Environmental Sciences, University of Guelph (1995).
Wilson, Edward O., *The Diversity of Life* (New York: W. W. Norton & Company, 1992).

Department of Philosophy
University of Guelph
Guelph, Ontario, Canada
N1G 2W1